Energy Planning Manual 2017

olade
Latin American Energy Organization

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ACRONYMS

AGEERA	Association of Electric Energy Generators of Argentina (Asociación de Generadores de Energía Eléctrica de la República Argentina)
AIF	International Association for Development (Asociation Internacional de Fomento)
ALC - LAC	América Latina y Caribe – Latin America and Caribbean
ANH	National Agency for Hydrocarbons (Agencia Nacional de Hidrocarburos)
ANP	National Agency for Oil, Natural Gas and Biofuel (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis)
AT	High Tension Lines (Líneas de Alta Tensión)
BEEF	Energy Balances in terms of Final Energy (Balances Energéticos En Términos de Energía Final)
BEEU	Energy Balances in Terms of Useful Energy (Balances Energéticos En Términos de Energía Útil)
BEI	Comprehensive Energy Balance (Balance Energético Integral)
BEN	National Energy Balance (Balance Energético Nacional)
BID - IDB	Inter-American Development Bank (Banco Interamericano de Desarrollo
BIRF- IBR	International Bank for Reconstruction and Development (Banco Internacional de Reconstrucción y Fomento)
BM - WB	World Bank (Banco Mundia)
BOMT	Build Operate Maintain and Transfer
BRIC	Brazil, Russia, India and China
BU	*Bottom-Up* Models
CA	Central America (Centro América)
CC	Combined Cycle
CEARE	Center for Students of Energy Regulatory Activity (Centro de Estudiantes de la Actividad Regulatoria Energética)
CEPAL- ECLA	Comisión Económica para América Latina y Caribe, Naciones Unidas Economic Commission for Latin America
CIADI -ICSID	International Center for the Settlement of Investment Disputes (Centro Internacional de Arreglo de Diferencias Relativas a Inversiones)
CII - IIC	Inter-American Investment Corporation (Corporation Interamericana de Inversiones)
CIIU	International Standard Industrial Classification (Clasification Internacional Industrial Uniforme)
CME - WCE	World Energy Council (Consejo Mundial de la Energy)
CNE	National Commission of Energy (Comisión Nacional de Energía)

CNEE	National Electric Energy Commission, Guatemala (Comisión Nacional de Energía Eléctrica, Guatemala).
CONELEC	National Electricity Council, Ecuador (Consejo Nacional de Electricidad, Ecuador).
CT	Centros de Transformation – Transformation Centres
CTI	International Technical Cooperation (Cooperaciones Técnicas Internacionales
CW - WC	Washington Consensus (Consenso de Washington)
DEG	General Energy Diagnosis (Diagnóstico Energético General)
DOE	Department of Energy of the United States
EBH	Bolivian Hydrocarbons Strategy (Estrategia Boliviana de Hidrocarburos)
EF - FE	Final Energy (Energía Final)
EIA	Energy Information Administration, United States
ENPEP	Energy and Power Evaluation Program
EPE	Energy Investigation Company (Empresa de Investigation Energética)
EPE	Energy Investigation Company (Empresa de Pesquisa Energética, Brasil.
ESMAP	Energy Sector Management Assistance Program (Programa de Asistencia a la Gestión del Sector de la Energía)
EU	Useful Energy (Energía Útil)
EUROPEAID	Direction of Development and Cooperation of the European Union
FB	Bariloche Foundation (Fundación Bariloche)
FODA- SWOT	Strengths, Weaknesses Opportunities Threats (Fortalezas, Oportunidades, Debilidades, Amenazas)
FOMIN - MIF	Multilateral Investments Fund (Fondo Multilateral de Inversiones
GEI - GEG	Green House Effect Gasses (Gases de Efecto Invernadero)
GISE	Energy Systems Investigation Group (Grupo de Investigation en Sistemas Energéticos)
GLD	Demand Side Management (Gerenciamiento por el Lado de la Demanda)
GLP - LPG	Liquid Petroleum Gas (Gas Licuado de Petróleo)
GNL - LNG	Liquid Natural Gas (Gas Natural Licuado
GTPIR-CEAC	Working Group on Regional Planning – Central America (Grupo de Trabajo de Planification Regional – Consejo de Electrification de América Central)
IAEA	International Atomic Energy Agency
IBGE	Brazilian Institute of Geography and Statistics (Instituto Brasileño de Geografía y Estadísticas)

ICE	Costa Rican Electricity Institute (Instituto Costarricense de Electricidad)
IDEE	Energy Economics Institute (Instituto de Economía Energética)
IEEE	Institute of Electrical and Electronics Engineers
IFC -	International Finance Corporation
IIASA	International Institute for Applied Systems Analysis
INE	National Institute for Statistics (Instituto Nacional de Estadística
IPCC	Inter-governmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LATAM	Latin America (Latinoamérica)
LE	Firewood (Leña)
LEAP	Long Range Energy Alternatives Planning System
LED	Light Emitting Diode
MAED	Model for Analysis of Energy Demand
MARKAL	Market Allocation Model
MCMLP	Model for Long Term Macroeconomic Consistency (Modelo de Consistencia Macroeconómica a Largo Plazo)
MDL - CDM	Clean Development Mechanism (Mecanismo de Desarrollo Limpio)
MEDEM	Model for the Estimation of Demographic Parameters (Modelo de Estimation de Parámetros Demográficos)
MELP	Model for Long Term Expansion (Modelo de Expansión a Largo Plazo)
MEM	Wholesale Electricity Market (Mercado Eléctrico Mayorista)
MEMSP	Patagonia System (Sistema Patagónico)
MESSAGE	Energy Supply Strategy Alternatives and their General Environmental Impacts Model
MIPE	Comprehensive Energy Plannning Model (Modelo Integrado de Planificación Energética)
M-Ref	Study Refining Model (Modelo de estudio de Refinación)
MSR	Projection of Residential Energy Demand Model (Modelo de Proyección de la Demanda de Energía Residencial)
MT	Medium Tension Lines (Líneas Media Tensión)
MW	Megawatt (Megavatio)
NGC	National Grid Company – UK
OEA- OAS	Organization of American States (Organización de Estados Americanos
OIEA - IAEA	International Atomic Energy Agency (Organismo Internacional de Energía Atómica)
OLADE	Latin American Energy Organization(Organización Latinoamericana de Energía)
OPEP - OPEC	Organization Of Petroleum Exporting Countries (Organización de Países Exportadores de Petróleo
OPTGEN	Generation and Interconnection Capacity Expansion Planning Model

OSINERGMIN	Supervisory Agency for Investments in Energy and Mining. Lima Peru (Organismo Supervisor de la Inversión en Energía y Minería, Lima Perú)
PBI-PIB - GDP	Gross Domestic Product (Producto Bruto Interno o Producto Interno Bruto)
PCB	Polychlorinated biphenyls - isolating material used in power transformers ((Policlorobifenilos,)
PCI - LCV	Low Calorific Value (Poder Calorífico Inferior)
PDE	Ten Year plan for Energy Expansion (Plano Decenal de Expançao de Energía
PEMEX	Mexican Petroleum Company (Petróleos Mexicanos)
PEN	National Energy Plan (Plan Energético Nacional)
PESE	Strategic Plan of the Energy Sector (Plan Estratégico del Sector Energético)
PICC - IPCC	Intergovernmental Panel on Climate Change (Panel Intergubernamental de Cambio Climático)
PNE	National Energy Plan (Plan Nacional Energético)
PROCEL	National Program for Electric Energy Conservation (Programa Nacional de Conservación de Energy Eléctrica)
RB	Residues of Biomass (Residuos de Biomasa)
SEC	Securities and Exchange Commission
SEI-B	Stockholm Environment Institute-Boston
SENER	Energy Secretariat (Secretaría de Energía)
SHELL	Royal Dutch Shell Ltd.
SIELAC	Energy Information System for Latin America and the Caribbean
SIEPAC	Electric Interconnection System of Central American Countries (Sistema de Interconexión Eléctrica de los Países de América Central)
SPE	Society of Petroelum Engineers (Sociedad de Ingenieros en Petróleo)
TD	Model *Top-Down*
TG	Turbo Gas
TRL	Technology Readiness Level
UEE	Eficient Use of Energy (Uso eficiente de la energía)
UK	United Kingdom
UPME	Mining Energy Planning Unit (Unidad de Planeación Minero Energética)
URE	Rational Use of Energy (Uso Racional de la Energía)
USA	United States of America
USGS	United States Geological Survey
VMDE	Vice-Ministry for Energy Development (Viceministerio de Desarrollo Energético)
VP o VA PV	Present Value (Valor Presente o Valor Actual)
WASP	Wien Automatic System Planning
WEC	World Energy Council
WPC	World Petroleum Congress
WWF	World Wildlife Fund
YPFB	Annual Reports of the Marketing Unit (Informes Anuales de la Unidad de Comercialización de YPFB)

FOREWORD

The Latin American Energy Organization (OLADE) is well aware of the importance and benefits of energy planning at the national and regional levels for the formulation, evaluation, and monitoring of actions that contribute to energy security, sustainable development, and regional integration.

Our efforts are focused on strengthening energy planning through the implementation of actions, as well as the development of tools that support the management and administration of the energy information, energy prospective, energy policy and the transfer of knowledge between countries in the Latin American and the Caribbean region.

OLADE has carried out consistent efforts to strengthen the energy planning. In the year 2012, thanks to the support of the Government of Canada in the framework of the project “Sustainable Energy for Latin America” – sub-project “Capacity Development in Energy Planning”, this Manual was prepared, which constitutes a unique guide in the Region, and aims to become a reference tool for policy makers.

My administration has given great relevance to energy planning, with an emphasis on strengthening technical capacities and supporting the policies of OLADE’s Member Countries, in order to strengthen the development of planning and sectorial actions.

Planning is a key element of policy, and at the same time, it is a method and a practical discipline, which becomes a continuous process that deepens institutional strengthening.

The energy planning process starts with a diagnosis based on the historical behavior of demand and energy supply, a behavior that is analyzed in a comprehensive or sub-sectorial way. With this background, the development of forecasting scenarios will provide basic information for policy making and the short, medium and long-term strategies.

Hereby, this manual is made available to the energy community, a document that encompasses in detail each of the planning stages. Our interest is to achieve the practical implementation of this Manual as an exercise in strengthening the capacities of our institutions, so the past experiences and relevant knowledge can be replicated throughout the region.

Finally, I thank the authorities and technical teams of the member countries, consultants and officials of the Permanent Secretariat who have contributed to the preparation of this Manual.

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CHAPTER I

Introduction

KEY WORDS

Energy, State, Planning Instruments, Planning Models, Energy Planning.

I.1. Introduction

The integration of planning into the energy system of a country is a matter of vital importance to achieve sustainable development. This chapter introduces the importance of energy planning in modern societies, highlighting the fundamental role of the State within the mentioned process. In this context, Section I.2 informs us about the background, elements justifying the need for energy planning in order to guarantee a reliable and sustainable energy supply, and the goal of this handbook. In Section I.3, conceptual considerations about sustainable and energy development, which are the framework for a modern and adequate planning in line with environmental and social responsibilities of local and global order, are listed. In section I.4, the elements of an Energy Plan as general framework for the contents proposed in this manual are briefly described. Finally, in section I.5, a review of the next chapters included in this handbook are made.

I.2. Background, and Motivations, of the Manual

I.2.1. Historical references linking energy and human development

The development of humanity is deeply linked to the evolution of the domination over diverse energy sources, that nature has put to disposal, and the ability to transform and use them. As a matter of fact, through time, the historical increase of per capita energy use, and the efficiency of the methods used to take advantage of that energy, can be identified. This circumstance implies a direct and permanent relation between the sources of energy, as a part of the energy system, and the environment considered in an ample and systemic sense[1].

This evolution recognizes stages that could even be referred to as “socio-energy models” such as: Pre-agriculture, Agriculture, Advanced, Pre-industrial, Industrial, and Advanced Industrial.

The fact that a determined model prevails in a region does not mean that it has been applied in other places at the same time. These are conditioned by their sources of energy and its utilization, and when passing from one model to the next, there is an increase of energy in the *per capita* consumption as well as in the global consumption, opening the way to processes of energy transition[2]

In the initial stage, use is made of the *natural flows of energy* (sun, wind and water) in a direct manner that is without any type of equipment or intermediate technology. On the other hand, there existed a consumption of energy linked to food that was also obtained in a direct manner from nature. This is the primitive stage and its energy consumption, as presently measured, can be considered a marginal one. If we include the energy content of foods, we can estimate a value of approximately 2.000 kcal/day/person.

The discovery of fire will permit for the first time to go from consumption in the *form of accumulated energy,* firewood that can be considered as stored solar energy, through a process of photosynthesis, in a variable period of time but in the order of the magnitude of a human lifetime. This is the stage when the nomadic culture begins, the hunter that yet has to discover agriculture and whose energy consumption has been estimated at approximately 5.000 kcal/day/person, part of which corresponded to the “production” of fire. This is the starting point for a series of simple technological developments that enhance the capture of energy flows (sails, levers, the wheel) that improve the utilization of animated energy (human and animal) and therefore slowly start to increase the consumption of energy.

Among these developments, we can mention the use of natural gas by the Chinese (1000 years B.C.) using bamboo canes as pipelines, primitive wheels to capture hydraulic energy in Babylon, Egypt and China, the wind to move sail boats thousands of years before Christ, in spite of the fact that the human energy of slaves was an important source of energy up to 1000 years later.

Ancient Greeks, in a first scientific systematization of the concepts of physics, considered that fire was one of the four basic elements of nature, together with water, earth and air. On the other hand, the appearance of new social and economic activities such as agriculture, commerce (which implied transport) and handcrafts contributed to such an increase.

1 The definition and scope of the Environment includes components such as biotic, physical-chemical and anthropic.

2 The concept of energy transition is later explained.

Thus, human beings, which were organized in societies and settled in a determined geographical place, underwent a historical transformation process from subsistence farming, with a consumption in the order of 12,000 kcal/day/person, to a socioeconomic system of commercial development with long distances like the one during the Middle Ages in Europe. During that age, energy consumption reached 27,000 kcal/day/person in the most developed areas. This amount of energy consumption can be decomposed in 7,000 kcal for food needs, 12,000 kcal for other basic needs and trade, 7,000 kcal for farming development, and 1,000 kcal for transport. In today's industrial society, a typical human being consumes around 230,000 kcal/day.

This evolution has implied successive processes of an *energy transition,* understood as a change from one energy system to a different state in terms of *the quantity, structure of final use and quality of sources*, without forgetting that there existed and continue to exist, differences in *space* (where) and *time* (when).

The transition processes, as a part of the history of energy, imply changes of non-commercial and commercial energy, from renewables to fossils, of rural and urban consumption, from low energy to high energy, improvements in efficiency and productivity, a deepening of conversion (example. Electricity), increase in density supply/demand and/or de-carbonization, only to mention a few of the most relevant modifications.

I.2.2. Motivations for this Energy Planning Manual

Latin-American and Caribbean States' role in strategic planning matters have been limited by the changes in the economic and political view of the last three decades (neoliberal reforms, return to nationalization of firms and utilities, and an approach that highlights the strategically character of the energy sector), and global issues such as oil price volatility, and economic recessions which affect investment in the energy sector. As a result, at a national level, the agencies responsible for energy planning has been constructed and dismantled in many ways that caused a discontinuity in energy planning and in the adaptation of the capacities to the variation of loses in the energy sector.

Recently, in Latin America and the Caribbean, a clear need for increasing and strengthening planning capabilities has been identified. In some cases, in order to run again strategic energy planning agencies and the application of energy planning models, it is needed to deal with the new paradigms of energy demand and supply that mirror climate change issues, global politics and financial dynamics, price changes, and the public perception about the responsibilities of the energy sector.

In what follows, the approaches justifying the attributions of the States in matters of energy planning are reviewed.

Systemic approach

In the most recent stages of history, the consumption of energy in the world has almost quadrupled in the last 60 years. In order to satisfy this consumption, humanity has turned to the exploitation at a great scale of basically non-renewable resources. In modern cultures, the link between energy and society appears in all strata – from politics to economics – and the performance of the energy sector is crucial, inasmuch as it generates the basic inputs for the joint operation of the productive apparatus, and consequently constitutes a fundamental economic objective.

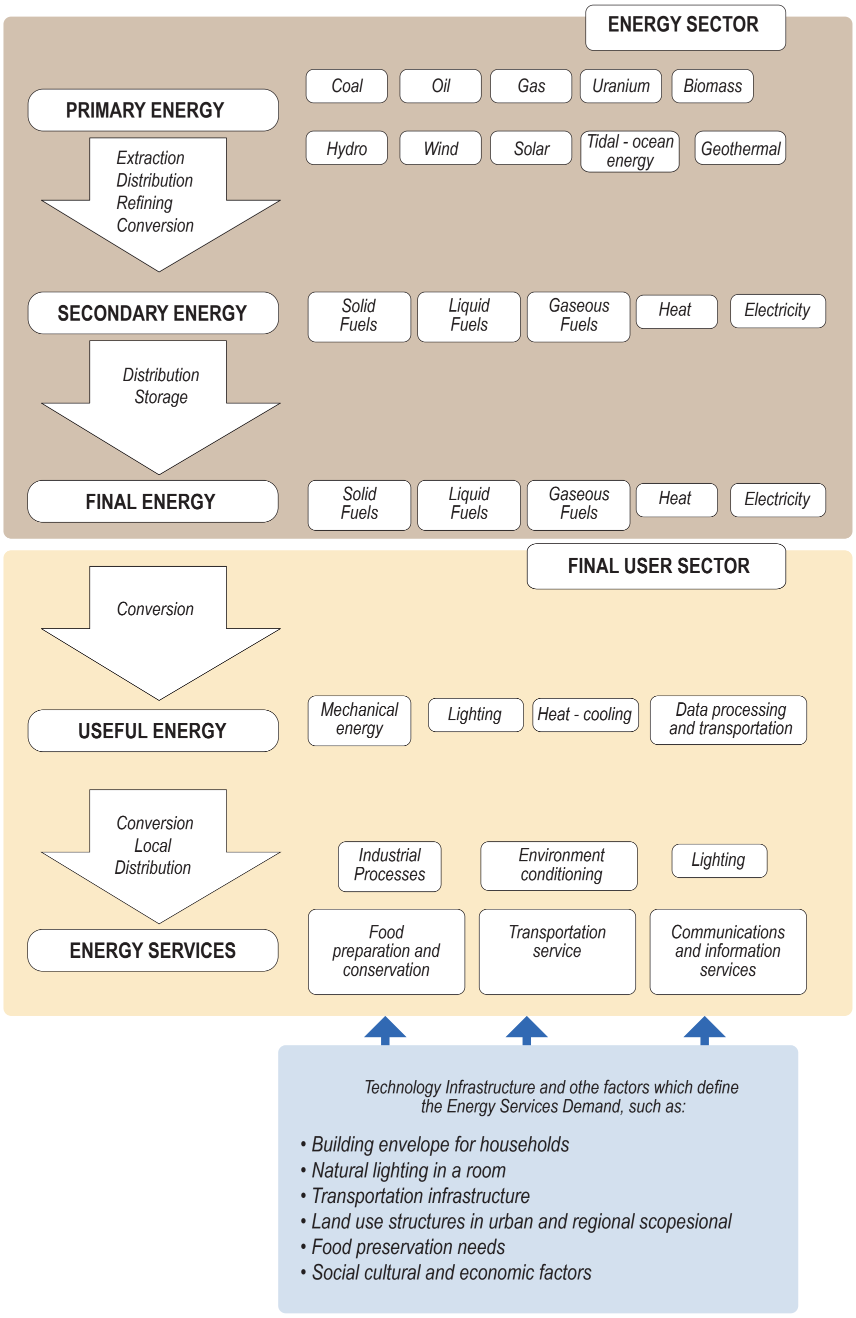
The evolution in complexity of energy systems, according to their technical, social and cultural, geopolitical, economic, and environmental dimensions has implied the need of more government intervention upon these systems.

A recent historical reference that could be considered as a breaking point is constituted by the shock of oil prices. Prior to the oil crisis of 1973, la activity of policy and energy planning was concentrated on the planning to assure supply as an answer to the growth of demand, without actions related to it that would constitute a part of the policy for intervention and planning. The energy industry and its different productive chains, considered as a sector, were the exclusive object of an analysis that was supposed to provide an answer to the requirements set forth by the social and economic system under analysis.

A notorious incorporation in the conceptualization of the energy analysis, constitutes the definition of an energy system, understood as a study of the social processes of production, transformation, transport or transmission, distribution and consumption of energy, in its entire multidimensional conformation. The center of attention is no longer fixed on scarce resources and unlimited needs, but also focuses on social agents that have administration power over resources and over those that embody such needs. In consequence, it transcends the vision centered upon the energy industry and introduces new dimensions in the link between energy and the social, economic and environmental system.

Thus, striving to achieve greater efficiency and processes for the substitution between sources, recognizing the need of acting upon the guidelines and patterns of energy consumption incorporates the consumption component to energy analysis and to policies for public intervention.

Figure I.1: Energy System



Source: Authors preparation based on the Summary for Policy Makers – Global Energy Assessment Report. GEA-IIASA – 2012.

The reasons that justify the need of such an intervention are that energy systems share, in varying degrees, some specific attributes. As a matter of fact, “energy is not a good as others” (Percebois, 2013).

> *“In principle, energy (s) possess in their nature a double dimension: on the one hand, they are strategic goods, and on the other they have the mission of a public service. It is not surprising that the different public powers involved in one or other of these dimensions (States, groups of States, Regions, local collective groups…) strive to control or supervise the access, development and functioning of these markets.*
>
> *Energy industries are characterized by having very high fixed costs: they are “capital intensive” and the programing of heavy investments requires long periods of time (20 to 60 years) in comparison to the majority of other industrial sectors, and with the horizon of financial markets.*

Taking into consideration, on one side its exhaustible nature, its space locations, its permanent differences of quality or certain differences in costs (production, transport, etc.), the activities of the energy sector are the ones that generate a large amount of income and super benefits, from diverse origin, nature and importance. The prices formed by these markets are a priori, very different of the costs of access (example: marginal cost of production) of these energies. It must be pointed out that even under a perfect competition, incomes exist and persist.

Different reasons (geographic concentration of many resources, technologies, legal provisions…) lead some of the stakeholders to enjoy a power in the market, in one or another place of the energy chain: producers, of course, but also transporters and even consumers, The consequence is the observation of very different market forms, and additionally highly evolving (for example, oil) that goes from (almost) perfect competition to the monopoly, traversing diverse oligopoly structures".

In addition, the development of the activities related to energy systems shows some special features that are here listed:

- The presence of natural monopolies in various segments of productive energy chains,
- The use natural resources of social domain,
- The importance of the natural environment in the production and consumption of energy, both in that which refers to the impacts generated by energy, such as the vulnerable nature of the energy system upon the environmental and weather systems
- The need for coordination due to the multiple internal interactions upon the Energy System, both in the provision of (Resources, Production, Transformation) as well as consumption (nodes of challenge, URE),
- The need to define the different energy chains,
- The imperious search for a greater productive efficiency of supply companies,
- The possibility of associating technological niches or actions for the regional development of energy systems.

Confronting features reinforcing the idea that energy cannot be considered in a fragmented manner (that is, without a systemic approach), and given as well its intrinsic features, the need of intervention through public policy it is notorious. Even more, energy planning, as an instrument of such policies, evolves into a set of strategies that contributes to achieve a sustainable development and its objectives will include different aspects of a society such as its politics, economic, and cultural activities.. Thus, energy planning, acquires a multidisciplinary and complex nature.

In synthesis, the State has the unavoidable responsibility of designing and putting into practice an active energy policy. This cannot be left in the hands of stakeholders in the system so that they may take decentralized decisions for the assignment of resources. This is principally due to the fact that these are the objectives of such stakeholders, whether they be public or private, and do not necessarily coincide with those goals set forth by society at the global level.

From a historical perspective

During the in the 90s, economic restructuration in Latin American and Caribbean countries has required an adjustment of the role of the state in regard to the energy sector in terms of coordination mechanisms and resource allocation. This adjustment has directly affected the energy sector.

On the one hand, this process prioritized market mechanisms as instruments for coordinating decisions and allocation of resources and has fueled a new scheme of decentralized decision making in energy production activities.

On the other hand, particularly reaching areas previously considered strategic, the reform included both the structure of the State as its policy implementation functions to the set of goods and services production activities in the public domain. In the energy sector and other productive ones, an explicit regulatory system has been established. This system has been used in order to clear up the area for fair competition based on market forces or to replace these forces when they are not considered appropriate for attaining satisfactory results or acceptable from the point of view of the community as a whole. These new forms of regulation have been embodied in institutions with different degrees of independence from the executive branch of the state (Latin American Energy Organization, 2003).

Correspondingly, the relationship between the central, sub national, and local governments, are also altered. That is, a progressive intrusion of local governments and sectors of society for the control or in the discussion of matters of public interest. Nevertheless, the latter forms of participation are still in an embryonic state and their channels are often not even properly constituted.

Although almost all Latin American countries have undertaken reforms affecting the institutional structures of energy markets, the recent international experience indicates that the state's role has been crucial both as when the abandonment of its entrepreneur role was very drastic and when it regained its leadership in the decision-making process of the sector (Cenergía, 2009).

Thus, it has been noticed that the state should get involved in the comprehensive planning of the energy sector. Otherwise, the multiple interactions of public policies with multiple private sector decisions could create severe coordination and sustainability problems in the energy sector.

Although it is likely to be considered as another economic sector which can be as well be guided by market forces, the energy sector is becoming an strategic sector of capital importance for the countries. Therefore, the countries must ensure a balanced energy supply in according to their realities in terms of economic development and social progress.

Therefore, it is very important that the State regains its planner role in order to provide for itself the possibility of direct action by identifying and implementing regulatory modifications that are necessary to follow the desired path. In this way, it would be possible to develop effective and favorable incentives to guide private investments in convergence with the collective interest and in compliance with the guidelines of a sound energy planning.

Within this context, the State must lead the planning of infrastructure expansion for energy supply, so preventing the gap between production capacity and demand decrease too much. That is, the State must detect problems and propose course corrections when these are required.

According to Cenergía (2009), given the institutional structure of the energy sector, even though the process of decision-making process could be bound by decentralized actions, setting polices, regulations, and coordination by the State, far from becoming a marginal or limited accessory for giving market signals, can be crucial. That is, if the market signals are understood as a component of this complex problem and if the coordination of punctual processes that lead to a proper planning sector will not disappear given the simple fact that the State has disclaimed its role as an entrepreneur of the sector. The responsibility of public policymaking is inherent in the role of the government, legitimate, and non-transferable. The needs to plan and to intervene increase with the decentralization of the decision-making process that originates from the presence of multiple private actors in the different links within the energy supply chains. Thus, if the market signals fail to induce private investment in the required time, it is essential that the State, through its public enterprises, carries out them. This should be taken into account so as to properly anticipate the incursions of the State as a provider of infrastructure.

All these lead to the need for the State to strengthen its planning agencies in order to guide the investments required according to an integral concept of the use of energy resources in terms of economic, political, social, and environmental goals.

I.3. Sustainability as a framework for analysis

I.3.1. Introductory Concepts

At the end of the second-world war, concerns relative to the problems of development were abundantly reflected in economic literature. Although the discussion relative to the nature of the development process, of its multiple dimensions and the design of policies directed to promoting its dynamic quality occupied a substantial part of such literature, clearly established were the difficulties to theoretically embrace the entire complexity of this process that deploys its dynamic nature in the long term.

The rapid growth of the world economy up to the middle of the decade of the 60s[3], led to partially forget, the incidence of social and environmental aspects within the development process. However, upon entering the decade of the 70s, the dissatisfaction concerning the characteristics and consequences of this growth became evident, which on another count had already depleted its sources of dynamism.[4]

The work of several authors linked to ECLA, express such a degree of dissatisfaction, referring to the "styles for development" that accompanied this growth in the LAC region, especially emphasizing its concentrating nature: in spite of some improvements in the living conditions of the population, social asymmetries had deepened. Such asymmetries became more severe during the decade of the 80s, as a consequence of the adjustments produced with the reversion of capital flows produced by the foreign debt crisis. In

3 This growth, essentially based on the technological paradigm created during the Second World War, had as its main sponsors the industrial metalworking sectors (Groups of capital, consumer durable goods) and petrochemical companies (substitution of natural materials). During that period, the world industry grew at an annual cumulative rate of 6%. The consumption of commercial energy sources tripled in the period 1950-1973.

4 The so called "Golden age of growth" started to evidence symptoms of a crisis towards the end of the decade of the 60s.

a majority of the countries of the region, the average income of the population suffered a drastic decrease and poverty indices were significantly increased.

On the other hand, at the start of the 70s, there were also concerns referring to the impacts of economic growth upon natural resources and the environment. During the "golden age of growth" problems of development were examined, awarding special attention to the scarcity of physical and financial capital (insufficient savings), and eventually making references to the existence and quality of human resources, but implicitly admitting the lack of restrictions in that which referred to the natural environment.

Thus, the development styles that had been historically established, implied a depredatory management of the natural environment: the extinction of species, deforestation, contamination of air and water as a consequence of the accelerated process of urbanization and of industrial contamination, with serious effects upon the health and quality of life of the human population. A considerable part of these problems have been expressed in the form of impacts upon the local environment, and in many cases making more severe the conditions of poverty in the regions of lesser development. However, the predominant concern regarding the environment is derived from and goes beyond the problems of a global nature: the potential impacts upon the atmosphere due to the emissions of greenhouse effect gasses.

Nevertheless, it is clear that there is a growing awareness regarding the progressive deterioration of the environment that is producing changes, which in many cases are irreversible, and may seriously affect the future development of society. This implies a questioning of the sustainability in time of certain styles of development.

Since it is linked to the dynamic nature of a complex system, considering the varied set of interacting dimensions, the notion of sustainability is not susceptible to simple definitions. Any definition that may be set forth must clearly establish the essential notes that must characterize a process for development so that it can qualify as being sustainable.

In 1987 the World Commission on Environment and Development (WCED) defined the concept of sustainable development as: "A development that satisfies the needs of the present without undermining the capacity of future generations to satisfy their own needs". Set forth in such a general manner, this definition of sustainable development may be acceptable for most analysts. However, it is not clear which is the notion of fairness with which it sets forth the satisfaction of present needs, nor which is the management of the natural environment that would guarantee that the capacity of future generations to satisfy their own needs is not threatened.

Thus, for example, the Commission for Development and the Environment of Latin America and the Caribbean, in its report entitled *"Our own Agenda" establishes, among other aspects, the basis for a strategy leading to sustainable development, defined as "A development that more fairly distributes the benefits of economic progress, protects the national and world environment in benefit of future generations and that genuinely improves the quality of life".*

Accepting the complexity, limitations and difficulties for the application of the concept, this Manual recognizes the importance of the issue in the definition of energy policies and sets forth the different dimensions of the framework of energy problems in an effort to determine such a sustainability and recognizing the need for a full, systemic and comprehensive approach.

I.3.2. Energy planning as a management tool for sustainable development

Energy planning is not a circumstantial event, but rather it is a continuous process. The energy plan, as a final deliverable of said process, lacks value if the strategies are not effectively executed and monitored, leading the progress of the plan, so that it can align the available resources and implement the necessary adjustments. Additionally, taking into account the inputs of all energy planning, it has a certain degree of uncertainty at the time of preparing the plan, which requires periodic revisions as new information is received, adapting the plan to at least a partial resolution of uncertain variables. It is important to plan the energy system, but even more important is that the energy system operates in accordance with that established in the plan.

An energy plan has important benefits to guide activities and resources of an energy system, especially during those times of deep uncertainty. It allows a decrease of it and identifies options and more robust paths without regrets. When faced with great uncertainties, flexibility is fundamental. When adopting a plan we do not waive dynamism nor flexibility, but much to the contrary, it is only possible to be flexible within the framework of a context of planning. Planning is not limited to establishing present decisions, but also estimates the future of present decisions, as well as planning future decisions when facing possible changes in the conditions of our environment.

System`s planning from the State, includes the contribution of all relevant stakeholders of the system that determine the direction and focus that the rest of institutions will adopt within the energy field, and is also a transversal approach to the entire social and economic system. Therefore, it is necessary to have an inter-institutional structure of the energy sector in order to clearly define responsibilities and the roles linked to the tasks of energy planning, and in addition not to skimp on resources in order to not only guarantee the execution, but in addition fully comply with the plan developed.

As will be mentioned, this is a continuous, dynamic and adaptable process relative to the evolution of the variables in the social system in which it operates (changes in economic variables, technological advances, political changes, etc.). Thus, Energy Planning is a systematic and analytical methodology that conveniently processes the information of the demand, transformation and provision of energy, and on the basis of this generates strategies to achieve the long-term objectives that have been defined.

In this way, the systematic process of energy planning may include several stages: definition of long-term objectives (normally determined by the energy policy), determination of the focus of the planning to be used, during the planning process to identify the necessary inputs, select the adequate methodology for analysis, socialize the results among those who are responsible for planning and the agents of the energy sector, prepare the energy plan, and periodically update it in function of the evolution of the conditions of the environment. (NDAYE NKANKA, 2009).

Within this context, depending on the juncture and requirements of each country or region, the energy plan may pursue several long-term objectives. Objectives that are basic, are generally identified in most of the cases framed within the principal lines of action of energy planning: *guarantee and security of supply, coordinated development of energy markets, adequate equilibrium with the natural environment to prevent irreversible changes from taking place, as well as the adaptation to the changes that take place in the natural environment, contribution to social objectives, specially an alleviation of poverty and a contribution to the sustainable development of the productive system*

Table I.1: Energy and Sustainability

Dimensions	Objective
Economic	Supply Security
	Timely Supply
	Energy Efficiency
	Costs and Competitiveness
	Commercial Balance
	Investments and Indebtedness
Social	Coverage of Basic Requirements
	Quality of Sources
	Energy Efficiency
	Social equity in Price and Tariff Policies
	Cost of Energy in Supplying Service to Families
	Energy and Basic Public Services
Environmental	Energy and the Use of Natural Resources
	Energy and Local Environmental Impacts
	Energy and Greenhouse Effect Emissions
	Energy Efficiency and Environmental Effects
Governance	Guaranty of Supply
	Sovereignty over Natural Resources
	Costs of Energy Supply
	Natural Monopolies and Regulation
	Energy Supply and Indebtedness

Source: Authors

The link with sustainability indicators permits the identification of the axis and challenges that may be faced by policies and strategies, and in consequence, planning and intervention on the system.

In this sense, the planning process must provide an answer or take into consideration certain aspects such as: Energy Efficiency, the role of new and renewable sources, technological development, access to energy, the guarantee of investments, diversification of sources and/or the minimization of negative environmental effects or the resilience of the energy system relative to changes in the natural environment.

The demands of sustainability imposed upon planning require a long-term vision, an adequate balance between all dimensions to determine priorities in line with national circumstances, to identify critical and relevant issues, to have clear and agreed objectives, to develop a viable and effective strategy with the adequate instruments and means and to have a corresponding legal and regulatory framework.

This is the search for a sustainable energy development and constitutes the reason for the need of planning, considering present trajectories, which in the majority of cases are not following the true paths of sustainability.

In virtue of this, the entities in charge of energy planning must be aware that their objectives are a part of the national objectives, considering that the energy system is an especially crucial element of the comprehensive plan for economic development and social progress of a State.

Therefore, these are the reasons for Energy Planning, the central objective of which is to define a comprehensive and sustainable strategy for the development of the energy system on a long-term basis. This is a “road map” that will precisely serve as a guide to generate coherent, viable and feasible strategies.

I.4. Development of an Energy Plan

The responsibilities that are implied in the design and implementation recognize a set of stages that are later explained in Chapter II and following.

Energy planning is somehow subsumed in energy policy and energy strategies that usually are hard to distinguish one from the other.

This implies that in a certain way planning is subsumed in energy policies and strategies, and that in many opportunities it is difficult to make a distinction between both processes.

What is certain is that the stages or activities necessary for the preparation of a national energy plan must include the following components:

a. Preparation of an energy diagnosis.

As presented in Chapter II, the diagnosis required for the formulation of an energy policy is of a nature and scope different than what is necessary for the project of energy planning. In both cases it will be necessary that the diagnosis describes the conditions of the international picture, both at the regional level as well as those relative to the world global picture.

The fundamental difference among the approaches for diagnosis refers to the fact that the diagnosis of the policy should point out to a characterization of the starting situation by identifying “problem situations” that the political intervention must face. In other words, it is not a matter of having a descriptive diagnosis of the characteristics of the energy system.

The diagnosis to establish a policy must contain a detailed characterization of the principal problem situations presented at the start by the State to establish a political intervention. This includes a detail of the causes that are linked to each problem, specifying the nature of the scope to which they belong, a review of the potential consequences with an identification of the scope to which they belong and that of the relevant stakeholders.

The desirable components that comprise a comprehensive diagnosis include an analysis of the international and regional energy situation, especially in those aspects that have an interaction or have an incidence upon the situation, activities and the development of the internal energy sector. The international and regional situation will have an impact upon exogenous factors that will condition the formulation, implementation and evaluation of Energy Planning in the measure of its interrelation and interaction with the situation and evolution of the national energy system.

At the national level, the diagnosis process involves a comprehensive analysis of the energy sector and its sub-sectors through a series of partial analyses, contemplating its principal components, links, crosscutting effects and results. Among them we can mention the following: analysis of the demand for energy, availability of energy resources, reserves, energy supply, technologies employed and the potential of access to new technologies, economic impact of the energy sector, social and environmental impacts, etc.

The diagnosis for Energy Planning must be much more detailed and should include both the sectorial global energy level as well as a description of the situation presented by the different energy chains, starting with the resources, going through the different stages of transformation, and reaching the stage of final consumption.

At the sub-sectorial level, it must examine the structure of all productive chains that integrate the energy system, considering the institutional and productive organization of the different links that comprise the chain, the stakeholders that operate in each link and the characteristics of their rational behavior as well as market structures. Also required will be a detail of the infrastructure and of its technical characteristics and a quantitative evaluation of human and natural resources required for the operation of the subsystem that is constituted by each productive chain.

b. Design of an energy agenda that identifies and awards priorities to the objectives, based on the problems identified in the diagnosis.

According to the nature of the Strategic and Specific Objectives of the Energy Policy, it will be possible to define an Energy Agenda that is the calendar, the resources, actions and instruments to reach the objectives set forth by the plan.

In other words, an agenda answers and explains a menu of objectives and actions, which for example could include the following:

- The proposal of a strategy for non-renewable resources and the capture and utilization of the rent generated by these.
- Promote the use of the most abundant energy resources and of lower cost.
- Promote and facilitate the access to energy
- Changes in the legal and regulatory frameworks
- Put in place the investments in infrastructure in energy chains

c. Preparation of social, economic and energy scenarios.

Scenarios are instruments for planning for the representation of hypothetical futures in the prospective analysis of energy, with the main purpose of reducing the degree of uncertainty in the decision making process.

Normally, the concept of a “scenario” in the field of planning has at least two meanings. On the one hand it is frequently used to denominate “results” of the prospective; on the other, it is also used to describe the “conditions that are considered as possible” for a certain planning horizon, that is to say, conditions that are prior to the exercise of the prospective. At the end of this Manual the second of these meanings is determined.

Under this premise, the scenarios in planning are a predictive composition of the relevant structural context that will frame the future of the energy sector under study, within a specified horizon. Therefore, this is a hypothetical construction, based on a hypothesis of structural behaviors that are rationally possible, underpinned by causal relations that are analytically consistent.

d. Formulation of an energy policy, relative to objectives, strategies and instruments.

In the definition of its **objectives of an energy policy**, countries reflect the **mission and the vision** of their national policies with respect to social, economic and environmental matters, within the framework of their historic idiosyncrasies and their particular strategies.

Energy policies, general or cross-cutting, globally constitute a particular specification of the national policy for development, with impacts upon economic growth, on the quality of life of the population and on the national environment.

Relative to objectives, the main lines rest upon social, economic and environmental issues, all of them based on long-term considerations but implemented in short and medium term actions. The general national strategic objectives involve social, economic, geo-political and other aspects. These may be such as: the development of certain territorial spaces or population centers, the promotion of certain productive activities, environmental and territorial protection or that of specific resources, integration with other countries of the region and others.

These national objectives of a structural nature constitute a primordial element as an input for Energy Planning and will have a substantive incidence upon the results of planning, on strategies and the resulting energy agenda and its future application.

As far as energy matters, it is necessary to refer to strategic objectives, as the premises on which are based the practices of planning, such as: the long-term social, political, economic, fiscal and environmental sustainability of energy development, all of which come under the vision and the legal and institutional foundations of the country.

e. Definition of short, medium and long term goals.

The possibility of verifying compliance with the objectives of the plan implies the need of establishing quantified and temporal goals that permit an evaluation of the degrees of progress and to revise the eventual deviations and the adjustment to comply with the road map provided.

For example, these quantified goals refer to:

- Policies for the efficient use of energy. Incorporation of renewable sources (wind – solar) and to reach a specified percentage of participation of renewable energies over the total consumed throughout a specified year.
- Establish goals to be reviewed in specified years for a regulatory and institutional reinforcement; Improve access to financing; incorporate wind, biomass and mini-hydro projects; complete the regional interconnection; reaching a 100% of electric coverage.
- Temporary goals for the implementation of regulatory proposals, of infrastructure, adequate signals for an expansion coordinated with the sectors of gas, electricity, coal, oil and new sources.

f. Preparation of the energy prospective. Applying models.

Thus, energy prospective constitutes a field in complete evolution that intersects with the studies of the future and with the analysis of public policies of strategic planning. Fundamentally, it strives to clarify the priorities of government and of the region, sector or productive chain under study. But its wider purpose is that of promoting a great cultural change, a better communication, a stronger interaction and a greater mutual understanding among stakeholders to think of their future and take decisions at the present time.

The additional contributions that the energy prospective can provide by executing its activities are:

- Develop visions of the future relative to technologies and key aspects of development.
- Provide sources of knowledge.
- Make possible a dialogue among stakeholders.
- Mobilize and ample public debate to reflect upon the future.
- Promote the creation of networks for collaboration.
- Provide information for the definition and the development of technological policies.
- “Explore the future”, under the modality of “what-if”, by using the technique of scenarios to reduce the degree of uncertainty in the decision making process.

g. Strategies and plans of action in the medium and long-term basis. Investments and financing.

A development policy addresses the structure of the social and economic system; therefore, it includes a long-term policy, the components of which could be grouped in crosscutting or general policies and sectorial policies.

Energy policy is a sectorial nature that is a part of the long-term social and economic policy. On the other hand, by taking into consideration the productive chains of the energy sector, such an energy policy is able to become disaggregated in a manner that is similar to the policy for development: in general or cross-cutting policies (determination of rates, supply, institutional, environmental, rational use of energies, training of human resources, etc.) and sub-sectorial policies (electric, renewable sources, oil derivatives, etc.).

Upon starting analysis of scenarios and the forecasts developed, begins the process for the formulation of strategies and actions to reach the objectives and goals defined, that is the way to act to reach such results. There is the hope of reaching a desired situation, evolving through a series of intermediate stages that surround the ideal situation. The excursion of the State is carried out by applying a set of actions (strategies), revised and adjusted as certain objectives are being attained in each stage, in accordance with the availability of resources and the risks based on the process of Energy Planning. All of this under the national and international contexts of all social and economic sectors linked to the energy sector, as well as the changes observed and foreseeable.

Actions must be combined to construct the viability of each operation of the plan. The fundamental strategic principle consists in achieving a combination by means of which each action opens the path for the one that follows, until all have been performed within a determined trajectory.

h. Evaluation of impacts. Revision and adjustments to the strategy.

To carry out the evaluation and control of the application of Energy Planning, it is necessary to undertake a follow-up of its development by means of the use of “Performance Indicators” that permit the measurement, quantitatively and qualitatively, of the advance in achieving the goals established for the plans or programs of action, within the strategies established.

Monitoring of indicators is the process that permits us to follow their evolution with a periodic frequency, so that it allows an evaluation that helps us to see if performance falls within that programed or if it deviates from what is expected. This will provide the instructions and political actions leading to an eventual reformulation of the planning, analysis and reevaluation of the strategies, plans and goals, by means of periodic processes that require frequencies that range from one to several years.

The objectives of Monitoring are:

- Verify compliance with the short, medium and long-term goals established in the plans of action.
- Carry out the evaluation of the actions that have been planned.
- Identify the corrections that are necessary for the implementation of adjustment programs.

CHAPTER II

The Planning Process

KEY WORDS

Energy – planning – strategy – Latin America and the Caribbean – energy policy – energy diagnosis.

II.1. Introduction

According to what is stated in Chapter I, the formulation and implementation of public policies constitutes an unavoidable task of the administration of the State. In that which refers to global policies (cross-cutting) or of a sectorial nature and that relative to a temporary scope, these may be directed to the short or long term. Long-term policies try to have an incidence upon structural aspects of the social, economic and environmental system, and therefore may qualify as policies for development in the measure that they pretend to guide the trajectory of said system.

In such sense, it must be recognized that in general terms, development policies have been subjected to border situations and that these must perform in situations of shared power and therefore the construction of their viability constitutes an essential part of the strategy for implementation.

It is clear that in the short term, under ideal conditions, actions of public intervention should have coherence with the trajectories outlined for the long-term. However, the complexities found in contingency situations frequently alter, in varying degrees that ideal coherence. This type of distancing may be the result of sudden border changes in the international environment and/or due to pressures from different social groups upon those who are responsible for the design and execution of public policies.

Periods that immediately precede changes in government can also be the cause of deviation from established trajectories. But whatever may be the causes for the contradictions between short-term actions and trajectories defined by development policies, the former must have precedence over the latter, thus giving rise to a state of confusion that is detrimental to the efficacy of public policies.

In this manner, and with the purpose of acquiring greater efficacy, it is recommended to transform the guidelines of the development policy into a State Policy. Of course, it is reasonable that each effort of the government strives to incorporate into these guidelines for the long-term, the nuances of its Political Project, but it is of fundamental importance that its intervention does not imply an abrupt change of direction, except if the modification in the conditions of the context so justifies it.

As has been stated, development policy is comprised by two joint sets that are closely linked: general or cross-cutting policies (prices and income, employment and human, institutional, social, environmental, technological, financial, commercial, etc. resources.) and sectorial policies (mining, agricultural and livestock, forests, industrial, energy, transport, etc.).

In accordance with the conceptual framework set forth, it is possible to conceive Energy Policy as a long-term sectorial policy that is inserted into a global development policy. This definition of energy policy has the purpose of highlighting the following aspects:

- This is a sectorial policy that is subordinated to a global nature policy. It is therefore possible or frequent that its formulation should include supra-sectorial objectives.
- This is a long-term policy and in that sense it should be considered as a State policy; this means it should not be used for cyclical reasons.

However, in those countries where energy exports constitute a fundamental determinant of the performance of the national social and economic system, decisions or strategies linked to them transcend by far the sectorial energy policy.

II.1.1. Energy policy and planning

Considering the existence of different productive chains within the energy system, the corresponding policy must also be formed by ***general or cross-cutting energy policies*** (prices, financial, institutional, technological, environmental, training of human resources, rational use of energy, etc.) and ***sub-sectorial energy policies*** (oil, gas, electricity, coal, new and renewable sources).

As has been previously stated, general energy policies shall incorporate the objectives set forth at the level of global policies. The following example may illustrate this: If within the social and economic policy there is established an objective of reducing the degree of social asymmetries; this can have its correspondence in the level of the energy policy by providing a greater coverage (in quantity and quality) of the energy requirements of the population with lesser resources, that could imply certain goals within the scope of the different energy productive chains (sub-sectorial objectives).

Another similar example could be linked with the objective of economic policy that refers to an improvement in the competitive nature of productive activities when confronted with imports or the potential of exports; This objective may have a specification in the scope of the energy sector under the form of: improving the productive efficiency of the principal energy chains (which in turn could imply the need of some institutional-regulatory reforms) or the promotion of Energy Efficiency.

In that which refers to the area of the natural environment, it is possible to set forth the objective of the preservation of forest resources. At the level of energy policy, this objective could correspond to the provision of rural energy based on commercial sources. But it is clear that such an objective must be translated into objectives of the agriculture and livestock policies that refer to a national expansion of the agricultural frontier.

These examples, especially the second and third, likewise show that sub-sectorial policies frequently set forth objectives that have a cross-cutting nature of greater or lesser scope in the sense of being translated into more specific objectives for a set of sectors of the economic system. In the second example (objective of improving competitiveness), there are clear implications for public services sectors, in addition to the energy sector.

But additionally, general or cross-cutting energy policies will have a specification at the sub-sectorial level and will not necessarily have the same character upon all productive chains. For example, if the institutional energy policy has as its objective that of providing a greater emphasis to market mechanisms at the sub-sectorial level, this objective will have a specification in the oil subsector that will be different than in the electricity subsector.

In function of this conceptual approach to energy policy and its link to planning we may conclude that:

- Planning, like energy policy has to set forth a systemic approach, considering the set of energy productive chains and all their internal interactions, both in the upstream, in transformation centers and at the level of final consumption, providing special attention to the disputability between sources in the nodes of intermediate and final consumption. Additionally, this systemic approach implies a consideration of the interactions between the energy system with the different dimensions of social, economic and environmental scope (Refer to CEPAL/OLADE/GTZ (2003), pages 146-148).
- Therefore, planning must recognize a general level of the energy sector and specify the treatment to be provided in the sub-sectorial level, providing attention to the strategic guidelines set forth in the policy.5
- The process of energy planning must evaluate the different options to satisfy energy requirements, on the basis of the available national resources and/or eventual needs of having to resort to imports. In this respect, it also worthwhile to consider the possibilities and advantages with respect to energy integration (See CEPAL/OLADE/GTZ (2003).
- The planning process at the sub-sectorial level must have a much more detailed specification and must therefore prepare a more descriptive diagnosis, although it must provide attention to the key or critical points that affect energy supply.[6]

II.1.2. Relevance assigned to energy policy at different periods of history.

Both the focus as well as the relevance of public intervention interfering in and/or complementing the action of market mechanisms and/or decentralized decisions in social and economic systems has changed. In certain cases this has been a radical change along the last 60 years, in accordance with the cycles that existed at the international level, which had a strong incidence in the countries of Latin America and the Caribbean.

The idea of this section is to briefly characterize a set of historical stages at the level of very stylized traits that were accompanied by the predominance of different conceptions regarding the action of the State and its intervention by means of public policies, the need and relevance of such policies and the correlations of modalities taken over by planning.

This manner of presenting the different modalities of planning presents an advantage when compared to the simple conceptual enunciations of attempting to understand the social and historic situation that existed and contributes with an explanation that provides context to those situations.

5 As will be shown in section II.2, this implies the need of taking into account general and specific objectives, goals, strategic lines set forth with relation to each specific objective and the instruments established to give an operational sense to such strategies.

6 This matter will be later examined.

1) In the second postwar period rises a stage of rapid economic growth that continues to the end of the decade of the 60s. At the world level, industry grows at an annual cumulative rate of 6%, as a consequence of the contribution of technological innovations generated during the war period and their incorporation into the productive apparatus.

This is a period that over 25 years is usually referred to as the *"golden stage of growth"*. During this period, the intervention of the State in social and economic systems gathers a great deal of prestige and it is even accepted by those that follow the liberal ideology. This is the era of *"Keynesian consensus"*[7] and due to the needs derived from reconstruction and development, planning is practiced in many countries, not only in the Soviet area.

With respect to this, it is necessary to point out that there existed a vision that the planning State enjoyed the consensus of social stakeholders with relation to its proposals (of objectives and instruments) contained in planning or that it had the sufficient power to impose them[8].

This conception of planning may be referred to as the ***deterministic and normative approach to planning***.

This is not a copy of the type of planning that prevailed in the area of the socialist countries, in spite of the enormous prestige that it enjoyed at that time[9], but based rather on an optimistic vision regarding the consensus that the State could achieve with the social stakeholders concerned, that conceived the State as an actor external to all society and devoid of internal contradictions.

2) In the decade of 1970, the sensation of frustration generated by the "development style" that was being adopted by Latin America and the Caribbean became increasingly clear. Industrialized nations and particularly the United States and England, were facing serious problems to maintain their rate of growth, and simultaneously they were facing a growing competition from Japan and Germany. This was a period of transition for the world social and economic system that put an end to the "Keynesian consensus".

In LAC, the obstacles encountered by the industrialization process during the decade of 1960, that advanced towards the production of intermediate goods of a restricted dissemination, of durable consumer goods and especially of capital goods, led even those countries of greater market dimension to resort to the participation of multinational corporations.

The growing trans-nationalization of the economies of the region adds an increasing complexity to the formulation of policies that are correlated to the planning process.

The installation of dictatorial regimes in the countries of the Southern Cone of the Region radically changed the focus proposed for planning.

7 Keynesian Consensus rises during the Second Postwar. It is comprised by the model IS/LM income and the rate of interest, the labor market including employment and salary, the relation between employment and prices based on the Phillips Curve and the theory of growth. It therefore determines the existence of balances with involuntary unemployment, at production levels that are lesser that their potential. Such circumstances create instabilities that must be avoided, since these prevent general welfare. State intervention, through fiscal or monetary policies or by a combination of both may lead to a balance with full employment. The Consensus implied the adoption of two fundamental objectives: full employment and a certain level of variation in prices. To reach these, recourse was made to the management of aggregate demand accepting the "quid pro quo" between activity levels and prices, in the context of the Welfare State. Economic Planning and Programming were used as instruments to rationalize the action of the State and to direct certain actions of the private sector in the economy.

8 "During the seventies there existed an environment of optimism towards the challenges of development. World economy and trade expanded and the region recognized the enormous tasks that had to be faced by countries, but at the same time there was confidence that the Latin American States would have the necessary political will, institutional mechanisms and capacities to launch great transformations required by the region in its productive apparatus, the orientation of production, the creation of jobs, the needs of investment and social inequalities." Mrtner R. and Máttar J. (compilers), "The basics of planning of development in Latin America and the Caribbean. Texts selected from ILPES (1962-1972)" CEPAL, Santiago de Chile 2012, pages. 8-9.

9 "The term programming had been used as a synonym of planning to avoid correlations with the exercise of planning in European countries of the socialist block since this could lead to confusion in the region" Mrtner R. and Máttar J. (compilers), op cit, quote at the bottom of page 9.

However, the constellation of power felt its way at the international level as well as in the Region that did not permit in practice the adoption of this approach. The validity of the so-called "Consensus of Washington"[10] was gathering strength as well as the influence of the neoliberal paradigm.

3) It is necessary to mention that the neoliberal proposal practically took over the principles that had been stated in the "Consensus of Washington", but privileged in a fundamental manner those relative to currency exchange, fiscal discipline, financial liberalization and processes leading to privatization.

This is how, during the last 25 years of last century, there is a loss of all validity of the formulation of social and economic policies that held an approach that was opposite to the neoliberal orientation trend that was adhered by, in a larger or lesser measure by all of the countries of Latin America and the Caribbean, that were financially pressed by the problems of foreign debt. According to this paradigm of economic thought, the assignment of resources should be managed by private stakeholders directed by market mechanisms.

4) During the first years of this century and after several countries in Latin America experimented deep crises, a new stage opened under the term "Washington Dissent" [11] stage in which some works were presented what were called the "dissent of Washington" that pointed out the rejection of the conceptions that had been adopted up to the start of the XXI Century.

Certain countries of South America went through a period of high dynamism and set forth a greater autonomy with respect to industrialized nations. Including the revitalization of the initiatives for integration, setting forth the expectation that they may become a new economic block with a strong political leadership. Intra-regional trade currents increased considerably and there rose the project for the creation of a new regional bank for development.

In consequence it was possible to observe a renewed optimism regarding the possibility of formulating social and economic policies for development.

10 The list of reforms contained in the Consensus of Washington, such as presented by Williamson in his well-known paper *Latin American Adjustment: How Much Has Happened?*, is the following:

i) fiscal discipline;
ii) priorities in public expenditure;
iii) tax reform;
iv) financial liberalization;
v) flexibility in currency exchange regimes;
vi) liberalization of trade;
vii) direct foreign investment;
viii) privatization;
ix) promotion of free competition and maintenance of justified market regulations, property rights

11 World Bank, "Latin America and the Caribbean's long-term growth. Made in China?", September 2011; see Figure 1,7 (Panel B) page. 23.

Some references to Energy Planning in the Region

Types and nature of planning in LAC according to the sources of countries.

- Brazil. "Decade Plan for Energy Expansion". In the "Presentation" it indicates: "The Brazilian State exercises, under mandate of the law, the planning functions, which are obligatory for the public sector and indicative for the private sector" (Brazil 2012).
- Colombia. "Plan of Expansion of Reference – Generation and Transmission 2006-2020" of UPME (2006) of Colombia, that states that "in compliance with that established in Law 143 of 1994, Electric Law, it identifies the needs of the country relative to new capacities for generation and recommends projects for the expansion of the National Transmission System– (STN, in Spanish) – with the goal of assuring an adequate provision of electric energy in the immediate future and in the horizon that goes to the year 2020". This is a clear reference to indicative planning.
- Chile. The study of energy planning (OLADE-CADI) points out that "relative to energy planning, the Chilean model does not grant to the institutions that carry this out, an obligatory character of its indications, since the model is based on private decisions directed, as in any other private commercial activity, by the signals offered by prices and profits expected. Nevertheless and even though planning in this sense is not binding, in practical terms, for the authority it has become a tool to promote, in greater or lesser measure, the development of offer since it constitutes a tool for guidance and a signal for private investments".
- Ecuador. Under Law 364 establishes a Master Plan for Electrification[12] "to be directly executed by the State, with its own resources or in association with other specialized companies …. Or under concession …" This legal scheme implies a mandatory planning for the public sector relative to its objectives, with a degree of flexibility for its execution.
- Central America. "Indicative Regional Plan for Expansion of Generation. Period 2012 – 2017", prepared by GTPIR, whose objective was to "design optimum expansion plans for the generation of electricity in the countries of the Central American Isthmus, through the analysis of different alternatives, considering the most relevant future scenarios". As its name states, it has an indicative planning nature.

To these we must add the examples of Mexico: "National Energy Strategy, 2013 – 2027", Secretariat of Energy of Mexico (SENER, in Spanish); Peru: "Strategic Planning in Peru up to 2021", National Center for Strategic Planning" (CEPLAN, in Spanish"); and Argentina: "Elements for the Diagnosis and Development of National Energy Planning", that also fit under the type of "strategic planning".

II.1.3. Entities and teams in charge of formulation, execution and control

With relation to the entities that are in charge of the formulation of proposals for policies, planning and energy, it is clear that it is necessary to deal with the stakeholders that belong to the public area. Normally, the specialized entities of the state apparatus must lead the processes for the formulation of proposals. However, since it refers to the proposals of policies as well as the formulation of plans that have to be approached under a systemic focus, it is necessary to have the participation of multiple stakeholders of a public nature.

Specifically addressing energy planning and policy and that which concerns the entities and teams entrusted with the tasks of formulation, execution and control, the following must be stated[13]:

- The direction of these tasks must correspond to the Ministry or Secretariat of Energy.
- However, in the process must be included all State entities that are linked to the energy question, so as to cover, in a multi-dimensional manner the energy phenomena, both at the sectorial as well as sub-sectorial levels.
- On the other hand, according to what will be set forth in sections II.2 and II.3, the teams that are required for the tasks relative to policy and planning process will necessarily vary in size and qualifications.

12 Art. 3°. Reformatory Law to the Electric Sector Law (26/9/2006). Cited in CONELEC (2007).

13 Since these issues will be developed later, here we will only make a summary and preliminary presentation.

II.1.4. Nature of the diagnosis for the formulation of energy policy and planning

Above all, it is necessary to point out the importance of social and economic information systems to make possible the tasks of formulation of policy as well as formulation of energy planning. This matter is dealt with in depth in Chapter III of this Manual. However, it is necessary to state in a categorical manner that in the absence of a sufficiently complete and reliable system of information, it is not possible to build an acceptable proposal for energy policy, and much less to be able to prepare the corresponding plan.

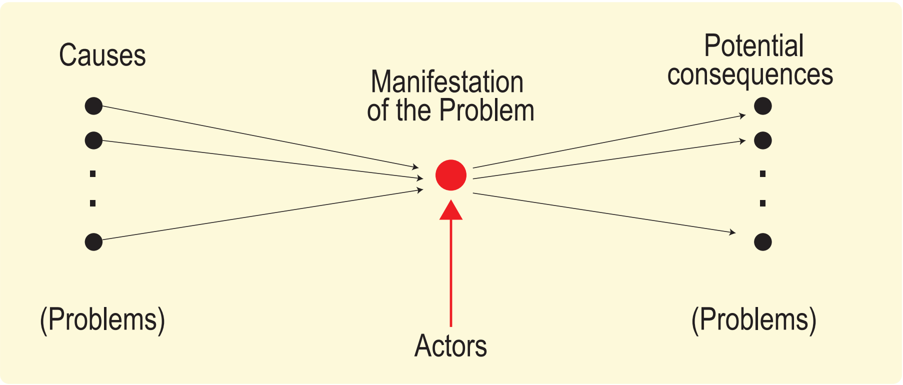
The diagnosis that is required for the formulation of an energy policy is of a different nature and scope than that required for the process of energy planning. It will be necessary in both cases, that the diagnosis describes the conditions of the international environment, both at the regional as well as global levels.

In the case of the formulation of energy policy, the diagnosis must lead to a characterization of the starting situation by identifying "problem situations" that political intervention must face. That is to say that it is not a matter of a descriptive diagnosis of the characteristics of the energy system.

As depicted in Figure II.1 in reality, problem situations constitute a problem tree, where the expression of the problem (it is a present problem) has a set of preceding causes and a set of potential consequences that are very likely to take place if there is no intervention in the situation by means of an action of policy. As indicated in this Figure, the causes of consequences will also exhibit the characteristics of the problems.

But in addition, the characterization of problem situations must be completed with the identification of all relevant social stakeholders with respect to the expression of that problem in the measure that they are affected in a positive or negative way with the type of policy intervention directed to the problem in question.

Figure II.1: Structure of "problem situations"



Source: Authors.

As a consequence, the diagnosis for determining a policy must contain a detailed characterization of the principal situations of the problem present at the starting point of political intervention. In other words, the detail of the causes linked to each problem, specifying the nature of the scope to which they belong, the potential consequences as well as an identification of the areas to which they belong, and all relevant stakeholders.

Table II.1 shows the type of information referred to problem situations that are included in the diagnosis. As may be observed, for each element of the "Problem Situation" the field to which it belongs is suggested.

Table II.1: Characterization of problem situations for diagnosis

Elements of the PS Scope or Dimension	Causes	Manifestation of the Problem	Potential Consequences	Relevant Stakeholders
Strictly Energy Related				
Economic				
Social				
Environmental				
Political Administrative				

Source: Authors

“Problem situations” may be illustrated with the following example that is quite common in the countries of the Region:

Statement of the problem: Institutions involved in the energy system work without coordination and leadership.

Causes of the problem:

- The abundance of public institutions with competence over energy matters.
- The absence of a legal-institutional framework that determines with precision the missions and functioning of entities with respect to the energy system.
- There is no single institution that is responsible for policy and sectorial planning functions, with a sufficient allocation of human and budget resources.
- Energy crises that motivate the government to act in specific situations.
- Legal framework does not effectively assign the required responsibilities.
- Lack of perception of the importance and transcendence of the energy sector.

Foreseeable consequences of the problem:

- Absence of an energy policy that is coherent and comprehensive.
- Difficulties to have available an energy information that serves as the basis for the formulation of policy and the comprehensive planning of the sector.
- Disorder in the development and execution of investment projects for the supply of energy.
- Wrong decisions that lead the nation to unsustainable situations.
- Citizens are not provided with adequate and reliable information regarding the problem.
- Legal-institutional framework does not include the coordination of hydrocarbons, biomass, electricity and other energy sources.
- Permanent crisis in the energy sector, high prices of energy products.
- Slow decision making for the development of renewable energy projects.

A detail of problem situations that must be included in the diagnosis, requires the establishment of a ***vision*** or of a government project that permits its identification, since what represents a problem for that vision, at the same time may constitute a promising situation for another stakeholder.

The following offers a detail of an example of a vision to build the diagnosis:

The energy system will strive to assure internal supply by means of the best use of the resources available locally and regionally, contributing to the sustainable development of the country (economic, social, environmental and political), under the guiding role of the State. In function of this, special attention must be awarded to Energy Efficiency and to the search for a greater diversification of the Energy Matrix, incorporating national resources, of a renewable nature, that increase the use of labor, having a greater impact on productive activities, taking care of the preservation of the environment and providing a greater dynamic nature to regional integration. At the same it will be necessary to design legal and institutional instruments so that these are duly aligned to the development of the energy system, incorporating specific national characteristics”.

The diagnosis for energy planning must have a greater detail and must include both at the level of the sectorial global energy level as well as a description of the situation presented by the various energy chains, starting with resources, going through different centers of transformation, and reaching the stage of final consumption. This matter will be developed further on.

II.2. Energy policy[14]

II.2.1 Nature of energy policy

In accordance with what has already been stated, ***Energy Policy is a long-term sectorial policy, inserted in the global policy for development.*** Therefore, it must incorporate in its guidelines those matters that are pertinent to that global policy.

But in addition, the outstanding emphasis in this conceptual definition of energy policy is that this is a long-term policy and must not be affected by cyclical urgencies. Its guidelines must be constructed as a **State Policy**.

This is why, due to the slow maturation of investments corresponding to the energy infrastructure, it is necessary to insure that the supply of energy determines the construction of the works required with anticipation.

Thus, the formulation of an energy policy requires a prospective analysis that formulates scenarios that have a realistic projection of the future trajectory of the system, particularly providing attention to the evolution of the energy requirements at the level of final consumption[15].

It is also necessary to highlight the responsibility of the State in the formulation and implementation of active energy policies. The principal foundations for this are:

- The importance of the Energy Sector is due to its close association with all of the dimensions of sustainable development (Economy, Society, Environment, and Governance).
- The fact that natural resources are a social property and therefore the State must ensure the proper use of them in representation of the entire community.
- There is a strong presence of natural monopolies in productive energy chains (High concentration in the offer side), consequently public power must oversee that there are no abuses rising from dominant positions.
- There is a need for coordination due to the multiple internal interactions in the Energy System, both in the supply (Resources, Production, and Transformation) as well as in consumption (nodes of dispute, URE).

II.2.2. The team in charge of energy policy formulation

As has been established, ***the initial proposal must rise from the public sphere*** and must be led by the entity of the Executive Power that is responsible for the coordination of the activities in the energy sector.

Nevertheless, in view of the multidimensional nature of the energy system it is indispensable to have the presence of other entities within the public sphere that are responsible of other areas of government that have a great interaction with the energy system.

Normally these other entities correspond to the following areas: Public Energy Companies, Economy and Finance, Mining, Transport, Agro-Forestry, Social Assistance, Education, Science and Technology, Environment, Regional Public Authorities, Representatives of Congress, etc.

However, taking into consideration that which is advisable for the formulation of the proposal is to organize a meeting-seminar to present the diagnosis and to determine the principal "problem situations" that must be faced by political intervention. And later hold a series of participatory meetings with the representatives of the previously mentioned entities. The number of stakeholders present must necessarily be limited. It is also recommendable that such participatory sessions be carried out using the technique of visualization so that at the end of such meetings-seminars it is possible to have available an agreed proposal for an energy policy.

Taking into account the characteristics of the procedure that has been proposed it is convenient that stakeholders present at the meeting-seminar are only those that privilege the general interest of the community over private considerations.

As will be later shown, after having completed the formulation of the proposal with all of its elements, the construction of its viability will require that it be submitted to the consideration of the entire society represented by a large group of relevant social stakeholders. This stage of socialization will strive to obtain a social consensus regarding the proposal submitted.

14 OLADE has developed a Practical Guidelines for Energy Policy (2015). It is recommended to read this material in order to have a better overview about the procedures for the formulation and monitoring of energy policies.

15 The matter of scenarios is dealt with in Chapter V of this Manual and the approaches, techniques and models for prospective energy analysis are reviewed in Chapters VI and VII.

In principle, ***the search for consensus for the proposal must start in the first place within the public scope***. The process described begins with the recognition that the State apparatus cannot be conceived as a non-differentiated internal stakeholder. Usually, there are internal contradictions that must be overcome before trying to achieve a consensus on the policy.

II.2.3. Approach to the formulation of energy policy. Starting point and image of the objective

Figure II.2 shows in a schematic manner the approach suggested for the formulation of an energy policy. As can be observed, the first task is to characterize the *present situation*, which is the starting point for the formulation of an energy policy, characterized by the set of "problem situations" that have been identified and are contained in the diagnosis.

At the other extreme of the diagram we place the ***desired situation*** that represents the image of the objective that is the situation that should be achieved through the intervention of the policy. This situation represents the ***objectives*** of said policy that constitute the counter-position in a positive sense of the problems (which indicate a negative situation for the energy system).

In order to have the identification of the "problem situations" to help in the definition of the situation desired, it is necessary to start from a ***Vision***. The trajectory that begins with the present situation and runs through points P_1, P_2….P_n until it reaches the objective that is represented by the Strategy or by the ***Strategic Lines*** that indicate ***how to act,*** to be able to travel from the present situation to reach the situation of the objective.

That trajectory may require a lapse of time that normally exceeds one or two government periods. It is in this sense that energy policy is a ***State Policy*.**

However, this does not imply that it is not possible to establish achievements in the short-medium term that correspond to a period of government. In this case it is possible to establish ***Goals***, associated to each specific objective. Goals must always be specified in quantitative terms: a date or a certain level of compliance of the objective under consideration.

But it is important that short-term actions maintain the trajectory specified by the strategic lines that have been identified.

In addition, ***the selection of strategic lines for each objective*** have to consider the boundary conditions shown in the diagram be these external or internal order boundary conditions. The qualification of "external" or "internal" alludes to the fact that these are "outside" or "within" the scope of action of the policy maker.

In turn, boundary conditions of an external order may correspond to the international level or the national level and may constitute ***threats*** or ***opportunities***.

Examples of ***threats*** may be the following: high prices of oil and its sub-products and the volatility for hydrocarbons importing countries (in that which refers to the international context) or budget restrictions imposed by the Ministry of Finance (in that which refers to the national context).

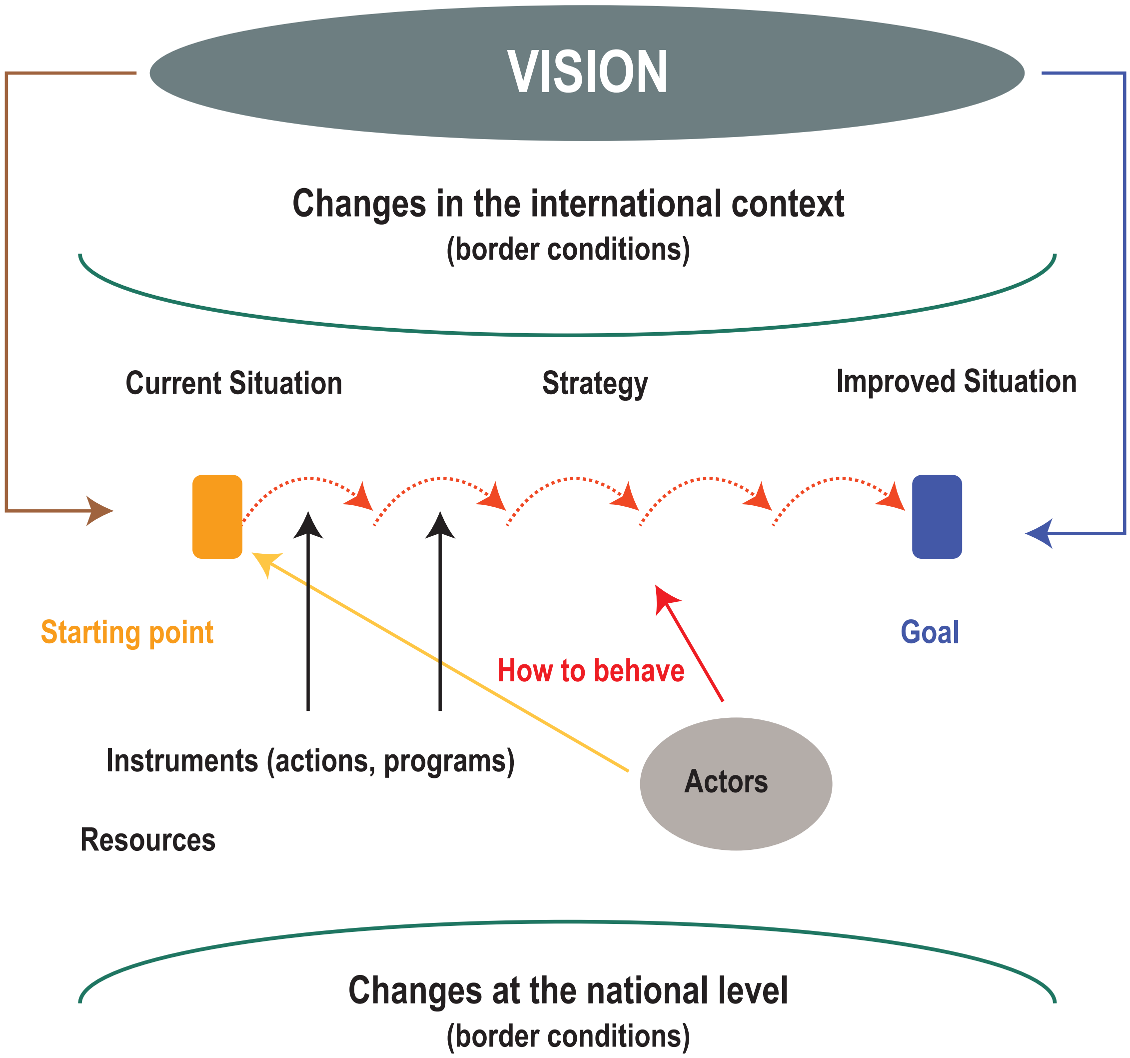
Examples of ***opportunities*** may be the possibility of having access to international cooperation to promote the use of renewable energies (in that which refers to the external context) and the availability of potential winds for the generation of electric energy (in that which refers to the national context).

The internal conditions of the energy system are those that can be modified from the area of the decision of the authorities of that sector and may constitute ***weaknesses*** or ***strengths*** for the achievement of the specific objectives proposed by the policy.

An example of ***weaknesses*** could be the presence in the crucial links of hydrocarbons chains of extra-national stakeholders with goals that do not necessarily coincide with national objectives.

An example of ***strength*** is the availability of entrepreneurial units of a public nature that exist in the principal energy chains.

Figure II.2: Schematic Presentation process for the formulation of policies



Source: CEPAL/OLADE/GTZ, 2003.

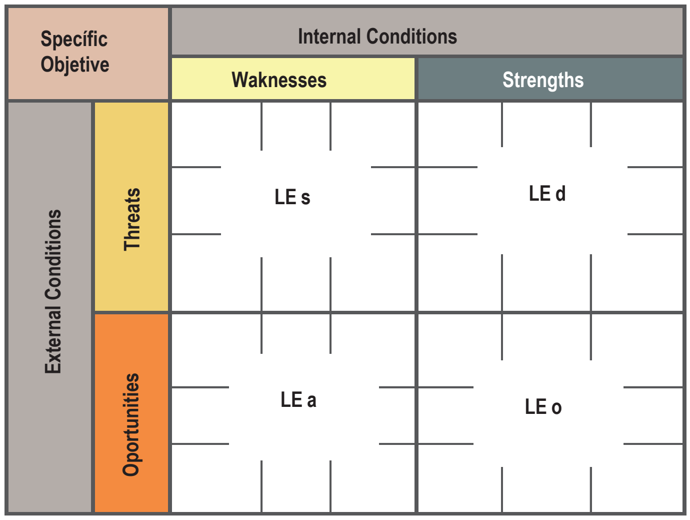
II.2.4. Objectives, strategies and instruments of energy policy

A consideration of the conditions of the context for the selection of lines for each objective, constitutes the first step in the construction of the viability for a policy proposal.

In effect, as indicated in Figure II.3, the confrontation of Threats and Weaknesses leads to the selection of *strategies for survival*; this is the quadrant of greater weakness that is faced by policy intervention. By opposition, in the quadrant of the confrontation of Strengths and Opportunities, are present strategic lines that represent more favorable conditions of power, in this case strategies for the offensive. In the remaining quadrants are located the defensive strategies (Threats versus Strengths) and adaptive strategies (Weaknesses versus Opportunities).

The meeting-seminar under the technique referred to as SWOT is used for the selection of strategies linked to each specific objective.

Figure II.3: Matrix for the identification of strategic lines

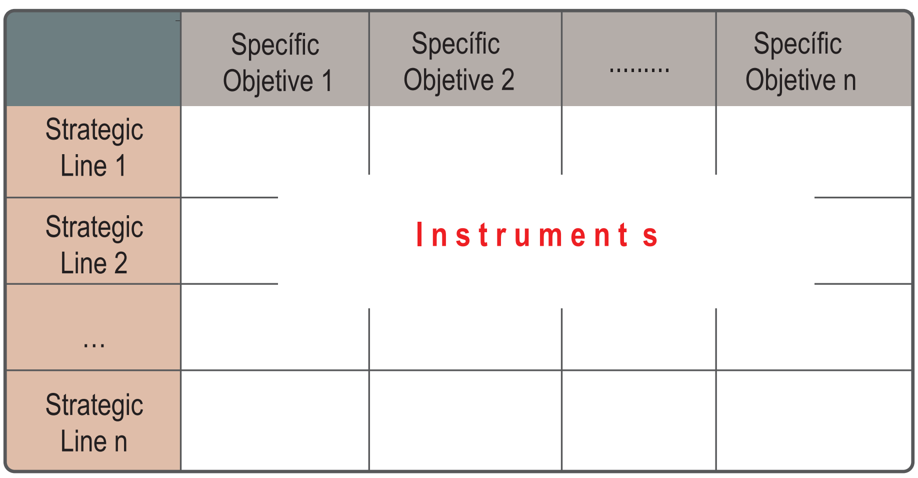


Source: Authors.

Strategic lines acquire operational nature starting with the definition of ***Instruments***, linked to each specific objective. Figure II.4 presents the Matrix for the definition of the instruments relative to each specific objective.

In the logic for the construction of said Matrix there is a strategic line that may be proposed to reach more than one objective and therefore, the same must take place with the instrument that will be used to provide such operational nature.

Figure II.4: Matrix for the identification of instruments



Source: Authors.

The nature of the instruments proposed may differ; the following is a brief presentation of the various types.

a) Policy Instruments that establish structures

Are those that are related to the productive and institutional organization of different productive chains.

- In that which refers to the productive organization, this basically deals with the actions that tend to determine the size and number of productive units that comprise the different links of productive chains and their degree of vertical and horizontal integration.
- In general, changes in the productive level are accompanied with modifications in the institutional organization and in regulatory principles, including at both levels, the role of the State in the sector.

Aspects linked to the Institutional Organization.

- Legal structure and degree of autonomy of entrepreneurial units (public companies).
- Nature of the property of assets of said entrepreneurial units (public, private, mixed).
- Organization of markets.
- Degree of jurisdictional decentralization (company management and/or control).
- Nature of regulatory entities (for the functions of regulation, audits and operational).

b) Instruments involved in functioning

- Direct intervention (Decisions of Investment are made through public companies, Fines for lack of compliance with contracts, etc.).
- Inductive or promotion policies (these tend to have an influence on the rational nature of those stakeholders that directly operate on the system; Taxes and subsidies, Royalties, etc.).
- Negotiated commitments and norms (establishment of specific commitments with several stakeholders of the system or specific regulatory norms negotiated with them).

Changes in situation that have been brought about by energy restructuring processes in that which refers to the formulation of policies within that scope, fundamentally affect the level of instruments available to achieve the objectives that have been set forth.

In accordance with the predominating guidelines that direct freeform processes, the State is no longer in charge of entrepreneurial functions and direct control over the activities of the sector.

Once the new structure of the productive and institutional organization has been set forth and the fundamental regulatory frameworks of the system are in place, the instruments of intervention left for the State are of a fundamentally indirect nature.

This does not mean that there is no possibility of applying positive measures or a direct action in certain areas; what this means is that a large part of the instruments will be based on promoting or discouraging certain types of conducts through methods that provide benefits or costs of an economic nature.

However, the new situations that prevail in energy supply systems of the countries of the Region are characterized by the growing multiplicity of private stakeholders (national or extra-national) and public (legally de-incorporated) the rational approach of which will not necessarily coincide with the formulation of decisions and the directions implicitly or explicitly established in the objectives of energy policy, thus setting forth a series of contradictions and/or conflicts in relation to the instruments used for the achievement of the corresponding goals.

II.2.5. The construction of the viability of the policy, the role of stakeholders and the stage of socialization of the proposal

The construction of the policy proposal implies the consideration of the reactions of relevant stakeholders in relation to each line of the strategic-instrument proposed. This is why during the meeting-seminar it is necessary to analyze the potential reactions of the principal relevant social stakeholders. It should be clarified that this does not refer to the real reaction of the abovementioned stakeholders but rather of the reactions expected in function of their interests.

Figure II.5 presents the Matrix of reaction, that is of a qualitative nature, the cells of which will contain the position of the relevant social stakeholders, that is to say that the cells will contain the following reactions A (approval), AC (approval that is conditional), R (rejection), I (indifference).

If in the Matrix there would predominate the cells with R (rejection) for some column, this would complicate the viability of the use of the instrument considered. If this is verified during the stage of socialization by the entity that is responsible for the formulation of the proposal of policy, it may opt between accepting the elimination of that instrument from the proposal or insist on maintaining it with the political cost that this would imply.

Figure II.5: Matrix of reaction

	Specific Objective of Energy Policy								
	Instrument 1		Instrument 2		Instrument 3		……	Instrument n	
Actor 1							……		
Actor 2							……		
Actor 3							……		
……	……		……	……			……		
Actor n							……		

Source: Authors.

As can be observed in Figure II.5 the full development of the proposal requires a definition of the instruments specified by means of actions that consist of programs or projects and it is precisely with relation to those concrete actions that in general, social stakeholders will see that their interest will be affected.

Therefore, it is with this complete proposal that the team that has formulated the energy policy must convene a wide range of social stakeholders to submit to their consideration the proposal mentioned and take note of the suggestions for change, striving to establish a social consensus for the proposal.

II.3. Energy Planning Process

II.3.1. Planning as a tool of energy policy

As has been expressed above, energy planning must be conceived as a fundamental tool of an energy policy, since the latter establishes the *vision* to set up the *energy agenda*, the objectives and strategic guidelines that must be followed by the planning process.

Therefore, the role of planning is to specify, to provide an operational nature in a coherent manner with the guidelines established within the energy policy. Of course, as is pointed out at the time of presenting the contents of the diagnosis for the process of energy planning, the analysis that is required of the energy system for planning will have to be much more encompassing and detailed, both at the global level as well as the sub sectorial level.

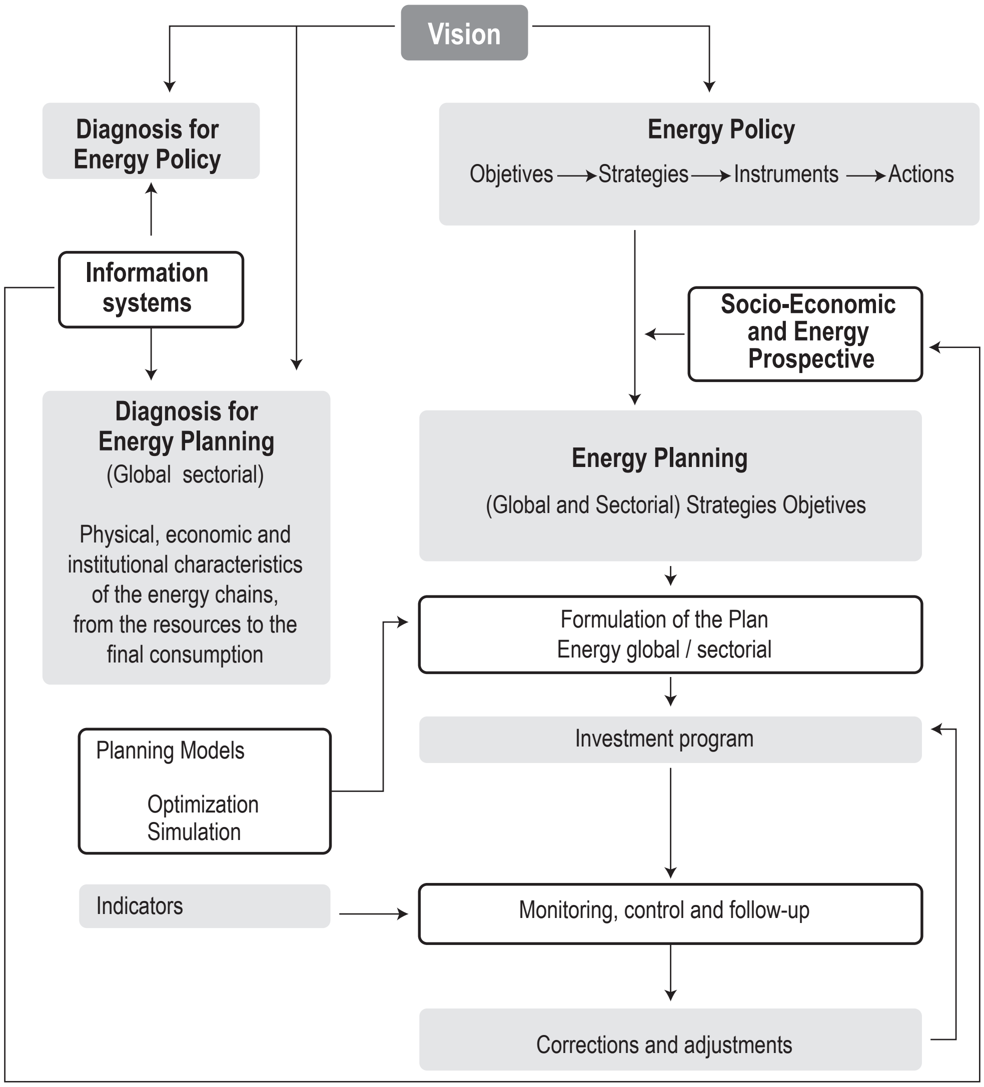
At the sub-sectorial level, it must examine the structure of all productive chains that comprise the energy system, considering the institutional and productive organization of the different links that constitute it, the stakeholders that operate in each link and the characteristics of their rational behavior and it also should include the structure of markets.

It will also require a detail of the infrastructure and of its technical characteristics and a quantitative evaluation of the human and natural resources required for the operation of the subsystem that constitutes the productive chain.

Likewise, it will be necessary to consider and/or propose the alternatives of the required expansion within the infrastructure that constitutes the links of productive chains, the corresponding investments, a preliminary economic evaluation of projects and the time required for their execution.

The following Scheme presents the links of energy planning with energy policy and establishes the sequence and articulation of the different stages and activities in planning.

Figure II.6: Stages in Energy Planning and their links with the tools for energy modeling



Source: Authors.

The search for the greatest possible consensus leading to the actions determined in the plan, is of vital importance for the viability of said plan. The search for this consensus must start at the very moment of its formulation. In effect, although the process must be led by an entity of the Executive Power responsible for the coordination of the energy sector, in view of the multidimensional nature of energy, the team in charge of the definition of the guidelines of the energy plan must include other entities of the public administration that are responsible for other areas of government that have a greater degree of interaction with the energy system.

This must be stated in the first place within the public scope. We cannot suppose that the State is a homogeneous stakeholder since its visions and purposes in each area may differ and even may be contradictory. Therefore it is important that the construction of a political viability of the proposal of the strategic guidelines for the plan be started within the public sector.

It is also necessary to take into account, that even before access is granted to private stakeholders to the different links of the productive chains and that the presence of public companies was predominant in most of the countries of the region of Latin America, frequently the rational management of such companies was not fully in coincidence with the objectives proposed by the global planning of the sector.

Starting with the reforms of the last two decades of the past century, the management of the system became much more complex due to the fact that the rationalities of the private stakeholders did not necessarily coincide with the global objectives that usually are incorporated into the plan and it is usually expected that these be divergent.

In consequence, the construction the viability of energy planning necessarily presupposes taking into account the interests of such stakeholders, trying to reach the greatest possible agreement relative to the actions included in the plan.

II.3.2. Energy planning modalities and different political-institutional contexts

Presented in section 1.2 was the historic evolution and the validity of public policy modalities and the conceptions of planning prevailing in each social-historic period that took place in Latin American countries starting with the second post-war.

In that which refers to planning, a brief characterization was made of the essential features of "*regulatory planning*", proposed in the decades of 1950 and 1960 by ECLA; there was criticism to this approach and disenchantment relative to the possibilities of planning during the decade of 1970; which was the period of validity of the neoliberal conception that denied the need and relevance of planning that was extended until the beginning of this century, and finally the reappearance of the need and relevance of intervention by means of public policies and of planning.

This section has the purpose of analyzing and characterizing modalities of planning in conceptual terms referring to the already alluded *regulatory planning*, to *indicative planning* and finally to *strategic planning*.

Regulatory Planning: This approach to planning favors economic aspects following technocratic criteria and pays little attention to matters of viability. In essence, attention is centered upon the coherence between the objectives proposed by the plan and the instruments proposed for that end. It fully trusts the power and capacity of the State (conceived as an internally homogeneous stakeholder) leading to the achievement of the planned system. In essence an effort is made to formulate a *book plan* that is technically efficient.

Indicative Planning: This deals with the formulation of a plan that represents, at the sectorial global level as well as the sub-sectorial level, in its physical and economic aspects (production, investments) the evolution desired from the energy system from the perspective of the entity in charge of planning. However, the execution set forth in the plan remains in charge of decentralized stakeholders of the system, be these of a public or private nature.

It refers to a *directional planning*, for decentralized stakeholders, that was valid in several countries of the Latin American region, following the reforms implemented in the last decade of the past century and which in its extreme conception is simply reduced to a *prospective* of the energy system.

The principal difficulty of this approach to planning is that it bases its trust on the economic signals from markets (prices and expectations of benefits and other economic incentives) that are sufficient to induce stakeholders and to execute actions of production and/or investment set forth in the plan. However, if these actions are not duly executed, or not carried out in time and form, it is possible that this may seriously threaten the security of energy supply, which is one of the most important elements of energy planning.

In view of these difficulties, it is necessary to have a permanent control and follow-up to be able to correct its deficiencies and modify the system of incentives previously set forth.

Strategic Planning: Differing from the previous modalities of planning, this approach includes mechanism that permit the construction of the political viability of the plan with *strategies and actions of a binding nature* in the sense of their implementation and execution that must be verified in an effective manner. For this purpose, a subsidiary activity of the planning State is established that determines specific mechanisms for its implementation in a direct manner or through public stakeholders in existence or specifically created for that goal.

The adoption of a planning modality presupposes the availability of highly qualified human resources, of the material means to launch the supplementary or subsidiary functions that must be performed by the state entity involved in the planning and of an institutional organization that controls the execution of the actions determined in the plan and that will eventually introduce the necessary modifications in function of the changes in context and the unforeseen reactions of social stakeholders involved in the system.

Under this conception, planning must be a tool to think and design a trajectory of the future for the energy system under conditions of a shared power. Although it is necessary to incorporate elements of the previously characterized planning modalities, in the sense of a correspondence between objectives and instruments, it must overcome these approaches by incorporating the complexity of social and political aspects that decisively have an effect on the planning process.

Under the present social and historic circumstances, it would not be viable to consider that planning proposes to completely substitute the decentralized decisions of social stakeholders or market mechanisms. To the contrary, it must start by recognizing the behavior of such stakeholders and to propose strategies and instruments that complement and correct the undesired effects derived from the assignment of resources that may result from the functioning of markets[16]. This is the reason why strategic planning requires the formulation of scenarios where different situations of possible futures are suggested for evaluation, and in function of these, the strategies or trajectories that will lead to the achievement of the objectives set forth are examined, recognizing at the same time the potential of social stakeholders. As stated by Carlos Matus, this must be conceived as "…the visible hand that explores where the invisible hand is incompetent or does not exist." (Franco Huertas B, 2006).

The prospective refers to future situations and requires a formulation of plans that are prepared to meet them, anticipating problems, weaknesses, threats, opportunities and strengths.

As an "instrument" of energy policy, planning is materialized through different tools for strategic leadership that help to support the process of decision making of the political authority in relation to the present situation and future actions, facing the changes and demands of the environment and to be able to achieve the objectives of the energy policy.

It consists of an exercise for the formulation and establishment of objectives of a priority nature, the principal characteristic of which is the establishment of courses of action (strategies) to attain such objectives. From this perspective, energy planning is a key instrument for decision making in public energy institutions and stakeholders.

Based on a diagnosis of the energy situation, planning establishes which are the actions that must be taken to reach that "desired future", which may be referred to on a medium or long term basis.

Thus, the process of energy planning is a multidisciplinary task that in the countries that enjoy a greater organizational structure is considered as an inter-institutional task, such as a network of interrelated construction with specialized nodes in different matters which, in an adequate combination, permits arriving to robust hypotheses and conclusions relative to a complex and disseminated question such as energy.

The evolution of energy systems involves decisions that, in many cases have a prolonged period of gestation and execution and involve enormous technical and economic resources. In this context, planning presupposes the determination, with the use of adequate tools, of the routes of probable paths of the future evolution of the system and thus, provide to the intervening stakeholders and sectorial decision makers, the best elements of judgment to define sectorial pubic policies.

II.3.3. Energy planning Diagnosis. Global and sectorial levels

The analysis of the conditions at the international level is relevant to an energy planning process. Within the conditions of the international context, it is necessary to include an analysis of the world and regional energy situation, especially in those aspects that have an incidence upon the situation and evolution of the national energy system. This analysis becomes relevant for the formulation, implementation and evaluation of energy planning.

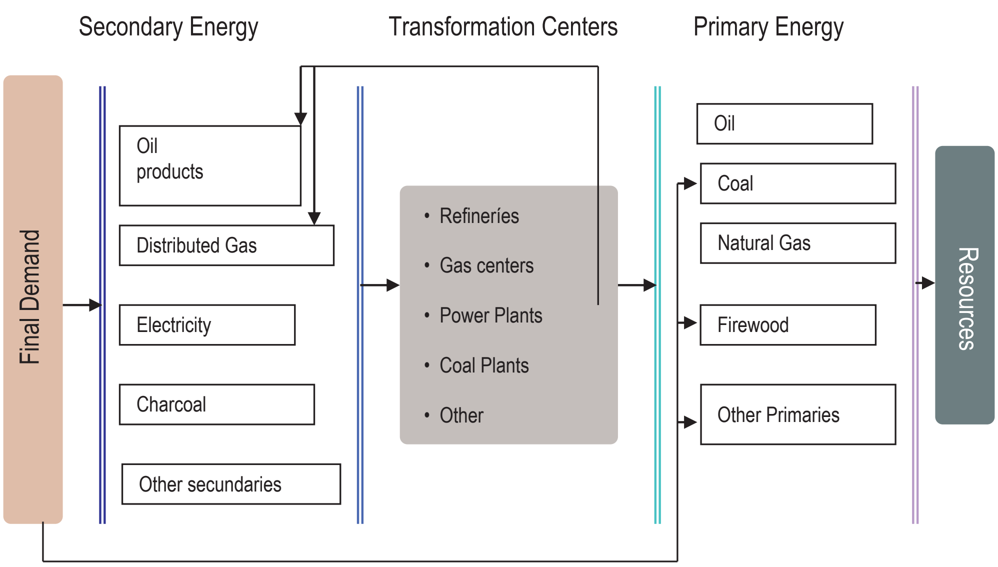
At the national level, the diagnosis involves a comprehensive analysis of the energy sector, comprised by a series of partial analysis of energy productive chains, interrelations at different levels (*upstream*, transformation centers and final consumption). Among these:

- Energy demand, its components, rates of growth, geographic and logistic dispersion of the supply. Historic evolution.
- Availability of resources. Reserves of coal and hydrocarbons, hydraulic, solar, wind power, geothermal, tidal, etc.
- Availability of conventional and non-conventional reserves. This refers to those resources that have been adequately quantified and evaluated in a technical and economic manner for their feasibility of exploitation.
- Energy supply, its sources (local or external), resources, reserves, production, environmental impact and supply logistics. Historic evolution.
- Technologies used and the potential of access to new technologies and to modern sources of energy and energy services.

16 "...planning is not opposed to the market, but rather it complements it and corrects its most noticeable deficiencies. Naturally, I understand that planning operates with intelligence and tact, without excess or clumsiness, a matter that not always occurs with traditional planning. All of this means that, even though planning is necessary in the limited economic scope; I would say that it is indispensable." Franco Huertas B., "PLANNING TO GOVERN: THE PES METHOD. Interview to Carlos Matus" Universidad Nacional de La Matanza, San Justo, 2006.

- Prices, taxes and subsidies, impact upon fiscal accounts.
- Economic contribution of the energy sector to the GDP and to employment; effects on the balance of trade and balance of payments.
- Efficiency level compared to the energy costs of the country and its regions, and if relevant, with respect to other countries.
- Energy Balance. Characterization of the supply of energy in the country as surplus, deficit or balanced in relation to internal demand. Historic Evolution.
- Coverage of and accessibility to energy under geographic and social aspects.
- Impact on the natural environment and climate change (supply and consumption).
- General and sub-sector characterization of governance issues that must be applied both for operation as well as expansion.

Figure II.7: Scheme of diagnosis for planning



Source: Authors.

As illustrated in the scheme that appears in Figure II.6, the process for energy planning starts with the analysis that must follow an inverse path to that of the flows of energy, starting with the final demand, both for primary as well as secondary energy, going through transformation centers and demands for the primary energy that feeds them, to reach the point of evaluation and quantification of the resources available in the country.

It is evident that this analysis requires certain interactions, in the measure that some transformation centers suppose the use of secondary energies.

The most notable case is that of electric power stations that may require oil by-products (fuel oil, diesel oil, etc.) and distributed gas.

Among the different chains that comprise the energy system in countries, the electricity chain is the one that presents greater complexity, due to the fact that electricity is a non-storable source that must be supplied instantaneously as soon as demand is present, it must have abundant links with other energy chains, it associates multiple technologies and electricity, is used by all sectors of final consumption and in certain cases it would be capable of supplying all energy services.

From this analysis of the diagnosis we can derive the **identification of strengths and the critical elements** of the national energy system.

II.4. Sub-sectorial and global analysis

The situation of the energy sector is analyzed through its sub-sectorial components, which is all of the productive energy chains that are relevant, and activities that comprise each one of them, in accordance with the reality of each country.

In addition to that stated, there are other questions that must be incorporated by the diagnosis. These are institutional aspects that characterize the energy system of a country, both at the global level as well as that of the different productive chains or sub-sectors. Some of the questions alluded refer to:

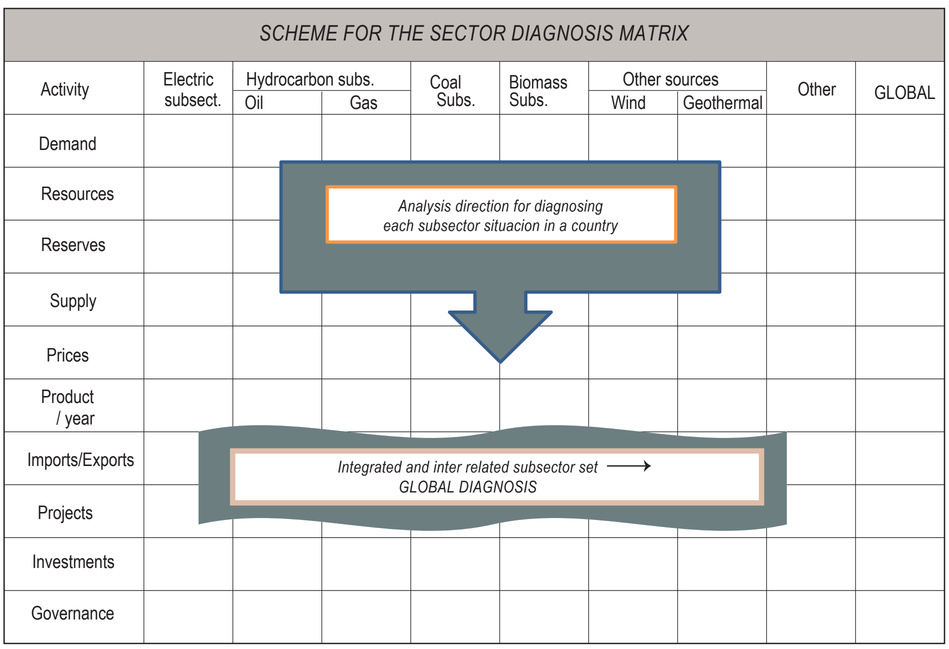
- Stakeholders in charge of the planning and coordination of the operation.
- Regulatory agencies and entities.
- Types of stakeholders present in the different productive stages: public companies and private stakeholders.
- Market structure.

Since in Latin America and the Caribbean there are differing energy characteristics between countries, both in their organization and institutional nature, in that which refers to the situation of surplus or deficiency of resources, it is necessary to adapt the general scheme to the characteristics of each country.

All countries face **energy demands** that must be satisfied, which in the measure in which these are supplied by means of the infrastructure and resources of determined sub-sectors, it is necessary that these be included.

With a vertical sense, the sub-sectorial analysis will describe how these energy demands are satisfied with local supply or based on local or imported resources, if the local supply generates exportable balances, the relation between demand and reserves and of demand with imports/exports, the relative magnitude of the resources and other relevant information for the configuration of the diagnosis, such as the existence and characteristics of projects for the expansion of capacity that have been planned for the short term or that are under execution, as well as the investments involved.

Figure II.8: Scheme of a sub-sectorial Matrix for diagnosis



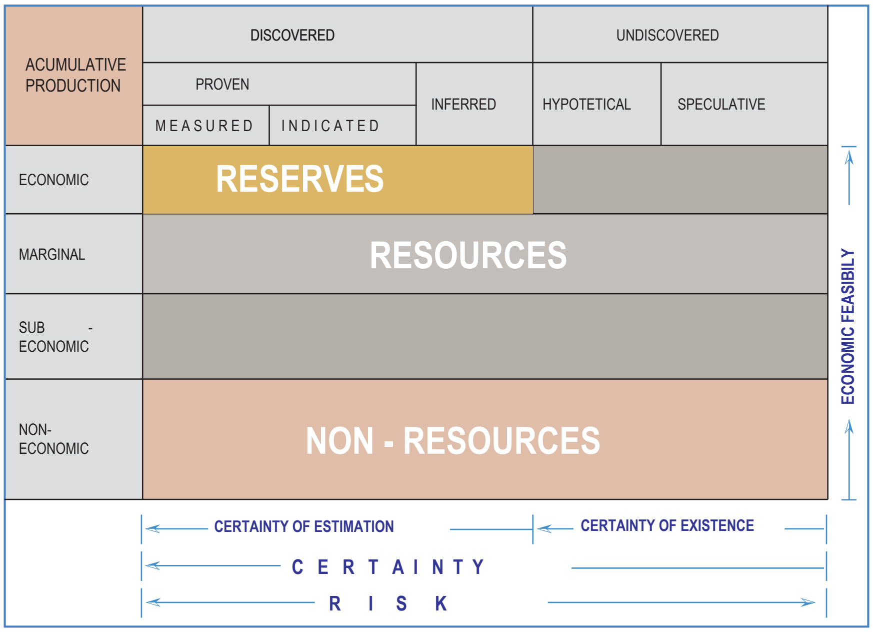
Source: Authors.

In relation to supply, the complexity and relative importance of energy sub-sectors in a country, would make it advisable to be able to open its components in order to undertake a homogeneous analytical treatment, that is more precise and in greater detail.

In the case of hydrocarbons, habitual analysis treats oil and its derivatives separately from natural gas and its derivatives. Likewise and on a parallel basis, they establish a difference in the analysis of resources, reserves, exploration and exploitation (upstream) from the stages of refining, distribution and marketing (downstream), whose operations and logic and business approaches are different (Figure II.10).

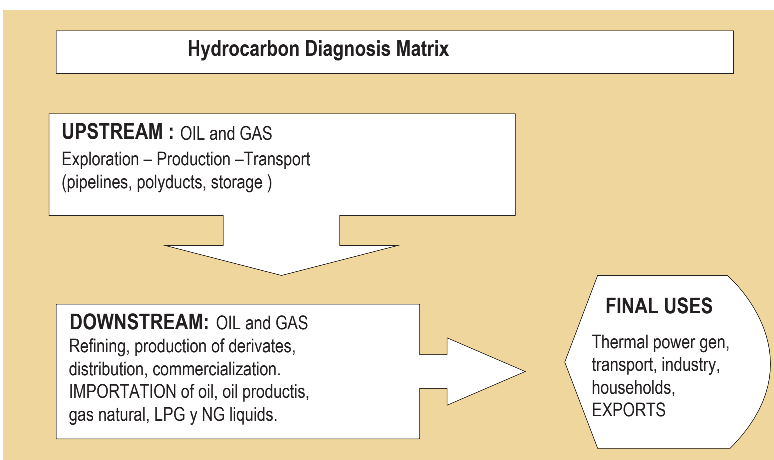
For the diagnosis made on hydrocarbons *upstream*, in those countries that have the resource, it is of great importance to include in the analysis a relationship with the characteristics presented by the resource. For this purpose it is possible to use the Matrix developed by McKelvey (Figure II.9).

Figure II.9: Analysis of hydrocarbons resources: Matrix by McKelvey



Source: Authors based on McKelvey.

Figure II.10: Scheme for the diagnosis of hydrocarbons



Source: Authors.

In the case of electricity (Figure II.11), normally the offer of generation must be studied in its different components of technologies and fuels. Thus it is possible to normally open the information and analysis for hydraulic generation (of greater, medium capacity or mini-hydros[17]; with or without reservoirs; of pumping), for thermic generation (nuclear or conventional of the different technologies and modules), for generation with renewable resources (wind, solar, geothermal, tidal, biomass) also on a parallel basis for the different fuels (coal, natural gas, CNG, LPG, fuel, diesel oil, biofuels, etc.).

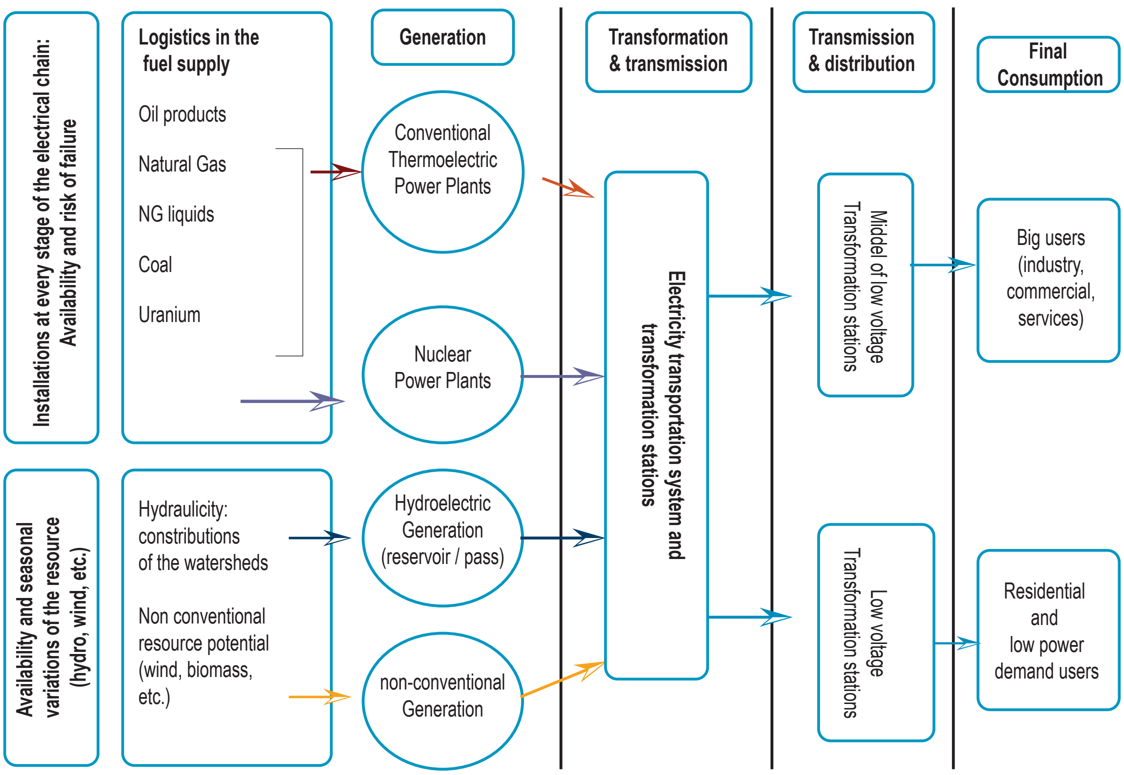
17 In some cases – for example Argentina – the mini-hydro is considered as a part of the category of generation with renewable resources, while larger hydraulic resources, although the water resource is used and are considered as naturally renewable, are classified within the category of traditional generation.

The productive flow of energy presents a key link that must be considered by all diagnosis that exists between the coal and hydrocarbons sub-sector (gas and liquid fuels) and the electric sub-sector regarding the supply of fuels for thermal generation (TV, TG, CC and diesel engines).

A key aspect of the analysis of supply is also constituted by the logistics that include all of the emerging capacity of the available facilities for transport, transformation and distribution of energy products, be these for primary or secondary energy, up to its final utilization. In some energy systems, these logistics reach levels of complexity and its operational reliability should not be disregarded at the moment of diagnosing the capacity that is available, and which constitutes what matters when determining the accounting for the supply[18].

In this sense, we must interpret the Matrix for sub-sectorial diagnosis that has been schematically drawn in the above diagram, as merely indicative of a similar but much more detailed and encompassing analysis that should be carried out for each sub-sector or even for each technological segment if the size and complexity so warrant it.

Figure II.11: Scheme of the Electricity Diagnosis



Source: Authors.

The result would indicate the characterization of each sub-sector and the identification of “problem situations” that it faces, permitting likewise to make an estimate of the projects that are under development and the amount of the economic resources involved or to be assigned, according to the policies established and strategies to be conceived on the basis of the diagnosis reached.

The integration of sub-sectors, taking into account the interrelations that exist in the productive chain between them, allows reaching a global diagnosis, as the economic summation of the energy sector of the country and it will reflect the strengths and critical elements of the energy sector.

The structural nature and the strength and critical elements, will permit a delineation of an energy policy of a country, establishing the objectives that are in consequence with the corresponding –qualitative-quantitative goals and strategies to achieve them.

The sequence is completed with the interrelation of the Diagnosis with the Objectives of Energy Policy, regarding the fact that in many opportunities these objectives have been predetermined in the countries – explicitly or implicitly– and are made before the analysis of the diagnosis.

18 Many countries of Latin America and the Caribbean have energy suppliers that are distant from the points of production or ports of import and storage, linked by storage systems or networks or systems for transport basically radial and unique, with little or no alternatives when facing failures or eventual interruptions.

In accordance with the nature of the Strategic and Specific Objectives of the Energy Policy, the Energy Agenda will be defined.

II.4.1. Impact and governance

Beyond the energy balance, the diagnosis is interested in the effects and impacts of the sector in economic, technologic – industrial, social, environmental aspects and the establishment of institutional and legal frameworks – and regulatory issues of its governance.

The economic aspect that comprises the energy diagnosis, at the global and sub-sectorial levels, is extremely important. This includes:

- The level of annual average, unit prices, expressed in the official currency for planning of the country and alternatively it is also recommended that it be expressed in a currency of international comparison (usually American Dollars or Euros).
- The sectorial and sub-sectorial production and its relative participation in the total gross domestic product of the country and in internal regional economies.
- A comparison of the prices of national energy products with respect to the rest of countries (especially in industrial activities) to verify the impact of energy in the competitiveness of these items.
- The participation of energy in the trade balance (exports and imports) and in the external balance of payments of the country.
- The contribution of energy to the fiscal balance of the country and its internal regions, when this is relevant; and the existence and importance of fiscal subsidies.
- The morphology and composition of markets, characterized by the level of competition or of concentration (index of Hersfindall-Hisrchman).
- The contribution of energy to employment and related population, social and environmental policies, when the positive or negative impact may be relevant and of interest.

From the technological–industrial point of view, to determine the capacity of the country to have access to the necessary equipment and inputs for the energy sector, whether of local production or purchased abroad, it is necessary to analyze the following aspects:

- The existing and potential capacity of industries and technological services that supply the energy sector and its sub-sectors, with its corresponding economic, social and environmental impact.
- The capacity for innovation and access to new technologies to increase the capacity, efficiency and modernization of the energy sector.

In that related to the social and environmental impact in the country, it is of interest to include in the analysis the following aspects:

- The level of territorial and population coverage of energy services, considering the access to them for the different strata that comprise the social complex.
- The effects of the energy system on the natural environment and climate change, in supply and consumption.
- Vulnerability of energy systems to environmental conditions.

Governance that corresponds to the energy sector and to each subsector is also a central element of the diagnosis for each country. It includes information on the structure, rules and norms that govern the operation and development of each subsector as well as aspects that refer to public/private participation and that of foreign capital, sectorial and sub-sectorial regulations, relative to the environment and control of competition and customs and tax regimes in the measure that these are specific to the activity and are different from the rest of the general activities of a country.

II.4.2. Energy Planning Tools

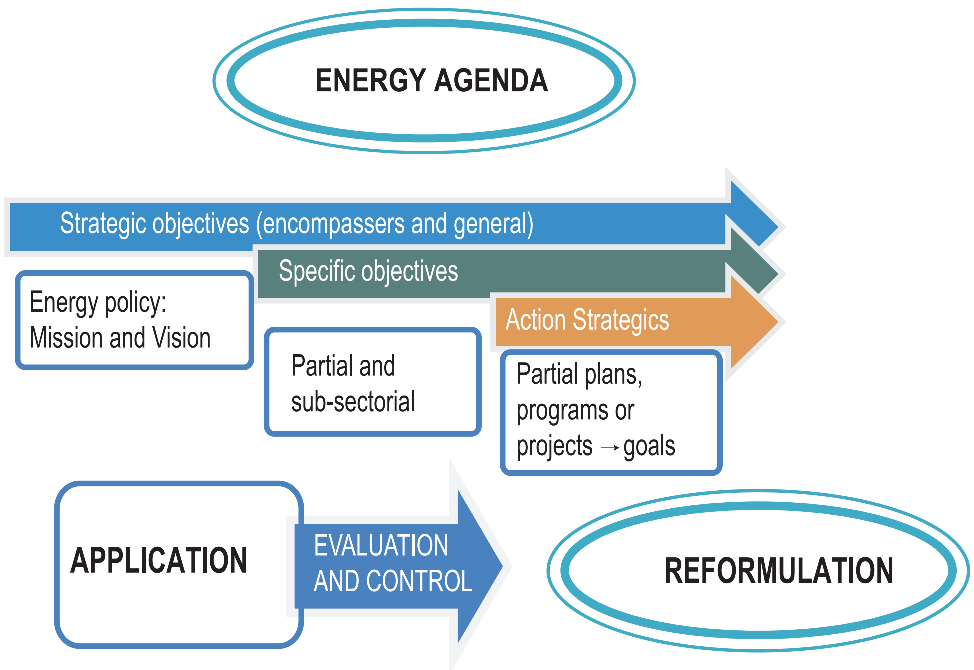
Among Energy Planning Tools we can highlight the following:

- Economic and energy information systems (see Chapter III).
- Energy prospective studies including conditions in an economic and social context at national and international levels (see Chapter IV and V).
- Models used for planning in the global and sub-sectorial energy levels (see Chapter VI).

II.4.3. Stages of formulation, implementation, control and revision

The stage of **formulation** becomes concrete in the determination of the Energy Agenda derived from the energy policy that specifies the general and specific objectives that must be developed by the planning process. Figure II.1 illustrates the function for the establishment of the Agenda, its implementation in the framework of the plan and succeeding tasks.

Figure II.12: Planning Agenda and application



Source: Authors.

In the definition of its **objectives of energy policy**, countries reflect the **mission and the vision** of their national policies regarding social, economic and environmental matters, within the framework of their historic characteristics and particular strategy.

As will be mentioned, general or cross-cutting energy policies, globally constitute a specification of the national policy for development, with impacts upon economic growth, the quality of life of the population and above all on the national environment.

On the issue of objectives, great objectives rest upon social, economic and environmental conditions. All of them on a long-term basis but implemented on short and medium term actions.

National general strategic objectives involve social, economic, geo-political and other aspects. These may include: the development of certain territorial spaces or population centers, the promotion of certain productive activities, territorial environmental protection or that of specific resources, integration with other countries of the region and others.

These national objectives of a structural nature constitute a primordial element as an input for energy planning. They will have a substantive incidence on the results of planning, on strategies and on the consequent energy agenda in its ulterior application.

General objectives may be characterized as long-term objectives of a general nature that involve structural transformations relative to the present situation. They answer to the determination of sectorial policies that may have different priorities, constituting an agenda of priority issues for energy development of the country.

Such **General Objectives are** generic encompassing premises:

- Long-term social, political and environmental sustainability of energy development, in accordance with the vision and legal and institutional foundations of the country.
- Economic sustainability, through the application of a methodology that permits expansion that reduces to a minimum, both the costs of investment as well as those of the operation of systems.
- Fiscal sustainability, in its incidence on finances and the external sector of the country.

The specific objectives derived from general objectives, disaggregated and focused on the different subsectors and linked to long-term plans or programs within optimized terms and specific goals to be achieved in defined horizons.

These objectives are normally established and expressed in more detailed objectives, such as:

- Balancing the structure of energy consumption with that of the available supply;
- Promoting Energy Efficiency in all consumer sectors, to improve the efficiency of the economy;
- Promote renewable energies, to reduce the dependence and consumption of fossil fuels and reduce contaminating emissions;
- Supervise an adequate access to energy for all social sectors;
- Territorially spread the scope of energy systems to cover isolated, least favored or minimum coverage zones;
- Improve energy quality to satisfy high productive demands;
- Increase the efficiency of energy production to achieve competitive supply prices and tariffs;
- Increase energy interconnection and integration with countries of the region;
- Install or expand the refining capacity and logistics for the distribution of liquid fuels;
- Install or expand port facilities or of transport of hydrocarbons or gas and the networks for electric distribution, etc.

Therefore, according to each country, the strategic objectives of energy policy may be some of those already mentioned or others that emerge from the particular characteristics of each country.

These specific objectives may be linked to qualitative and quantitative goals to be achieved within specified time horizons that normally coincide with planning terms. Such goals must be established on the basis of the diagnosis of the energy situation of the countries, of the specific objectives to be reached and the strategies, means and instruments that will be later referred to.

Goals are established and these correspond to the programs of action that include **strategies for their achievement**, a matter that will be developed in the following section.

The **application** of the Plan that emerges from planning is also a strategic task. This may be very variable, according to the organization of the country and of its energy system, but it must basically answer a scheme of the following type:

In the first place it is necessary to have a conceptual and practical design of the guidelines and contents of the plan, by means of:

- Formulation of a proposal for a policy, that corresponds to the public sector. Understanding this as the approval, official sanction, communication and dissemination of planning, granting it the legal and regulatory characteristic that correspond to the country.
- Socialization of the policy proposed, by means of the participation of all relevant social stakeholders that are committed to or affected by the plan.
- Interaction with relevant stakeholders for a proper understanding of the plan and the establishment of the necessary commitments to assure the results desired.
- On the basis of this, it is possible to consider that the energy policy has been validated in the first instance of its implementation, without detriment of ulterior actions for the evaluation and control of the plan and of its cyclical nature, a matter that will be later discussed.

In the **public sector**, the implementation of the plan may recognize the following needs:

- Appropriateness in the organizational structures of the planning State.
- Appropriateness in the strategy, structure and controls of the organization.
- Management of conflicts that imply the application of the policy and the process of change.

In that which refers to the state organization it is necessary to have the conformation of a correct structure that implies definitions related to the following:

- Distribution of authority among the different hierarchical levels
- Method of integration between sub-units
- Definition of the number of organizational levels
- Determination of the degree of centralization or decentralization of authority in making decisions.

In the **sectorial scope**, there may emerge barriers against the implementation of the policies and strategies of the plan, during the entire process: during the formulation, during the stage of validation or even after, as well as during its implementation.

These barriers may emerge from private and public stakeholders, who due to different reasons and interests may resist the formulation or application of the plan.

In cases of resistance, it is important to carry out the “socialization” of the strategies proposed and the verification of their viability and feasibility in accordance with the reaction of such stakeholders, within the legal and regulatory norms established.

This way, it is possible that eventual conflicts that may emerge from the implementation of the plan can be minimized and resolved within the framework of governance and legal and institutional nature of the energy sector to which it is directed and the institutional framework of the country in those aspects that comprise the general interest.

The ulterior stage of implementation consists in the application of the Plan, follow-up, control and evaluation of its development, and its eventual reformulation, that is next examined.

During the process of implementation of planning it is possible that unforeseen events take place that change the initial conditions, affecting the conditions under which the plan was formulated. It is also possible that barriers may be generated for different reason that cannot be resolved and that make it difficult to carry out the application foreseen in the Plan.

Discount rate associated with the process of energy planning

Energy plans necessarily include the installation of an important quantity of infrastructure required for the supply to different links of energy productive activities. The indivisibility of the investments required for the installation of such an infrastructure leads the function of cost to prevent a discreet image with discontinuities that are more or less marked.

In consequence, the scaling expression of the functions of cost must imply the need of expressing the costs as referring to a same point in time, and therefore the updating and/or capitalization of the already mentioned disbursements of capital, must take into account the times when these have been carried out compared to zero time, that was considered at the start of the planning process.

The rate of discount is a key parameter in the factor of recovery of capital r_N:

$$r_N = i/[1-(1+ i)^{-N}]$$

where

i = rate of discount
N = useful lifetime of the investment

Note must be taken that when N is large, the factor of recovery of capital tends to go to the rate of discount.

When dealing with non-renewable energy resources, the rate of discount also plays an essential role in the cost of the use of resources: *the larger the value of the* rate *of discount, the lesser is the conservation of the resource*.

In the literature directed to the regulation of services that constitute natural monopolies, the use of WACC (Weighted Average Cost Capital) is suggested to determine the rate to be used as a cost of capital. This is a formula that is devoid of a serious fundament within economic literature, since to obtain it, it requires that there are efficient financial markets and perfect competition in all markets.

In reality, the rate of discount is a policy parameter that depends on the negotiation capacity of the country with respect to the international financial market. In the last instance, this will depend on the financing needs that the country has, of its degree of foreign indebtedness, of its level of reserves, etc.

In the treatment of the natural heritage resources, such as is the case of the economy of the environment, social rates of discount are generally applied.

However, when dealing with very capital intensive energy activities with a strong presence of private stakeholders, as frequently is the case in energy planning, it is better to use private rates.

To be able to detect such anomalies, it is necessary to have available information systems on the evolution of the plan in its different areas of application. It is necessary to establish a system of control to adopt the appropriate corrective measures and preserve the achievement of the desired results[19].

Likewise, it will be necessary to generate **mechanisms of evaluation** that permit the verification of compliance with the plan and the obtainment of the results expected, establishing otherwise the causes for a lack of compliance.

Evaluation is basically a process that permits detecting the gap between the desired results and those attained, what aspects of planning failed and the responsibilities for such failure. In reality, evaluation is a process that is permanently participating in the plan: ex -ante, with the purpose of defining the most adequate alternatives for its implementation; ex – dure, during its development, to verify compliance with that which has been predefined; and ex –post, with the purpose of checking the achievement of results.

Unforeseen events

Planning normally determines a set of time horizons (short-run -4 to 5 years – medium-term -8 to 10 years – and the long-run – 25 years or more -) with goals to be achieved in each of those horizons.

These goals are linked to the strategic objectives set forth in the plan and the actions specified for the short term that must be compatible with the trajectories designed on the medium and long term, inasmuch as the possibility of reaching the strategic objectives set for such temporary horizons is undermined.

Therefore the crucial importance of a permanent monitoring of compliance with actions and partial goals that permit the introduction of the necessary corrections.

But there also may be changes that happen in the data of the environment that escape the sphere of decision of planning authorities and that in a significant manner alter the basic conditions under which the strategies and actions specified in the plan were formulated.

The presence of significant changes in environmental conditions may require an adaptation of strategies to the new data.

These types of situations may be exemplified due to the alteration of the functioning of the world oil market in that which refers to price levels as well as conditions of supply.

Changes in the international context:

a) Situation of global market of capitals

Long-term financing provided by financial institutions for development has been traditionally granted under more favorable and stable conditions for the funding of projects, than that forthcoming from private banks. This implies that even under unexpected critical global financial circumstances, it is less probable that financing already provided by the former instead of the latter will be affected.

Basically, infrastructure projects in Latin America and the Caribbean have been financed with regular resources from the public sector, with private capital or with loans that were principally obtained from multilateral or bilateral organisms for development. During certain periods and under varying global contexts, the participation of each one of these sources varied.

Although up to the eighties, governments took over the financing of infrastructure with the important assistance provided by the world multilateral development banks, the foreign debt crisis during that decade generated a retraction of public financing and opened the door to private participation.

This change in the paradigm for the financing of infrastructure, facilitated by reforms implemented in the region during the decade of 1990, was not totally satisfactory: there are studies that show that several of the countries of the region were destining to infrastructure – including energy and telecommunications – a lower historic percentage of GDP than that of other emerging economies. This means that private financing was not able to compensate for the fall in public investment that was also affected by a decrease in the contributions of multilateral organizations whose strategy at the time helped to strengthen private financial flows (Cited in ECLA, “The financing of infrastructure. Proposal for sustainable development of a sectorial policy”, Rozas Balbotín et al.).

The affluence of private capital, basically foreign, decreased in the measure that the assets of governments were depleted when they decided to privatize or grant concessions. Likewise, for a large majority of these countries, private investment in basic infrastructure

19 Aramayo, O. (Univ. Chile).

was largely associated to the transfer of assets and not to the formation of capital, except in certain activities that were promoted due to the emergence of new technologies. Not less deleterious upon the decisions for investment of private agents was the financial crisis that exploded at the end of the 90s.

This generated a revision of the role of public investment in infrastructure development. Particularly, new forms of financing appeared that involve public-private associations; in turn, multilateral organisms for development are reconsidering their financing strategies (World Bank, IDB, BIRF, CAF, FONPLATA, FOCEM, Central American Bank for Economic Integration, KfW (German Institute for Credit for Reconstruction), Bank for International Cooperation of Japan, BNDS and others.

Here rises the recommendation of awarding priority to financing sources that may provide more stable conditions, even when facing unexpected alterations in the international financing market, with the objective of not altering the execution of projects that have been started under a plan. Such is the case of the multilateral banks for development.

b) Changes in the conditions of the international energy market

The international and regional energy markets, although this has been profusely and permanently analyzed by different entities and companies, referred in the “Diagnosis of the Energy Situation”, may present unexpected alternatives that have an effect on the objectives and goals of planning in a country and also have an incidence on its implementation.

Such unexpected alternatives may rise from natural disasters or serious political upheavals that affect peace at the regional or world level. Even though the country in question is not directly affected, a relevant consequence may be an alteration in international reference prices of hydrocarbons that decisively have an incidence on investment options and decisions, affecting strategies, plans and projects.

During the last decades, the price of oil and its derivatives has presented a high degree of volatility and this trend seems to continue. Due to the direct effects on investment projects and the operation of systems, this price volatility may affect the application of planning and its energy agenda, more so if a sudden change in prices appears that exceeds the normal oscillations of the market.

Faced with the volatility of the last decades, countries have adopted actions of internal policies and of international cooperation, regarding supply, demand and markets (International Energy Forum. Flores-Quiroga, A.)

Regarding national policies on supply, mention has been made of the use of subsidies, regulation, excess capacity, strategic reserves and diversification. Addressed on the demand side are the application of taxes, efficiency in consumption and regulation. Referring to market process, there are suggestions relative to policies for competition, mechanisms for the establishment of prices, physical and financial coverage and of regulation.

With reference to international cooperation of a multilateral nature, mention has been made for the side of the supply of the establishment of quotas for production[20]. To be able to manage the demand there are agreements to reduce consumption and emissions. For both sides, there is also the dialogue and efforts to reach agreements among producing and consuming countries, investigation and the sharing of experiences between countries. For the functioning of markets, there is the negotiation of energy treaties, initiatives for a greater exchange and transparency of experiences and data.

These actions, some of which may have the nature of being sustained through time that are meant to control the trend of price volatility, may also be used in situations of unexpected emergencies, but applied as mechanisms of action of a transitory nature. Measures of a more direct and immediate action will be mentioned when referring to national policies, the implementation of which will not require third parties, as is the case in the international context.

Changes in the national context:

c) Opposition of civil society:

During the last years, the appearance of civil movements of opposition especially to large hydroelectric projects, has gained importance.

Several of these cases may be cited: development of Hydroelectric Power Stations in the Amazon region of Peru (projects such as Inambari, Paquitzapango and others, with financing and sale of energy to Brazil), Belo Monte (on the Xingú River, in Brazil), Corpus (binational project between Argentina and Brazil on the Paraná River, with civil opposition from the population of Misiones – Argentina),

20 Case of OPEC (Organization of Petroleum Exporting Countries).

Garabí (binational project between Argentina and Brazil on the Uruguay River, with civil opposition of the populations that live on the Argentine and Brazilian margins) and others. Some of these projects that had been planned and even started, were forced to be suspended. Others have been adapted.

Another example of civil opposition to energy projects, is that which is emerging in the south-west zone of Argentina where there is an exploration of hydrocarbon resources in clays, the exploitation of which requires new technologies of hydraulic fracking of the base rock, are facing opposition of the local population and of civil society. Mention must also be made of the opposition of the original dwellers of the Ecuadorian and Peruvian Amazon jungles regarding the oil exploration in their traditionally occupied areas.

This type of opposition has led some countries to zealously adopt an approach to adequately inform and clarify their energy projects before the civilian population, on their environmental impact, of the measures for preservation and mitigation and to try to get the support of civilians as a relevant instance for the progress of these types of projects. For this reason, new projects that may have a high environmental impact, foresee as preparatory tasks of their study and evaluation, the need to provide information and establish relations with civil society through their institutional expressions and the formation of a representative public opinion.

d) Particular situation of the country

The positioning of a country in the global market can be effectively altered during the temporal horizon of planning and this will modify the financing condition of those projects.

The unexpected source of such changes may be due to varied stakeholders, as well as natural disasters or sudden economic, political or even social alterations of a relevant and extended effect that substantially alter national activities and have a negative incidence upon internal clarifications and financial perspectives.

In extreme cases of a deterioration of the country-risk and faced with the absence of financing provided by multilateral credit organizations – whose disbursement commitment cannot be suspended due to that cause[21] - the execution of projects may become more expensive and even be paralyzed. Projects that can be delayed or suspended would be those that are financed by commercial or investment banks.

In these cases as well as under other unexpected circumstances, it is necessary to adopt energy measures, of the nature of those mentioned to face sudden alterations of the international price of energy products as well as the revision of projects and their financing and eventually the reconsideration of objectives, strategies, plans and goals of planning.

II.4.4. Frequency and participating stakeholders

The frequency of the formulation of plans depends on the characteristics of the institutional organization of the entities in charge of the coordination of the energy system of each country and the conformation of energy planning offices. However, in general terms the most usual frequency in the formulation of plans is around 5 years. Monitoring, Control and Follow-up activities are necessarily of a permanent nature in those planning entities that are properly organized and have the sufficient human and material resources.

Stakeholders that participate in the stages of Formulation, Monitoring, Control, Follow-up and Revision are generally of a public nature; and may require permanent technical personnel of the energy planning entities or, eventually, of professionals that belong to public companies that integrate the principal productive chains of the country and which collaborate in the formulation of plans with planning offices. In the operative execution of the actions that have been foreseen in the plans, the participation of private stakeholders can be expected, especially starting with the reforms introduced, following the last two decades of the past century.

II.5. Indicators

For the evaluation and control of the application of energy planning, it is necessary to follow its development through the use of "Performance Indicators" that permit a quantitative and qualitatively measurement, measure the progress towards the goals determined for the plans or programs of action, with the strategies established.

Recommendations to define a system of performance indicators, based on the strategic definitions of planning (Vision, Mission, Strategic Objectives, Specific Objectives, Strategies and Plans of Action), are[22]:

21 Projects financed by development banks, generally of a multilateral nature, have the guarantee of the States and once that financing has been granted and committed, this is not altered even when conditions in the international financial market change or the rating of the debtor country is modified.

22 Taken from Armijo, M. (2009), and adapted to the energy sector.

- Establish the areas of relevant performance to be measured (there appear critical variables that need to be monitored)
- Indicators should facilitate the knowledge of performance of processes (intermediate results) to identify delays and difficulties.
- They must inform of the level of advance and progress towards the achievement of goals.
- The number of indicators must be limited to a few that points to the essential aspects and that these can be used and controlled.
- Adequately nominate the indicator and its method of calculation.
- Establish the source of data, the goals and references for comparison (base line, performance of other systems, similar processes or plans).

The monitoring of indicators is the process that permits us to follow its evolution with a periodic frequency (from monthly to annually), so that it permits evaluation if performance is in line with that programed or if it deviates from what is expected.

On the basis of following, **Indicators** and the evaluation of effective compliance of the implementation of **energy planning**, it will be necessary to proceed with the production of the pertinent reports and communications, relative to the performance achieved.

Target groups and users of such information will be public instances of opinion and decision in matters of general policy and energy policy of the country. This will generate the instructions and political actions for the eventual reformulation of planning, analysis and re-evaluation of the strategies, plans and goals, in periodic processes that observe frequencies of one or several years.

Returning to the example of SENER, Mexico, that we have used in the guide for "Implementation" and for the design of the "Agenda of the Plan", and in relation to the **Strategic Indicators** therein stipulated, it reports that instruments were designed with the purpose of evaluating if the measures of the selected policies have been adequate to reach the strategic objectives.

Indicators may be of three principal types:

- Indicators of Processes: their purpose is to evaluate the degree of implementation of the development of activities and programs contained in the Plan.
- Indicators of Results: measure the effects of instruments, activities and programs implemented in relation to the goals and strategy of energy planning.
- Global Indicators: evaluate the results of the plan within the entire energy system. Here included are indicators to evaluate the economic, social and environmental impacts of the actions of planning.

The main purposes of Monitoring are:

- Verify compliance with short, medium and long term goals established in action plans.
- Undertake an evaluation of the actions planned.
- Identify the necessary corrections in the implementation of adjustment programs.

The basic components of Monitoring are:

- Definition of methodologies for evaluation
- Determination of control indicators
- Verification of mechanisms for financing the actions foreseen in the plan
- Establishment of information systems for control and follow-up

CHAPTER III

Information Management

KEY WORDS

Systems for Energy Information, Planning, Statistics, Energy Prospective and Indicators.

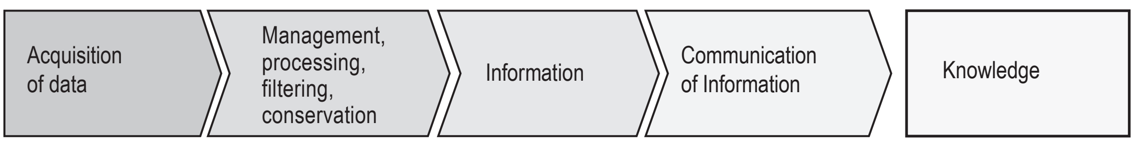
III.1. Introduction

The comprehensive planning of the energy system of a country is a matter of vital importance for sustainable development. In comprehensive planning there are several entry variables, the objective of which is to obtain realistic, executable and reliable energy plans. It is therefore relevant for any planning process, that in a first instance it must generate reliable information that permits us to know the present panorama and in addition, will permit with a certain processing, the ability to generate future scenario alternatives, based on which the energy planner may select the best in function of the objectives and policies of the State of its respective country; it also helps to continuously analyze the social, economic and environmental impacts generated by selected policies and strategies, to latter verify if in reality sustainable development is being promoted or if these must be adjusted. In summary, there is an imminent need to take well-informed and balanced decisions that can only be taken based on adequate knowledge of reliable energy information and indicators. This is the reason for the reference that has been stated, of considering information as a vital planning tool.

Information is a simple word that has a great meaning. It comes from the Latin: *form*, thus referring to a figure, an image. On its part, the Latin suffix–*tion,* indicates action and effect, and the prefix *in-* indicates a direction towards the inside. Therefore the word information may be thought of as: action and effect of placing a form in the mind of another individual.

In this sense, information could be defined as a set of processed data, that constitute a message (or a form) and which has the objective of changing the state of knowledge of the individual (or system) that receives it. Therefore, in order to generate knowledge it is necessary, in the first instance, to acquire data, then process it to generate information, that must later be communicated to the individual whom we wish to inform, so that it is finally transformed into knowledge. This latter can be schematically presented in the following diagram.

Figure III.1: Process for the transformation of data into knowledge



Source: Authors.

When referring to the energy sector, and especially to the quantity of information involved, the following questions rise: a) what information should be gathered? and b) how to gather and manage it so that it can be useful for making decisions? Apparently it seems like a simple matter, but in reality it is very complex. At the moment of gathering the information two situations are present: the first is that the information provided by producers and administrators is available in an orderly and classified manner and the second that it is specially presented from the demand side where information is more voluminous, dispersed, without classification; that makes it difficult for the planner to proceed with its analysis. With the purpose that the data available will carry out its cycle until it is transformed into knowledge, it is determined that the management of information should constitute a comprehensive tool that involves a series of processes that provide answers to initially formulated questions. Under this context, information management has as its objective that of maximizing the value and benefits derived from the analysis of that information, to minimize the costs of acquisition and processing, determining responsibilities for its effective and efficient use, and thus to assure the continuous flow of information.

This Chapter provides a reference of the energy information that is necessary to characterize each one of the sectors and activities involved and sets it forth as a tool for the administration of information, its use or the development of an energy information system.

Section II of this chapter highlights the importance of information in the process of energy planning. Section III deals with the characterization of energy information. Included in this matter is a conceptual explanation of the variables or dimensions that characterize the energy system in general. It also has considered that in turn, these variables are also the ones that determine the characteristics of energy information, and these have been categorized as: physical, economic, environmental, technological, political, legal and social.

Section IV deals with the initial considerations for the handling of information. In this part, it is looked for guiding the planner through the methodologies for the management of information, and above all through the sources where it will be necessary to search for this information. This section has studied the sources of information, both documental and administrative. A large part of this section is linked to surveys in the energy sector. Types of surveys are presented and as well as the methodologies that are necessary to carry out an energy survey. In general, these methods are valid to carry out surveys in any energy subsector. Nevertheless, given its complex characteristics, special care has been dedicated to those surveys that correspond to the biomass subsector. Following this, methods to estimate or calculate the missing information are presented. These methods can even be applied for information that can't be estimated or obtained from carrying out a survey.

Section V provides details of the types of information needed for energy planning, statistical or historical information. Prospective information, and indicators. The importance of having available a historical series of energy balances is stressed as a principal instrument of energy information. Prospective information permits a visualization of the directions of energy policy and of the different scenarios that have been formulated, as well as to make an ex-ante evaluation of the impacts of such scenarios; while the preparation of indicators substantially contributes to the monitoring and evaluation of the results of the policy, and in turn it helps in the learning process and corrections or adjustments to the instruments or the measures of the policy.

Section VI refers to information systems as an adequate instrument to manage information and it looks at the different functions of these and the experience in LAC in information systems for energy planning.

III.2. Information for Energy Planning

Within the context of what has been developed in previous chapters, one can understand that the decision makers (those responsible for the design and implementation of public policies) need to have available the necessary and adequate qualitative and quantitative information to enable them to develop viable and sound policies.

On the basis of the foregoing, if the correct energy information is not generated from sources of reliable data and through adequate methods of processing, it will be difficult for the promoters of energy resources to know the level of their inventories, to develop adequate policies to promote the optimal transformation of such resources, to invest in new technologies, to make efficient use of their resources, and to be able to plan a sustainable energy future based on a complete knowledge of the present energy situation of the corresponding country or region.

III.3. Characterization of Energy Information

In a simplified view of the economy in a country or region, the economy can be classified in two sectors:
the first sector, the farm (rural sector), and the second sector the city (city sector). This is a simplified conception of the economy: to bring together all of the activities that take place in the farm sector, whilst the entire industrial, commercial, residential and government sectors are grouped in the sector of the city. Notwithstanding this, the representation is incomplete since it does not include the work that is performed by the environment to support human economic activity. In other words, it does not include the environment sector.

In addition to the sectors of agriculture and the city, a more exact structure would be achieved by adding the lands that include vegetation, swamps, prairies and other natural goods. These natural systems constitute the environmental sector of the economy that provides many "gratis services" to human activity. The circulation of money still belongs to the agricultural and urban sectors, while there is no money that circulates in the environmental sectors. However, there is a feedback from the city to the environment, represented by the recycling of nutrients, of brackish waters and other waste, in addition to the efforts to control natural ecosystems.

Although much has been said about energy and its relation to the economy, there has also been interest shown in the interaction of energy with environmental, social and political variables. However, the panorama would not be complete without mentioning that there exists a technological development in the machines and equipment used both to produce energy, as well as to undertake other activities that would be easier to perform by using less energy, and also due to their cost, that probably the use of them would be widely expanded, which in turn implies the use of more energy.

When this system grows increasingly complex, as happens in the real world, there are a series of variables that come into play, also variables of a legal nature that serve to regulate the behavior of different stakeholders.

Traditionally considered, energy is regarded and represented as a supplier of services to guarantee the economic activity of a country and the quality of life of its population. Under this approach, an in depth analysis has been made of the direct and indirect requirements of energy of the agro-food system and of industry, depending on the productive technologies used. But proper attention has not been given, especially in developing countries, to the impact of the industrialization process that can produce the functioning of the energy system, not even in those countries in which energy activities, due to their relative importance, may act as true dynamic elements that promote economic activity.

The systemic approach (Bouille, 2004) conceives its goal as the study of the social processes for production, transformation, transport or transmission, distribution and consumption of energy, in its entire multi-dimensional conformation (physical, technological, economic, environmental, legal, social and political aspects). The center of attention is not only fixed in the relation between scarce resources and unlimited needs, but also and fundamentally on the social agents that have the power of decision over such resources and those that embody such needs. Within this focus, the matter consists of the study of the sub-energy system and its multiple interactions with the social economic system that conceives that the processes of production and consumption of energy systems are social processes, where the identification of the characteristics of the different agents or groups of agents becomes essential.

Thus, the physical image of the energy system must be completed with other types of information such as that referred to in institutional structures, the infrastructure or existing capacities in installations and equipment, economic information (prices, rates, financing), its internal functioning, environmental, technological, social and other types of information (Bouille, 2004).

Similarly, the form under which the planning of the supply system is conceived, becomes more compatible with the simulation models that permit dealing with the existence of multiple objectives that present a greater flexibility to study conflict situations.

Although there is no previous work that establishes a theoretical categorization of energy information, in this Manual, it is assumed that the energy system must be analyzed and planned taking into consideration seven dimensions: *physical, economic, environmental, social, political, technological and legal*. These dimensions may be of an endogenous or exogenous nature, quantitative or qualitative, etc.; and in turn are the ones that characterize energy information. This information will have its own characteristics and will be further examined.

III.3.1. Physical dimension

Physically considered, energy is governed by two important laws:

- The first is the Law of the Conservation of Energy that declares that energy cannot be created nor destroyed. In our case, this means that the energy that flows into a system is equal to the energy that is added to the deposit plus that which flows outside of the system.
- The second law is the Law of the Dispersion of Energy. This law declares that the availability for energy to undertake some work is depleted due to its tendency to dispersion (it is degraded). Energy is also dispersed in energy deposits. The energy that is dispersed in energy that is used is not necessarily wasted energy; its departure from the system is an inherent and necessary part of all biological or any other types of processes.

On the other hand, primary energy sources are present in nature in two different forms: renewable and non-renewable sources. The first must be associated to flows, while the second type is considered as existences. Renewable energies (hydraulic, solar, wind, bio-energy), in general are distributed throughout the entire planet, and permit the production or are captured in a decentralized manner. Non-renewable energies (oil, gas, coal, uranium) exist in limited quantities, although each such quantity has a significant degree of uncertainty, inasmuch as its volume depends on the degree of technological development, of new discoveries and prices levels.

The information associated with this dimension will include statistical data of production, consumption, efficiencies of conversion, balances, energy losses, reserves, availability of fuels, primary resources, etc.

As an example, an important piece of data that has to be considered in the planning of the hydrocarbons sector are reserves, world production and consumption, with the purpose of knowing beforehand the quantity of resources available and the future needs of exploration and exploitation. Capacities of storage and the variation of inventories also constitute important information.

The physical dimension is definitely what generates the greatest amount of information, and its characteristics are particular for each energy subsector; therefore it is necessary to undertake a deep study of the physical variables of the country, considering these as a basis for energy balances.

III.3.2. Economic dimension

Whatever is possible in physical or technological areas, is not always so in the area of economics. An expert may feel persuaded by the positive aspects of a high level technology he has developed from the economic point of view, but demands relative to the cost of such technology and the possible price of sale will exist.

Investments related to energy activities are of such a magnitude that these are always much greater than those that correspond to other industrial activities. Such investments in energy are not always divisible in time and require a gigantic financial capacity that the activity itself is capable of generating. This revenue is distributed among three main protagonists: large energy companies, importing countries and countries that produce/export. On the other hand, energy activity reveals a deep disequilibrium between the structure of demand and supply. A limited number of suppliers exist, compared to the multitude on the demand side. Additionally, the economy of energy is a complex system of actions and reactions, with the participation of a large number of stakeholders that strive to obtain economic benefits.

Within this dimension, the planner begins to work with macro-economic information such as Gross Domestic Product (GDP), rates of devaluation, inflation, etc.; and in addition it is necessary to have available information of a micro-economic nature such as: interest rates, rates of return in energy projects, financing, tariffs, production costs, investment costs in different technologies, taxes, subsidies, etc.

III.3.3. Environmental dimension

The activities of production, transport, distribution and consumption of energy are accompanied by significant environmental impacts. Although in a large measure these effects are the responsibility of developed nations, in the third world, the rates of growth of deforestation and pollution are being accelerated.

To the deterioration of ecosystems, produced by other economic activities, we must add the environmental impact of energy production and consumption, in particular the pollution produced by the use of fossil fuels. In reiterated opportunities, it has been mentioned that when facing the oil crisis, or the crisis of the wealthy, appeared the so-called crisis of the poor or the crisis of firewood produced by deforestation.

Taking into account the characteristics of this dimension, there is a variety of associated information that must be made available, such as: level of emissions, areas of affectation, type of flora and fauna affected, environmental policies, etc.

III.3.4. Social dimension

With certain frequency this dimension is closely associated to the environmental and economic dimensions. Nevertheless, there are differences that make it relevant to be considered as a dimension of independent information. Very often it is not possible to obtain the environmental approval of a project, however, there may exist rejections voiced by society as a whole. For example, when constructing an important transmission line or a power station, this may imply the need of displacing persons from their lands, a matter than can generate rejections from society. It is possible that in some of the activities of the energy chain frequent labor accidents may occur. This would naturally constitute a reason for a rejection from society. Another example is the number of jobs that may be generated by a project, which is something that would be of great importance in any society and which would lead to the acceptance of such project. In a similar manner, many social behaviors explain the patterns of energy consumption. The planner must take into consideration this information of a social dimension for the preparation of energy plans and policies, striving to reach a balance with other dimensions. The information that is relevant to this dimension may be contained in surveys, policies and regulations. Specific examples of this information are the rates of population growth, the index of human development, etc.

Although the index of human development is frequently used in the economic area, it provides information that is relevant to the social part to which it is directed. It is possible that a brief examination does not provide a direct relation with the energy situation of a country. However, if the information provided is adequately applied in conjunction with a set of economic indicators, especially of a social character, this may indicate the causes or consequences of the energy status of a country.

III.3.5. Policy dimension

The history of energy is marked by present political events caused by the economic “game” represented by the world market of energy. In many cases, the decisions taken in the area of energy are based on political will and not on economic evaluation.

When it is not possible to grasp the entire dimension of the implications of great energy investments (such as large dams) or the launching of plans and programs (for example nuclear plants, energy efficiency or energy savings plans) or when the technology to be used is not entirely understood, decisions are based on political wagers, frequently linked to international prestige or military concerns.

The relevant information to be considered must include within political aspects, the activities of energy planning that will always include the energy policies of the country under study, as well international trends and other documents that contain prospective information such as the policies for the rational use of energy, policies for the conservation of energy and the substitution of equipment, and policies that are adequate for the use of renewable sources, policies for subsidies, etc.

III.3.6. Technological dimension

The activity of energy is characterized by the degree of complexity in certain domains and by the extraordinarily ample scope of available technologies. If we consider this statement, we can appreciate the enormous abyss that exists between the first applications of solar energy and the design of the satellites that are propelled by solar engines.

On the other hand, to be able to satisfy present energy uses there is a varied array of different techniques, even though a definition is made to satisfy that need. An example will suffice: among other methods, an automobile is a means of transporting persons and such an automobile may function with gasoline, gas oil, alcohol, GLP, natural gas, and even with combinations of some of these fuels in the same vehicle.

Activities that are related to energy undergo a continuous process of inventions and innovations. These are carried out under its own dynamic nature where the continuous monitoring of technological progress constitutes a necessity for the planner. This information is associated to the costs of different technologies, the most efficient technologies, the adequate use and characteristics for the application of such technological advances, etc. Additional information regarding the technology variable for certain subsectors may be found in the section of prospective information.

III.3.7. Legal dimension

The political and economic relevance of energy activities increases the need of considering an additional ingredient that is the legal framework within which energy activities must be performed

In this sense, discussions ensue relative to the jurisdiction of the control authority over certain resources and activities (information at the national, state, provincial, municipal levels), the possibility that the domain of such resources or activities be public or private, reflections relative to property rights and their relation with the provision of energy services, the manner in which the constitution of a country determines a legal framework of norms for certain activities, are all elements of great importance that must be examined when the framework of problems associated with energy are examined.

This and other elements add a new topic to the already complex analysis of energy activities that presently acquires a growing and significant importance. In this case there is sufficient regulatory information available in each country regarding different topics (environmental, technological, economic, etc.) that must be known by planners.

III.4. Processing of Energy Information

III.4.1. Gathering of information

So that energy information is useful, there should be a solid base of sources, such as: statistical analysis standardized methods of calculation, information coming from national and international organizations, estimates and surveys among others. This information provided in a detailed, complete, timely and reliable form is indispensable for the preparation of energy plans and the monitoring of the energy situation at the national and international levels. Regarding the availability of information, the situation in each country is different. In certain cases, this information may not be readily available nor has the quality expected by a specific country. It is even possible that in some countries there may be a decrease in the availability and quality of the information gathered. Additionally, the evolutionary dynamics of energy issues at the global, regional and national levels makes it necessary to adapt existing information systems and eventually, to incorporate new information that is necessary to obtain a better knowledge of the functioning of energy systems and to be able to face new or changing challenges, (United Nations. 1983).

There are several reasons related to the deterioration of energy statistics that include the liberalization of markets, the requirement of additional data to those presently managed, budget reports, etc. In vertically integrated markets, a single company manages all of the information of its energy subsector (for example, gas, electricity, etc.). In a free market, energy planning personnel has to gather the information from dozens or even hundreds of companies in order to have a general vision of the sector. On the other hand, in a competitive market there is the implication of the confidential nature of data, a fact that makes the gathering of data much more difficult.

In any of the preceding contexts it is advisable to achieve adequate institutional, regulatory, contractual etc. conditions so that the authorities and persons responsible for planning and policies may have available the necessary information to enable them to comply with their functions. For example, the evaluation of contractual experience is an essential element in Public Administration. There is a background of contractual experiences with state companies, social organizations, regulatory entities, public and private civil society organizations, research institutes, governmental programs, etc., where the transparency in processes, given by the obligatory provision of reliable information, constitutes a part of the contracts entered into. When there exist models for the evaluation of contractual experiences, it is possible to overcome errors incurred in previous contracts, additionally considering that such models undergo evolution and in time they tend to improve and facilitate the identification of contractual mistakes, for example those related to information. In a similar manner, regulatory entities have the authority to demand the delivery of information and to carry out audits to verify the veracity of such information. However, it is necessary to continuously work to strengthen both the regulatory entity as well as regulations.

In general, each country must evaluate its programs and methodologies for gathering data, as well as the extension and quality of its energy information. This may include a review of agencies and organizations that gather data and prepare statistics and an evaluation of the data that is being collected.

The information required for energy planning does not exclusively include data of a purely energy nature, but also social and economic information, as well as environmental both of the country as a whole, and some specific subsectors (agriculture, residential, commercial, industrial, transport, etc.). The organizations where such information can be obtained include government offices that prepare statistics, income and tax collection agencies, central banks, institutes for investigation, and organisms of cooperation and non-government organizations (United Nations, 1983).

With the purpose of evaluating the programs and methodologies applied for the gathering of data, designed for the preparation of a proper energy system of planning and monitoring, the following actions are recommended for countries:

- Determine the organizations that are specifically responsible for the data and statistical analysis.
- Review and verify the scope, quality and reliability of basic data. This evaluation may include the availability of data, frequency of reporting or gathering of data, periods of time, quality, reliability and relevance. Statistics must be consistent in form and definition. Units of measure must be standardized.
- Determine the existence and type of energy indicators already being used. In this case it would be necessary to determine if these indicators are in harmony with those proposed in this chapter.
- Identify the sources of information and mechanisms and protocols to access such data.
- Evaluate the institutional structure responsible for the generation of information and the verification of an adequate systematic and organizational coordination.

A review of the quality and structure of data sometimes faces complications. For example, it may be difficult to find data or simply it does not exist. It is possible that the responsibility for maintaining energy data bases and related activities (data collection, compilation, and analysis) resides in several institutions such as national statistics institutes, ministries of energy, economy, commerce or industry, and national commissions for the environment and energy; in certain cases it is common that the information required by an organization be collected by another one, a matter that means a duplication of institutional efforts, etc.

Due to these complications, it may be convenient for some specific country to establish an office, working group or committee, that may be based on inter-institutional agreements, and which is established by taking advantage of the expertise and experience of existing organizations, and that uses an ample participation and consultation with all parties involved. The mechanism for participation must be transparent and flexible, and such an effort must help in avoiding the duplication of inconsistencies in information and gathering of unnecessary data. In addition, this effort must facilitate the incorporation of the analysis of information in a more ample program at the national level of management of statistical information.

Additionally, it is possible that some specific country needs to invest in improving its activities related to the management of statistical information on energy with the goal of taking full advantage of the products obtained for the activities of planning and follow-up of the energy sector. This includes improving the activities for the gathering of data of the energy sector, its follow-up and analysis. It is possible that there may be information that is missing and that needs to be collected or derived from some existing information. Likewise, it is important that the information be correctly compiled and interpreted, which will surely require proper training and an evaluation of the human capital involved in the process.

The gathering of energy data may be a complex and costly task that depends on the needs and circumstances of each country and of its legal and institutional framework. There may be cases in which the cost of gathering this information may exceed the benefits obtained, and the best solution could be that of establishing somewhat gross estimations without involving too many resources. This way, it is important that countries carry out this activity on the basis of well-planned strategic decisions, considering the scope and coverage of gathering of data, the organization of the data collected, the selection of sources of appropriate data and the use of reliable methods for data collection.

III.4.2. Scope and coverage of data gathering activities

The scope and coverage of activities for collecting energy data are defined by:

a) A conceptual design that includes the objective and matters covered.

b) The institutions and organizations from which data will be obtained.

c) The geographic coverage.

d) The period of reference.

e) The frequency with which such data are collected.

a) Conceptual design

It is necessary to establish a clear general objective relative for the gathering of data. In the scope of this issue it is necessary to take into consideration the structures of the different productive chains and their up-to-date situation and the type of statistical data to be collected. As an example, the flows and inventories of energy products, and the units of measure. It is also necessary to apply international standards in the process for the design of the database.

It is necessary to take note that the scope of the collecting and treatment of the information is within the context of the comprehensive planning of the long-term energy system and policy.

The objective is to collect the necessary information, from adequate sources, with the goal that this be used as the gateway to the planning activities mentioned before. Information is characterized according to seven dimensions or variables (see section 2) such as: physical, technological, economic, environmental, legal, political, and social information. This information may be numerical (mainly statistical), but may also consist of qualitative information presented in the form of policies, regulations, energy trends, etc., that may be found in documental form.

b) Institutions and organizations from which data may be obtained

In order to carry out an efficient work in the gathering of data, it is necessary to be aware of the organizations and institutions from which such data will be obtained. It is recommended that these be classified into the following groups: energy companies, small producers of energy and consumers.

Energy companies are represented by several organizations in which their principal business is directly related to the production, transformation, transport, transmission, distribution and sale of energy; and frequently are concentrated in a particular type or group of energy, or a part of the energy supply chain (there are also entrepreneurial associations that bring together companies in the same subsector and regularly produce information). These organizations compile a great quantity of energy information, both for operative purposes as well as for reports to organizations of regulation, provided that the appropriate collecting mechanism exist within these institutions.

The institutions that belong to the energy industry may be differentiated according to their public or private status as private industries, public industries, or mixed capital industries (public – private). The degree in which the government (provincial, departmental or state) is involved with these industries has a significant effect on the ease with which this data may be collected and the range of data that may be considered as reasonable to be collected. In view of the fact that such companies are able to provide information relative to the majority of energy flows, these must be considered with special attention and be included in statistical surveys or using adequate administrative resources. In the event that there is a large number of energy companies and the compiler of energy statistics does not have contact with original sources, these are to act as intermediaries and simplify the process for the gathering of data. However, in such an event it is necessary to assure that the quality of data is not compromised.

On their part and within the group of self-producers of energy, are included organizations (including consumers) that produce energy for self-consumption and at times they offer the service of energy to other consumers, but this not a principal part of their business activities. Due to the fact that these activities are not the principal objective of these companies and because of this reason, they would be partially or fully exempted from energy legislation and regulations. It is expected that in these companies there does not exist or there is no gathering of the amount of information necessary to satisfy the needs of compilers.

Although in a majority of cases, energy self-producers account for a small part of the national production, it is important that these be taken into consideration due to, among other reasons, that there exists a growing pressure so that these producers increase their production, and in view of the fact that energy consumption is important to measure the effect of greenhouse gasses and the calculation of indicators of Energy Efficiency. In countries where self-producers play a significant role in the national production of energy and consumption, it is necessary to determine adequate procedures to obtain information from these. In certain countries self-production (that also includes equipment for cogeneration) requires a Government license that facilitates the monitoring of these companies and creates the means to obtain such information.

Energy consumers may be grouped according to the energy needs of their economic activity, in general, following the methodology of the guide SIEN M-1, consumption sectors are defined as: i) transport sector, ii) industrial sector, iii) residential sector, iv) commercial and public services, v) agriculture, fishing and mining, vi) construction sector and others, vii) final consumption of the energy sector and viii) final non-energy consumption, (SIEN, OLADE, European Commission. 2004). The gathering of data regarding the consumers of energy is quite complex since it is necessary to consider the diversity, mobility, and that their activities may be multi-purpose. To facilitate this task, due to their particular characteristics, it is essential to design specific methodologies and strategies of compilation for different groups of consumers. Note should be taken that if energy consumers do not fall within the category of the institutions or organizations from which data can be obtained; notwithstanding the fact that it is possible to obtain consumption data from consumers that can be determined through direct measurements (electric subsector) or through surveys. Large consumers and chambers and entrepreneurial organizations are groups of duly organized consumers from which it is possible to obtain energy information.

It is usual in the case of energy distributors that these provide information relative to how much energy is provided to their users. They also provide a full breakdown of the total of the supply provided to various groups of consumers, taking into account the differences in rates or taxes applied to those consumers. Notwithstanding this, and with the purpose of filling any information gaps, it may be necessary to obtain additional information through surveys made to consumers, for example in the case of information related to the use of biomass. In these cases it is necessary to assure coherence between data based on the information of the supply of energy to final consumers and the information reported by consumers.

Alternatively, in several countries it is usual that an important part of that energy information is already available from different organizations such as statistics institutes or offices, ministries, coordination, audit and control organisms, international organizations, etc. Normally, these institutions have carried out prior work for the collection of such information; however, the planner must have a proper knowledge regarding the scope of such information and of the methods that were used for the gathering and processing of it.

c) Geographic Coverage

Geographic coverage identifies the area for which statistical data is collected. In general, it is fundamental to gather statistics at the national level, with the purpose of being able to formulate adequate energy policies. However, some countries gather their energy statistics at the level of regions, a matter that implies having a better coverage of the information, in view of the differences that exist in the different regions. For example, the gathering of statistical data at the regional level is essential for the future planning of infrastructure due to the fact that it permits taking into consideration different locations of production and consumption. In that which refers to consumption, it is necessary to have a regional disaggregation because the use of energy may significantly vary according to the climate, local customs, economic activities, income, availability of energy products, etc. There is an evident relation between climate and use of energy; in places that have extreme climates, the use of energy is more intense than in places with a temperate climate, particularly in the residential and commercial sectors and public services. For example, in sectors with a warm climate, there is the use of electrical devices for air conditioning and ventilation, while in colder regions it is necessary to use heating. However, the gathering of such detailed information requires a considerable experience to assure the adjustment of regional data within the framework of national information, since there is the frequent presence of omissions, duplication of data, etc., which also implies a high cost of collecting data.

The geographic disaggregation of information is necessary to carry out strategic planning; the planning of energy supply must also be carried out in a geographically disaggregated manner.

d) Period of reference

This refers to the time period of the data collected. In that period of reference, data may be collected with a frequency of hour-to-hour, day-to-day, month-to-month, etc. Data regarding the different load curves of demand for electricity have a period of one hour; while the production of petroleum or the consumption of its derivatives may have a period of reference of one month; data relative to the use of energy by consumers may have a period of reference of one year; while the data relative to the measures used to evaluate the results of a program for the reduction of the use of energy may have a period of one month. Nevertheless, it is frequent to collect data for annual periods with different frequencies of collection.

The period of reference of data must be carefully planned and recorded, since the data gathered may have a cyclical or seasonal behavior. The latter may establish a great difference in the analysis, and could be a source of error in the case that the season of the year in which such information is gathered may not be the adequate one.

e) Frequency for the collection of data

The frequency for the collection of data adopted by a country must represent a balance between the priority assigned to the time spent gathering of specific data, at the level required, the availability of such data and the resources available. The objective should be to have the complete data on a yearly basis, since determining a greater frequency of collection would be a not very realistic objective. This activity may be promoted in all countries, so that the collection of data in a regular form is guaranteed, especially in those areas that represent energy priorities.

The annual collection of data includes data of energy related with the most basic needs of information. In general, this is information of greater detail and covers production, transport and consumption.

The collection of data by month, quarter or semester basis is carried out when there is a priority for such a frequent collection of data (example: monthly production and marketing of petroleum), however this is of lesser scope than that collection carried out on an annual basis, since the increase in frequency of collection implies an increase in the costs associated.

A collection of data with a lower frequency than annually is generally developed for special reasons, such as filling voids in the information of data collected annually, to establish a baseline of information, etc. It is also used in those cases in which data collection is particularly costly, such as in large surveys among consumers.

III.4.3. Organization of data collected

An adequate organization of data is a fundamental step in the preparation of energy statistics. The first important step in the organization of data is to identify production, transport, transformation and consumption flows for each energy source, with the purpose of clarifying processes, procedures and the agents involved. In a second instance, it is necessary to make a draft of the potential sources of data for each stage of flow with the purpose of determining if it is feasible or not to obtain the precise information on a regular manner from such sources, making use of the information that they already possess for their own operative procedures. This makes it possible to determine the type of energy data that can be obtained from energy related companies, and from other industries and organizations that produce energy, as well as the way in which such information may be obtained through its regular programs of surveys and administrative processes.

Gathering and organization of data is a process that also depends on the regulatory framework and dialogues and inter-institutional agreements, as well as the consensual use of the methods for collection, and the use of data and statistical registers of the business of each one of the companies in the energy industry, or the use of surveys to obtain the relevant information. It is necessary to select the most adequate method for the collection of data in consideration of the nature and characteristics of energy activities, the availability of data and budget restrictions for the implementation of the adequate strategy.

Collecting energy data must be viewed as a comprehensive part of the activities for the gathering of data for the national statistics system, with the purpose of assuring the comparability of data and cost efficiency. In this context, it is extremely important that there exists a close collaboration between the compilers of energy statistics, industrial statistics and population statistics, statistics relative to work forces, financial, etc.; such collaboration must be fully stimulated and systematized. A relation of collaboration will promote a better understanding of the information and represents an opportunity to incorporate elements relative to energy in specific non-energy questionnaires. Especially important is an integrated approach to data collection on the consumption of energy, since it is possible to use several sources of different data and these can be even correlated, compared, etc. (United Nations Statistics Division. 2011).

The establishment or improvement of present programs for the collection of energy data must be a part of strategic long-term planning within the scope of national statistics systems. This program must be correctly designed and executed with the purpose of obtaining a full coverage and guaranteeing the gathering of precise, detailed and timely statistics.

It is recommended that the organization of data observe the following hierarchy:

1) Data in accordance to their characteristics: Physical, Economic, Social, Environmental, Political, Legal and Social.

2) Data organized by subsector: Electricity, Natural Gas, Petroleum, Solid Fossil Fuels, Wood and Vegetable Coal, Energy Crops and Biomass Residues.

3) Data organized by geographic area: Country, Region, etc.

4) Data organized in accordance with an energy balance.

III.4.4. Sources of information

The information required for the planning process has its own characteristics, as has been studied in the previous section. This information is of a differing nature and must be collected from varying sources. In the following subsections these sources of information and their particular characteristics are studied.

a) Operative and Documentary Information

Operative information within the scope of energy is dispersed in several organizations of a private and/or government nature that although closely linked to energy systems, do not have a specific purpose of providing services to energy planning. This information is normally used by these organizations for their management activities.

Sources of operative-administrative data collected by public entities

Some State agencies or institutions gather data with different purposes, for:

- Monitoring, registering and supervising activities related to the production and consumption of energy,
- Facilitating the development of activities for regulation - auditing, and
- Evaluating the results of energy policies, investment programs, incentives, etc.

The application of an auditing system (example: for customs and taxes), usually involves a register of the institutions, companies, homes, etc., covered under such a scheme. Data stored in this type of register may be efficiently used to prepare statistics for the energy sector.

There exist a series of advantages related to the use of operational data, of which the most important are:

√ Reduction of total costs related to the gathering of data,

√ Reduction in the time required for such gathering of data,

√ Reduction in the errors derived from surveys made on a sample of population, principally due to the coverage of population that is greater when the information is forthcoming from the application of a regulation,

√ Sustainability in time due to lower additional costs and long-term accessibility,

√ Greater frequency in the up-dating of data,

√ Increased possibilities for cooperation between different agencies, facilitating feedback, exchange of views and identification of areas of common interest,

√ Data quality improvement potential,

√ Multi-purpose usage of operative-administrative data

√ Possibilities for correlating data from different sources, etc

However, since operational data are not always collected for statistical purposes, it is important to pay particular attention to possible disadvantages such as:

√ Inconsistencies in the concepts and definitions of the data,

√ Possible discontinuities in time series due to changes in regulations, and

√ Legal restrictions regarding access and confidentiality of data.

It is therefore very important that, when compiling energy statistics, the different sources of operational data available in the country are identified and reviewed, and that it is also in a position to identify which are the most appropriate for the elaboration of such statistics. It should be noted that the above mentioned advantages and disadvantages are not of generic nature but depend on the specific situation of each country (*United Nations Statistics Division. Department of Economic and Social Affairs, 2009)*.

Some examples of operative-administrative sources of data that may be important for energy statistics are:

- √ Customs records (imports / exports of energy products),
- √ Records of value added taxes (VAT), and other types of taxes on fuels for the transport sector, etc.
- √ The records of operators in the regulated markets of gas and electricity, etc.
- √ Population census.
- √ Information of cadasters, among others.

Differing from the statistical data that are administratively managed, there are documentary data that not only offer some type of statistical information, but also provide qualitative information on energy policies, energy plans, specific projects for energy expansion, technological trends in determined areas of the energy sector, etc.

This type of information cannot be catalogued as quantitative (statistical) and is of great use for planners and decision makers in the different areas of the energy sector. It is possible to use some information from specific feasibility studies and compare how profitable two or more specific projects may be, or to have an idea of the environmental impacts that a determined project may generate. There are also infrastructure projects of a public or private nature that could have important energy needs and which would be vital for the development of energy plans and energy future of each country. The planner must bear in mind all of this information in order to assign priorities to determined energy needs.

Another fundamental source of data that the planner must consider for its activities consists of the plans of different sectors such as those of the economy, agriculture, transport, urbanization, social, rural development, etc. These sources of information in the form of sectorial plans could contain information relative to strategic objectives, instruments for the execution of those plans, results expected, and the way to measure these. Special care must be provided so that the information used to prepare energy plans must be in accordance with the information contained in different sectorial plans. For this it is necessary to carefully investigate the type of sources that were consulted in the preparation of such plans. In special cases, it may even be necessary to have a close collaboration with the personnel in charge of preparing such sectorial plans. This is easier to carry out if there is a regular inter-institutional dialogue and collaboration.

Sources of operative data collected by private entities

Certain data may also be collected by organizations of the private sector and by commercial associations. Normally this is done to assist the industrial and commercial sectors to understand some of the important aspects related to their productive activities. However, such data can also be useful for those who are in government, as well as for those who generate policies and decision makers.

In this sense, the statistics organism that is responsible for energy information must work in cooperation with private organizations in order to have access to such data and to maximize its information value. This will avoid decreasing the resources that a company destines to providing information, by not requiring that it must provide information to the private organization as well as the organization in charge of statistics on a separate basis. However the organization in charge of statistics must guarantee the quality and objectivity of the data that this organization provides to private organizations, considering that the objective of the latter is not necessarily the same as that of generating information of the energy sector. An example of this type of information is that of the automobile industry, whose objective may be to forecast the increase in demand of new automobiles for a specific year. Such information could be adequately correlated with the growth expected for the consumption of fuels such as gasoline or diesel. There are also consulting companies or individual consultants that generate studies of varying nature related to energy issues such as: pre-feasibility studies, feasibility studies, energy studies, surveys, etc., that could eventually provide documentary information that is useful both for statistical purposes as well as to obtain documentary information. On certain occasions, these studies contain sophisticated methods that are developed to fill the lack of information, something that can be useful in the generation of energy plans. It is also possible that this information may be of a confidential nature, for which purpose it will be necessary to free the restrictions of confidentiality in the best way possible. Information coming from consulting companies that are dedicated to the study of energy projects, or marketing studies, may represent some cost, for which reason it is necessary to evaluate the cost-benefit related to such a source of information so that it satisfies the needs of planning.

b) Surveys

A typical source of statistical data relative to energy is the survey. This is an activity that is carried out focusing on the population of interest under consideration. Surveys can be carried out in the entire population (census) or taking as a base only a part of it, that is selecting a sample (survey properly named).

In general, the execution of a census in matters of energy is not to frequent a task, since a census represents efforts that consume great resources of time, persons, infrastructure, and also represent a heavy load of questions regarding the population in general. However, in special cases, depending on the population of interest, resources available and priorities of the country, the census may be a viable option to obtain energy information. A complete census in the area of interest of the energy sector may be appropriate when a specific country does not have available an up-to-date register of energy producers, or there is a great interest of users to have available data relative to the energy situation in small geographic areas.

On the other hand, surveys are a means of obtaining information from a part of the populations of interest, called the sample, from which it is possible to infer information for the full population. Naturally, surveys are always less costly than a census. There are some types of surveys that can be used to obtain statistical energy information: i) industrial surveys (these surveys can be seen from the point of view of the supply of energy, carried out with companies that produce energy), ii) surveys to homes (groups of persons with similar economic and social characteristics); these surveys are used to determine the characteristics of energy demand, and, iii) combined surveys that are a mixture of the previous ones.

In general, with the objective of avoiding a duplication of efforts, it is recommended that countries undertake efforts to establish a program of surveys that meets the needs of energy information in a comprehensive manner, and which can be a part of a general program of surveys, both for companies as well as for groups of persons of similar social and economic characteristics (United Nations.1983).

Design of Energy Surveys

Before carrying out a survey, it is fundamental that an adequate design of it be made. This objective may be met by observing the following steps:

- Identify the needs of specific information as well as the objectives of the project, emphasizing priorities, budget, flexibility, geographic disaggregation, etc. To achieve this, it is useful to take advantage of previous experiences acquired in similar projects in other areas taking into account international recommendations (International Recommendations for Industry Statistics, 2008) applying existing national norms and regulations. This phase requires the multidisciplinary participation of specialists in matters of energy, statistics, engineering, etc. Likewise, inter-institutional coordination and participation are important.

- Once that a specific question has been determined for the survey, the next step consists in selecting the specific items within this area of interest, assuring that the selection be carried out under an adequate classification and definition that determines each one of the concepts of the items specified.

- Select a population or sample that will be the object of the survey; this is a critical step to adequately comply with the objectives of the survey. Within this phase, decisions must be taken regarding the size of the population (in the case that this is not a census) that will be interviewed with the purpose of assuring representation, considering the restrictions of time, budget and degree of precision desired. The sampling technique to be applied will depend on the population or populations that will be sampled, as well as of the information available from other regular programs of surveys, statistical systems and registers of companies and of persons. This will offer a much clearer panorama of the context of the project that is being carried out.

- The following step consists of the design of questionnaires and supplementary documentation. It is necessary to decide on the profile that the interviewer must have, the method of interview that better meets the objectives of the project (personal, telephone, e-mail, online, internet/intranet, etc.), the temporary scope of the specific items of the survey and the way in which each one of them and associated concepts will be presented to those surveyed, in order to insure a perfect understanding of the survey. It is also necessary to determine the type of questions and sequence that each one of these must have, attempting always that the language used is clear and direct. In addition, it is essential to use correct units of measure in terms in which it is desired that questions be answered by those surveyed. Small units of measure such as kilowatt-hour, cubic meters, etc., are perfectly appropriate for consumers or for gas stations respectively, but not for industries that provide energy.

- An important part of the design of the survey is the preparation of clear and concise instructions that will help to clarify any potential doubt that those interviewed may have. It is important to mention that several adaptations to the design must be made so that the survey fits correctly within the specific context of it, its geographic scope, the interviewed and the interviewee, as well as the procedures that are pertinent to the survey. The persons making the interview must be adequately trained in the techniques to measure the different types of energy vectors. In addition, in those cases where it is necessary to measure certain special energy resources such as biomass, it is extremely important to have available the correct instruments of measurement to be able to carry out physical measurements of the fuels really used.

In general, all personnel involved in the survey project, in addition to the knowledge they must have regarding energy matters, they must also have adequate knowledge regarding the design of surveys, by sampling, techniques for interviewing and analysis procedures. These responsibilities may be taken over by the national office for statistics or by personnel of the institute for academic studies on energy or any other analogous discipline. There is less possibility that experts are to be found in the Ministry of Hydrocarbons or of Energy, whose contribution to the survey could be of a more technical nature relative to the problems associated with energy.

It is also possible that surveys have to reflect the needs of information of more than one ministry, a matter that requires an inter-institutional dialogue and coordination. However, it turns out that some ministries carry out independent surveys that overlap with others, under the wrong conviction that surveys, from the point of view of quality and opportunity are better handled by those who have greater knowledge of the issue. This may lead different ministries to reach contradictory conclusions that served as the basis to determine separate policies and impose preventable inconveniences for those surveyed.

Due to the foregoing, emphasis should be placed on the importance of coordination and dialogue between the different organizations and parties interested, that will bring about a general recognition of the need to have the input of a variety of experts in different fields of engineering, statistics, energy, etc., to be able to project, execute and take the fullest advantage of surveys.

Industrial Surveys

These are surveys directed to companies to gather details of information relative to their consumption and use of energy (these could also be prepared to gather details of the energy supply, if the survey is carried out among energy producing companies). Depending on the source of the framework of the sample, such surveys may be classified as follows: i) Surveys based on a pre-existing list of companies/industries and, ii) Surveys based on companies/industries that operate within determined geographic areas. In the latter case, it is necessary to establish a sample of geographic areas, then to follow one or more steps of selection it is possible to identify the set of areas within which those companies have jurisdiction. A sample is selected from this list and data is gathered. In general, it is preferable to use surveys based on predefined lists due to the fact that very often it is difficult to establish the companies within an area, and in addition, surveys based on geographic areas are not appropriate for medium or large size companies that operate in several areas, due to the difficulty of collecting data from those geographic parts of companies that have jurisdiction in the areas selected.

Energy statistics surveys for specific objectives

These types of surveys are extremely useful to fill vacuums or a lack of information. An example of a survey with specific objectives is a survey specifically designed to measure the amounts of consumption of fuels and bio-fuels. The sample will probably be a group of consumers and possibly small scale rural industries that operate under the normal thresholds required for the sample. Data will generally cover the weight (or volume, in case adequate conversions can be carried out to the unit of measure of weight at a later phase) of the different fuels consumed for different purposes. If there is a seasonal pattern in the use of fuels, then the interviews should be carried out throughout one year so that they can be representative for all seasons. Results must be carefully analyzed by the size of the consumer to be able to obtain a range of consumption per capita.

In general, energy surveys with specific purposes are very useful instruments to evaluate the activities of energy consumption, monitor the impact of energy programs, examine the potential of energy savings programs and/or energy efficiency and determine the feasibility of future programs.

The design and implementation of such surveys may imply the need of excessive human and financial resources and requires a multidisciplinary professional effort with the purpose of identifying the appropriate design of the sample, the techniques for interviews, and the procedures for analysis. Therefore, it is recommended that there should exist an inter-institutional cooperation between energy ministries and agencies, national offices for statistics, institutes of investigation, etc.

Ideally, surveys on energy matters must be designed in such a way so that these can be undertaken normally with the periodicity that corresponds. An emphatic recommendation is made for countries to assure that the design of the survey be optimized, taking into account the use for which it is intended and the correct interpretation of its results. Likewise, it is necessary to avoid including non-relevant information. Due to the costs implied in the execution of these surveys, it is necessary to design the survey in such a manner that it guarantees the greatest benefits and assures its consistency throughout time.

Surveys in groups of homes and combined surveys

These are surveys in which the elements of the sample are consumers. In combined surveys (industries-homes), a sample of consumers is selected and each consumer unit is asked if any of its members operate some informally established company (informal sector). A list of companies is then compiled and it is used to select the group of companies from which the desired information will be collected. Combined surveys are useful to only consider certain informal companies (or homes) that may be numerous and cannot be easily registered.

Although consumer surveys are not specifically designed for the compilation of energy data, these may provide valuable information relative to residential patterns of consumption and potentially information on the production of energy of some of these consumers. In view of the complexity of the characteristics of the consumption of energy of certain consumers, it is necessary to obtain estimates and other measures of energy from surveys by using the information provided by those surveyed. Regarding the matter of energy, useful information is related to the average number and size of consumers, the level of penetration and property of the devices of consumption, their characteristics and parameters of use, the type of energy used for cooking, heating and air conditioning, the sources of electric energy (solar, self-production, national electric network, etc.), the types of elements used for illumination, etc. Notice must be taken of other forms to determine the characteristics of the devices of consumption of users, such as efficiency and age that can be obtained through the use of administrative registers or surveys that record the sale of such devices.

The frequency for undertaking these surveys to consumers is another key element to be able to obtain information on a regular basis, in view of the behavior that this sector presents caused by a strong variation due to prices, technologies and fuel availability. The appearance in the market of new consumption devices creates new habits of consumption that should also be taken into consideration.

Finally, these surveys must be representative not only at the national level, but also in urban and rural areas with the intention of preparing an appropriate analysis of the data.

Surveys that are typical for the energy sector

Energy surveys, both the very general as well as those that are limited to a certain number of sectors and subsectors, provide information associated to different fuels and with energy matters that are not to be found in other sources. Particularly, surveys are better than the analysis of supply of fuels of the registers of companies, to show the structure and final purpose of fuel consumption by sector and subsector of specific types of fuels. In addition, this permit to undertake an analysis of consumption, and surveys can also clarify information on energy consuming equipment, that is to say, that they can provide information on the number of vehicles, artifacts for the home, ovens, etc.

The following are the typical objectives to carry out surveys in the energy sector:

- √ Determine the quantity and type of electric equipment used in the residential, industrial, commercial and services sectors, in urban and rural sites.
- √ Determine the average consumption of electricity and habits of use of existing electric equipment used in residential, industrial, commercial and services sectors.
- √ Determine the electrical devices that have a greater or lesser presence in homes and companies of the industrial, commercial and services sectors, at the national level.
- √ Determine the average consumption of fuels (gas, gasoline, etc.).
- √ In general, determine all the types of energy consumed, equipment used, frequency of use, load characteristics, etc.

These objectives may lead to deal with surveys under other classifications, in accordance with the consumption and use of energy.

The procedures studied in the preceding sections are intended to design and prepare energy surveys in all energy sub-sectors. However in the case of biomass, which is special due to its peculiar characteristics, this will be studied in the following sub-section. The description in the Biomass sector mentions the general aspects of surveys of energy use and consumption that may be extrapolated to other subsectors, as well as the particular aspects of the Biomass sector and which are specific for that sector.

Surveys on the frequency of use and consumption for the Biomass subsector

a) *Frequency of use*

The information necessary for surveys regarding the consumption of firewood and other fuels of biomass is divided into two principal categories. The first refers to the information of the frequency of habitual use, that is a measurement of the number of inhabitants in whose homes firewood is consumed to cook, and how many have access to other types of fuels, as well as how many have the need of heating their environments (during the entire year or during certain seasons). This data must be analyzed by rural and urban zones and by homes of different sizes, (OECD, IEA, EUROSTAT. 2007).

The gathering of this information through surveys requires a proper preparation of the questionnaires and must be based on correctly designed samples. The sampling technique to be used will depend on the population or populations where samples are to be taken; if the survey must cover all homes or only rural ones, if all rural zones will be represented or if some will be excluded for economic or other types of reasons. It is probable that these problems will appear in some measure, in all surveys carried out in a country.

It has been proven that there is great importance in trying to include populations that live in more distant rural zones, where there is a concentration of an important proportion of biomass, and which are generally omitted in national studies related to other areas. Where it is not practical to include in the sample all population subgroups that would be desirable to take into account, it may be convenient to carry out estimates with respect to these. These estimates may be based either on the results of surveys, in other groups with similar geographic social and economic characteristics, or in realistic hypothesis relative to the modalities of energy consumption, (it may be assumed that all of the homes in a forest zone use firewood for cooking, and perhaps they may need heating at least during one quarter of the year).

In general, the information derived from such surveys to determine habitual use is based on “yes” or “no” answers to question such as: “Do you use firewood for cooking? In an affirmative case, “is this the only fuel that you use for that purpose, the principal one, or only occasionally?” Such questions are easy to make and easy to answer. Although these surveys, as any other, are also subject to sampling errors, these will not be affected by systematic errors due to misunderstandings or calculation errors on the part of those interviewed or the interviewers, (Flores. W.2009).

Surveys on the frequency of use are relatively inexpensive. Questions can be added to a general questionnaire of home surveys. The ensuing analysis will probably be quite similar to those undertaken in other types of surveys, and do not require a very intensive training.

b) *Consumption*

This type of survey is designed to measure the quantities consumed of firewood and other traditional and commercial fuels. The sample unit may be the home and perhaps other types of sites of small-scale rural industries that will probably be under the limit established for other sampling surveys. The data that is obtained with this type of survey refers to the weights (or volumes) of different fuels consumed for different purposes. If there is a seasonal cycle in the use of fuels, it will be necessary to carry out interviews throughout the year so that the sample represents all seasons. It is necessary to analyze the results according to the size of home to be able to obtain information on per capita consumption.

Consumption surveys require an evaluation or physical measurement of the fuels really consumed, which often results in differences derived from the measurement of the existences taken at two or more different moments. After taking into consideration these differences, and considering new acquisitions, these will be comparable to consumption. The operation implies a procedure of costly and complicated interviews. The time that it takes to obtain data from each person interviewed and the specialize techniques applied during interviews, in practice prevent that the gathering of data can be simultaneously made with those of the data of a survey of homes already in execution. It is necessary to carefully train interviewers in the techniques used to measure the different fuels, something that is especially difficult if firewood is comprised by varying types of materials such as branches, tree trunks, plant stalks, palm tree branches and other vegetation products, that cannot be easily weighed and which are probably measured in handfuls, loads carried on the head or back or in a car.

It is practically impossible to avoid systematic errors in consumption surveys, when the wood is drier when consumed it therefore has less weight and a different content of energy that when it was originally weighed.

It is necessary to design procedures for analysis to be able to demonstrate the aggregate consumption in homes in common energy units. This requires the conversion of the data obtained for different fuels by means of adequate conversion factors.

Although there may be proper reasons that justify that a country carries out a special survey to gather data, note must be taken that before launching this type of survey, the material that probably will be more useful for the planners of the energy sector is that which is relative to the changes in consumption habits, that can only be measured through periodically repeated surveys. In view of their high financial cost and in other resources, it is necessary to project a sufficiently good design to be able to repeat it several times in the future, maintaining its compatibility with the techniques for measurement, the design of the sample and the techniques for analysis.

c) *Integrated Surveys of consumption and frequency of use*

Information obtained from consumption surveys that are periodically repeated, among other things, will help to show the consumption of firewood, coal made from wood and other biomass fuels on the part of users, for each type of fuel (expressed per inhabitant for the different sizes of homes).

Frequency of use surveys will show more exact information than consumption surveys, of how many homes correspond to each category of user. It is probable that frequency of habitual use surveys, due to their relative simplicity and low cost, can be repeated. Such repetition will show the changes in quantities of users by defined categories.

In a majority of countries, modifications in the consumption of firewood and biomass fuels, in general occur due to changes in consumption by user. For this reason it is very important to control the changes by means of frequent surveys of habitual use, although the possibility of obtaining informative material by means of surveys of consumption repeated once in a while, should not be discarded. Another great attraction of this method is that it obtains data on habitual use is that it requires less time and therefore does not need the same level of advanced planning as in the case of consumption surveys.

c) Missing Information

In those cases in which there is missing information, it is possible to obtain a part of that information by undertaking surveys; however, it is possible that part of the missing information cannot be completely obtained. It is possible that certain relevant data do not exist, some can be difficult to find and others may be dispersed in different government institutions and departments. There may be duplication in the gathering of data, or some of the information may be collected in different units of measure and under different assumptions.

Sometimes, it is very difficult to fill in the missing information by carrying out a new effort for the gathering of all of future information required. Some part of the missing information could be estimated by means of known techniques for the interpolation of known data. In other cases, such missing information may be obtained by using certain approximations in a deductive manner. If for example, there is no information relative to the level of deforestation resulting from the use of energy, this information could be determined from the quantity of non-commercial fuel used and the total deforestation resulting from all of these causes. As an alternative, it is possible to use data from other countries that can be adapted or scaled to cover the lack of local information. Of course to be able to cope with the above, it naturally requires a certain degree of creativity coupled with statistical experience and a correct implicit understanding of the problem.

Notwithstanding these problems, there are statistical methods and procedures to overcome this lack of information and/or non-congruent information, principally directed to the undertaking of surveys, although in certain cases these are applicable to other cases of missing information; these methods are next described.

The compilation of data refers to statistical operations and procedures that must be performed on the set of data collected, with the purpose of generating new statistical information (United Nations, Statistics Division. 2011). In particular, these methods of compilation include the following operations:

a) Validation and edition of data,

b) Imputation of data, and

c) Estimation of the characteristics of the population.

These methods are used to face diverse problems related to the collection of data such as: incomplete coverage, lack of answers, answers that are out of reach, multiple answers, inconsistencies, contradictions and invalid answers to the questions formulated. In general, these problems are related to deficiencies in the design of surveys, with the lack of proper training of interviewers, with errors on the part of those interviewed and with errors related to the processing of the data. Therefore it is recommendable to periodically generate reports that specify the frequency of the occurrence of each one of the problems that appear, and thus be able to make possible the detection of the principal sources of error and to be able to carry out the necessary adjustments in the succeeding processes for data collection.

The following is a brief description of the most recommended methods for the compilation of data.

a) *Validation and edition of data*

In any survey, the person surveyed has a tendency to commit errors when completing the questionnaire. This affects the data due to wrong answers provided and by questions that were not answered. To solve these problems relative to the lack of answers, invalid or inconsistent answers, there are two operations that are an integral part of the processing of data provided from surveys, these are: validation and edition, and imputation.

Validation and edition, also known as the analysis of consistency, refers to the systematic study of data obtained from those surveyed, with the purpose of identifying and eventually, modifying values that are inadmissible, incompatible, highly questionable or are improbable answers, in accordance with pre-established norms; and it is an essential process to guarantee the quality of the data collected. There is an initial edition, entered upon the control of individual questionnaires, and the macro-edition, where controls are performed on the total of aggregate data.

Additionally, it is important to define the criteria for validation in a clear and systematic manner to confirm that the data is satisfactory, or not, that the requirements of integrity and congruency are correct, guaranteeing the general quality of such data. The criteria for validation are established by the statistical authority in accordance with the nature of the data and the analysis of the variables of interest, taking into account the magnitude, structure, trends, relations, causalities, interdependences and possible ranges of answer.

Validation and edition may be a costly component in the process of the acquisition of information produced from surveys. Therefore, attention must focus on important areas and issues, since many of the responses to a survey may have a minimum impact on the final result, and the effort necessary for the correction of errors in such answers may be inefficient and even unnecessary. Therefore, to maximize the efficacy of the process of validation and edition of answers, it is first necessary to identify those that will have a greater impact on final results, to then proceed with their edition and validation; this way, there will be a correct assignment of the resources dedicated to this purpose.

Likewise, questions that have been badly formulated in a questionnaire are one of the principal sources of errors in a survey. Therefore, it is better to direct efforts towards the elimination of such questions, than to try to correct them through the edition of incorrect answers generated by these sources of error. It is also very useful to prepare questionnaires that are tested before they are used in surveys for the collection of energy data and to go through a previous process to verify the quality of the form of the survey and to validate it through a pilot survey.

As has been mentioned, the edition of data can take place at the time of entry of such data (incoming edition) and/or at the end (outgoing edition). The following test of edition may be useful in the detection of errors in the data:

(*i*) *routine controls:* are used to verify if all the questions that should have been answered have been effectively answered. If a lack of answers is detected for certain parts of the survey, a possible solution could be to provide more time to the party surveyed; and when this is not possible, the value may be arithmetically estimated or by means of the use of statistical methods, on the basis that some of the answers can be adequately related, and even inferred by making use of the data compiled from other sources. Mention must be made that this latter process is known as imputation and it will be described in greater detail in the following section.

(*ii*) *testing the range of validity:* this is used to test if the answers are admissible or compatible. The answer to a section of the questionnaire is verified against an interval of values valid for the purpose specified. Any answer (data) that falls outside of the valid values may be considered as “atypical” This type of control may be performed at sight, or by determining thresholds of the data in a calculation sheet.

(*iii*) *rational controls:* this is a set of controls based on a statistical analysis of the data compiled. Many controls are based on well-known relations between two or more variables, and which should be within the limits specified. One type of a rational control is the arithmetic test, verifying that the summation of inputs is equal to that of consumption. Other errors committed by those surveyed, can generally be identified through the controls of credibility in the data, by means of a comparison of the data presented with preceding values. On a different basis than the previous controls, when using this type of control to discover inconsistencies, the planner needs to perform an arithmetic test as those performed on energy balances.

In recognition of the importance of the validation and edition of data, it is necessary to emphasize that no arbitrary alteration of data should be permitted and any change in data gathered must be based on well-known relations between the variables and the values of the answers. Additionally, in order to avoid out-of-range answers and inconsistencies, such ranges must be appropriately pre-defined for each question, it is also necessary to establish the congruence that must exist between questions and answers. Finally, it must be observed that not all of the mistakes committed by the persons interviewed can be identified by the statistical entity, since not even the most exhaustive process of edition of data will provide a database that is completely free of errors.

b) *Imputation of data*

In statistics, imputation refers to the substitution of one or more erroneous answers or unanswered questions with plausible and consistent values with the purpose of producing a complete set of data. This is used for the estimation of missing data, the person surveyed has not answered all pertinent questions, but only a part of them, or when the answers are not logical.

The lack of answers or the presence of answers that are not valid in the data will affect the quality of the results of the survey. Many of these problems can be eliminated when the corresponding rules of edition are followed. However, the detection of errors in answers during the process of edition may imply the suppression of one or more elements, producing as a result the case of "lost values".

To reduce the effects of the lack of answers upon estimates, there are two general strategies:

(*i*) all questionnaires with lost values are ignored and the analysis is limited to the forms that have been fully completed; and

(*ii*) missing data are estimated so that the Data Matrix is complete, which is precisely known as imputation.

The adoption of the first strategy involves discarding valid data contained in partially completed forms. Therefore, it is convenient to adopt the second strategy. There are a variety of methods of imputation that vary from the simple and intuitive up to complex statistical methods. Some of the methods more frequently used are:

(*i*) *subjective treatment:* imputation on the basis of values that are reasonable. The make a deduction of the consumption of fuels if the size of the vehicle park is known, specific consumptions and the km/year travelled;

(*ii*) *method of the modal value (media):* imputation of the missing data with the mean value of the variable. An alternative can be the imputation with the median with the purpose of eliminating the effect of atypical values;

(*iii*) *method of substitution:* this is based on the availability of comparable data. Data imputed can be represented by the values of the previous year`s survey, adequately adjusted to reflect its average increase (or its decrease);

(*iv*) *method of the cold deck* [23]: with this method, imputation is performed through a fixed set of values that cover all of the elements of the data. Such values are inferred by means of historical data, and of experience on the issue, etc. With these elements it is possible to generate a "perfect or donating" questionnaire, the objective of which is to fully or partially impute the missing data;

(*v*) *method of the hot deck*: in this method, as in the "cold deck", the missing value is replaced by the value that is extracted from the donating questionnaire, however in this case, the donating form is a similar participant obtained from the same survey (note that in the method of the cold deck the donating questionnaire is generated on the basis of the rest of questionnaires). The donor can be randomly selected from a list of possible donors with predetermined characteristics. Once selected, the missing answer is substituted by the donating answer (for example, electric energy consumed on a monthly basis in houses of similar characteristics).

(*vi*) *method of the close neighbor*: this is another method through which an attempt is made to find a donor. The difference from the previous method lies in that the selection of the donor is not made on a random basis, but rather is defined in a function to measure the distance in terms of other known variables. The questionnaire with the closest value to that of the missing answer is used as the donor;

There are other more advances techniques for imputation such as those based on a combined imputation, in multiple imputations, in systems of experts and in neuronal networks (*United Nations Statistical Commission and Economic Commission for Europe, 2000*). The election of the method of imputation will depend on the objective of the analysis and the type of missing data. It must be stated that no method is superior to the rest, and in fact, depending on the circumstances, it is often the case that a combination of methods is used (combined imputation). The following are some of the desirable properties in a process of imputation:

- √ The imputed register must be very similar to the register of the missing data, that is, it must contain, as far as possible, the greatest quantity of data that was answered. In other words, a minimum number of data must be imputed,
- √ The imputed register must satisfy all of the verifications of edition;

23 The methods of imputation of the "Deck" type are based on the generation of a donating questionnaire from which are extracted the missing data of the questionnaires obtained in the survey.

√ The values imputed must be marked both in the original values as well as the methods used for their imputation must be described through meta-data[24].

It is recommended that the compilers of energy statistics use imputation only when necessary, observing always the most adequate methods and applying them consistently. The latter is important since the degree of distortion in the information generated on the basis of the data varies considerably, depending on the quantity of imputations and of the methods used.

In this sense, it is important to observe that the number of imputations will be lesser in the measure that the number of missing data is also lesser. This number can be minimized by promoting an awareness regarding the importance of the data that must be gathered, providing incentives and preparing surveyors to fully cooperate with statistical authorities, through publicity, the emission of communiqués to those surveyors that have not responded and even having access to the application of the regulatory measures established in the national legislation. As a matter of fact, in certain countries, the units selected for surveys are under the legal obligation of providing answers to the national statistics office, otherwise they may be subject to penalties.

c) *Procedures for estimation*

After the data has been validated, edited and imputed, it is necessary to apply special statistical procedures to the values of the sample to obtain the characteristics required by the population. Data provided by surveys refers only to the units in a sample. Therefore, the estimates of the sample must be extended or extrapolated to be able to represent the entire population of interest. Estimation is the means by which this extension or extrapolation is produced[25] (Yadolah D. 2006).

In general, the procedure consists in extrapolating the value of the sample, through a factor obtained from it, with the purpose of obtaining the levels of data for the total of the population to which the sample belongs. In certain cases, it is possible to use more sophisticated statistical techniques for that purpose. To be able to properly apply techniques of estimation, implies the need of having an advanced knowledge of statistics, for which reason it is advisable to delegate this task to specialists.

The treatment of atypical values is an important part of the estimation, especially in energy statistics. Atypical values are data that are correct but with unusual values in the sense that these do not represent the population of the sample and can therefore distort estimations; later, if the atypical value is important and is included in the sample, then the final estimation will be excessively distorted and will not be representative. The simplest manner of facing such atypical value is to reduce its weight within the sample so that it only represents itself. Alternatively, some statistical techniques may be applied to calculate the most appropriate weight for an atypical value. Details relative to the treatment of atypical values must be provided through metadata. On the other hand, the existence of atypical values may be due to situations that are also atypical, such as hurricanes, earthquakes, etc., but at the time of evaluating these values, it will be necessary to verify the existence of said uncommon situations.

III.5. Information Quality Criteria

So that the information is efficient, it must meet a series of requirements, so that the usefulness it provides justifies the use of the resources that have been applied to obtain it. This list of requirements that are next presented, at the same time constitutes a list of general criteria to guide the design of information systems to evaluate their functioning.

a) Economy: The cost of producing information should not be excessive in relation to the benefit expected from its use.

b) Opportunity: Information must be available at the moment in which it is required. This requirement makes reference to the moment and frequency with which information must be provided.

c) Usefulness: All data that exist in an information system must satisfy a need. This means that the information must be considered unnecessary while its usefulness has not been proven. Every manager or systems analyst will maintain an adverse attitude to the creation of new computerized pathways (as lists or screens), or of new form for manual integration and processing. Except in the cases that this creation is due to a fusion, replacement or bringing up-to-date pre-existing exits, something that we can be absolutely certain of is that new exits will generate increases in costs (direct cost for the design of originals, printing, binding, transcription, files, transfer, processing, analysis, programing, operation of machinery, etc., (plus all of the indirect costs associated).

24 Meta-data are data regarding data. In the case of imputed data, its meta-data contain information regarding the original data and of the method under which it was treated.

25 The process of estimation is also known in English as “grossing-up”.

d) Comparability. Information must be comparable in space, in time and in scope. Comparability in space implies that the information of a country or region must be comparable with that of another; there is no comparability, in the case that the production of petroleum of one country is expressed in physical units and the other in monetary units.

   Comparability in scope refers to the case when information that is compared corresponds to similar entities. In this aspect, errors frequently originate in an inappropriate identification of the concept being conveyed. Information is provided from different sources under the heading "hydrocarbons production", which in certain cases includes or excludes natural gas liquids.

e) Flexibility: Every information system must be adaptable to changes in the system-object.

   This is linked to the satisfaction of the changing needs of information for executives and all the organization; that to a high degree depend on the methodology and the tools used for its design and maintenance. The techniques applied for the construction of database systems also acquire a singular importance, so that these databases are easier to organize, without falling into upheavals or the need for changes in computer programs or in the operations performed by users.

f) Clarity: Information should address the intellectual and technical level of users. The language and preferences for the persons it is intended for must also be taken into consideration.

   The requirement of clarity is expressed as the need that the information system should enjoy the greatest ease of understanding, learning, use and operation for its users. It is almost an axiom that an information system that is not understood nor answers the needs expressed by its users, will force these people to abandon it or even to "sabotage it", dedicating themselves to disseminating its faults or limitations.

g) Reliability: Information must be sufficiently reliable on which to take decisions. The quality of an information system is largely determined by the quality of its primary data. Reliability implies that for making decisions, information must be correct, but not necessarily exact. In this respect, it is necessary to keep in mind that while information tends to be exact through an arithmetic progression, the cost of achieving that exactness tends to increase in a geometric progression.

III.6. Types of Energy Information

III.6.1. Statistical Information

This section deals with the definitions and characterization of statistical energy information. From the point of view of energy information, the energy balance compiles the greatest amount of data of primordial use to be able to carry out energy planning. The basic concepts are established as well as a generic structure of an energy balance; and an effort is made to provide the planner with a series of advice to be able to work with the information contained in the balance. In addition, different subsections provide details of the content of the information contained in a general energy balance.

This section will not attempt to provide a detail of the methodology for preparing an energy balance, however, it presents up-to-date references that will permit an investigation relative to the methodology to be followed to prepare aggregate and detailed energy balances.

Energy Balances

The energy balance is an accounting structure that shows the set of relations of equilibrium that keeps account of the physical flows by means of which energy is produced, is exchanged with the exterior, is transformed, consumed, etc.; everything is calculate in a common unit, within a given country and for a determined period of time (generally for one year). The energy balance must express and contain all of the sources of energy within a common accounting framework and show the relation between entries and exists of energy beginning with the process of transformation. This balance must be based on the first law of thermodynamics that states that the quantity of energy within a closed system is fixed and cannot be increased or decreased, unless a certain quantity of energy is introduced into the system or sent outside of it.

Energy balances can also be prepared for any energy product in particular, following the same structure of the global energy balance.

Energy balance is a tool that facilitates the global planning of energy that must always be considered together with economic, environmental and social variables. In other words, considered on an isolated basis, the balance only provides an image of the physical relations of the energy system within a determined period of history.

Regarding bibliographic references on energy balances, it is recommended that the reader examine the following priorities: a. Methodology of energy balances of its own country (UNAM, 2012); b. Energy balances according to the methodology of OLADE (SIEN, OLADE, European Commission, 2012); c. Methodologies for extra-regional balances (IEA, 2013).

For more detailed information please refer to Annex I-A

Basic information to be considered when pursuing energy planning

In order to pursue energy planning, energy systems data and socio-economic information must be at least included. This information must include global, international, regional, and national data, specifically environmental and energy information linked to the whole energy system and to the subsystems conformed by the different energy supply chains. In what follows, we recommend a basic structure.

Supply´s Scope. For every supply chain, the required information refers to:

√ Physical aspects

- Reserves and potentials
- Flow systems (balances)
- Principal Impacts on the environment (global and local) in each one of the links of productive chains

√ Productive structure of the different links

- Technologies for production
- Losses
- Costs
- Degree of productive efficiency (indicators)
- Scheme for the financing of investments
- Levels of concentration (economic concentration, business links)

√ Institutional and functional organization

- Legal-institutional nature of companies
- Rationality highlights of stakeholders
- Organization of intermediate markets
- Organisms for operative coordination
- Audit and control entities (characteristics and functions)
- Principal characteristics of regulatory norms
- Organisms of sectorial policy

√ Structure of offer prices (prices to the producer)

- Mechanisms for the establishment of prices of supply (Modalities for the regulation of such prices)
- Relations between prices and costs (or gross margins between successive prices)
- Royalties (percentages over prices of offer)
- Principal characteristics of the norms for the regulation of wholesale markets

At the level of the supply-consumption interphase (scope of final markets) information required refers to:

√ Absolute and relative levels of final prices
√ Taxes and subsidies
√ Principal characteristics of the regulation of final markets

In the scope of the consumption subsystem, information should refer to:

√ Consumption structure by sectors (residential, mining, rural productive, industry, transport, commerce and services) and by sources.

- √ Matrixes of sources and uses in each sector (or at least the structure by sources).
- √ Degree of coverage of basic requirements of energy for the residential sector (levels and quality).
- √ Potential energy savings in the different consumption sectors.
- √ Environmental impacts of energy consumption (by sectors of consumption)

Information relative to the most important structural changes deals with:

- √ Structure of reserves and potentials
- √ Structure of production of primary and secondary sources
- √ Productive organization
- √ Institutional organization
- √ Modalities for coordination
- √ Fundamental regulatory principles
- √ Structure of relative prices
- √ Modalities for the financing of investments
- √ Structure of consumption by sectors and sources
- √ Principal processes for substitution between sources
- √ Structure of foreign trade in energy
- √ Modalities of energy integration

Among the relations between social economic and energy variables, the information system should provide the elements for calculation of the following:

- Ø Relations between energy consumptions of productive sectors with economic variables linked to each sector:
  - √ Relations between total energy consumption and the levels of sectorial activity.
  - √ Relations between sectorial consumption levels by sources, the corresponding prices and the level of sectorial activity (application of econometric models for the estimate of elasticity).
- Ø Relations between energy consumption in the residential sector and indicators of income, distribution of income and demographic variables (use of econometric models for the estimate of income elasticity).

III.6.2. Prospective Information

In order to achieve an adequate representation of future energy scenarios, within prospective information it is necessary to take into account the changes in the composition of the Energy Matrix of countries, which have originated in function of the long-term objectives and policies of the State. Such objectives include:

- √ Assure a reliable and ample provision of all forms of energy.
- √ Promote sustainable energy policies that stimulate economic growth, social equity, protection of the environment, especially in terms of the reduction of greenhouse effect emissions.
- √ Adopt new energy technologies to guarantee the future supply of energy and to mitigate its environmental impact, particularly by means of a greater Energy Efficiency and the development and deployment of low carbon technologies.
- √ Find solutions to the challenges presented by the increase in the demand for energy, through the participation of and establish a dialogue with industry, national and international organizations, etc.

The abovementioned objectives vary in a larger or lesser measure from country to country, in function of the availability of its energy resources and needs. However, a common denominator in the energy sector of almost every country is the need to guarantee the provision of energy and this implies achieving the lowest environmental impacts at reasonable costs.

In this sense, several countries have placed their expectations on new sources of energy, which in general are based on renewable resources, which can be practically considered as inexhaustible (although limited in power), either due to the immense quantity of energy that they contain, or because they are capable of natural regeneration. Among the energies obtained on the basis of renewable resources are: wind, geothermal, hydroelectric, tidal, solar, biomass and bio-fuels (also, with the exception of hydroelectric energy, these are referred to as alternative energies, since they differ from the conventional way of obtaining energy).

In a large measure, the final use of renewable energy resources are destined for the generation of electric energy, in lesser proportion to the production of bio-fuels for the industrial and transport industries and to a lesser extent, to the heating of water, water pumping and the cooking of food. In this context, the renewable resources subsector is in a close relation with the electricity subsector.

With the intention of achieving a greater participation in these primary resources within the energy demand matrix, it is necessary to undertake activities related to the design of policies of incentives to increase the penetration of the generation of electricity on the basis of renewable resources; the identification of energy potentials in the different countries to promote the development of new technologies that permit an improvement in the efficiency of processes of transformation of primary resources into electricity; planning of new transformation centers and their link to interconnected systems, among others.

In several countries of Latin America and the Caribbean, important industrial parks for the generation of electricity have begun to be installed on the basis of wind generators, photovoltaic panels and geothermal plants. These are very attractive alternatives, especially in the cases where the availability of hydrocarbons is limited or nil, especially in the present scenario in which the international prices of oil are increasing and this trend is expected to be sustained for the future (in Central America there is a strong energy dependence on oil and with the exception of Guatemala and Belize, that are non-producing countries). Additionally, alternative technologies represent a sustainable environmental option, since these indirectly contribute to the reduction of the emissions of greenhouse effect gasses, by displacing the traditional forms of generation of electricity based on coal or fuels derived from petroleum.

In addition, throughout the entire world, these technologies have received important financial support for their development. As a matter of fact, the cost of these technologies is progressively being reduced, and they are able to economically compete with traditional technologies.

An important matter that should be taken into consideration refers to the information related to the potential of renewable energy to be exploited in each country, such as maps of solar radiation, studies of wind potential, studies of geothermal potential, etc. and to analyze the possibility that these capacities could be truly exploited in accordance with the realities and needs of each country.

The penetration of renewable energies faces multiple opportunities and challenges, particularly related to the effective financing of energy projects. In general, the variables that may play in favor of the penetration of these forms of generation are the following:

- √ A decrease in the availability and a greater cost of financing of traditional sources.
- √ Stricter environmental legislation relative to emissions levels of greenhouse effect gasses.
- √ An increase in the international prices of petroleum.
- √ A reduction of costs and an increase in the efficiency of wind generators and photovoltaic panels, etc.

On the other hand there are aspects and variables that may run against and that should be considered, such as:

- √ A greater growth in demand with respect to the firm capacity of generation that may be offered by renewable energies.
- √ The availability of transport infrastructure (high tension electric lines) to take the resource from where it is generated up to the points of consumption (in general, in this aspect thermo-electric power stations are much more flexible).
- √ Lack of State policies and medium-term incentives with respect to renewable energies.
- √ Scarce financing for long-term projects.
- √ Technologies such as tidal energy, with a history of limited implementation and great needs of financing, face greater obstacles for development in the short-term basis, in spite of its enormous potential.
- √ In the case of geothermal energy, abundant in several countries of Latin America, the principal factor that plays against it is uncertainty during the exploratory stage, as well as the great initial investments required at that stage. But once that the risk of initial investment is covered, it turns out that when using this basic energy in the dispatch, costs are reduced in a general manner, displacing resources based on fossil fuels.

Possibility of hardening/weakening of environmental legislation

As previously mentioned, environmental legislation has an important role at the time of defining future energy scenarios. Evidently, stricter environmental laws may send signals to strengthen policies leading to a more rational and efficient use of energy, the purpose of which is to decelerate the consumption of contaminating energy products (coal, hydrocarbons, nuclear fuels), on the one hand, and on the other to provide incentives and accelerate the penetration of sources of energy based on renewable resources.

An example of the generation of future energy scenarios, considering environmental aspects, is found in (IEO, 2011), in which the International Energy Agency (IEA) presents a world energy panorama for the year 2035. This panorama is presented in three different scenarios, as follows:

- √ Scenario of Present Policies,
- √ Scenario of New Policies, and
- √ Scenario 450 (derived from the objective of limiting the concentration of greenhouse effect gasses in the atmosphere at not more than 450 parts per million).

The Scenario of Present Policies (or scenario of reference) shows how the future could be on the basis of the perpetuation, without changes in policies and measures that have been adopted by governments up to 2011.

The Scenario of New Policies incorporates the general commitments of policies and plans that have been announced by all the countries of the world to confront energy insecurity, climate change and local contamination as well as other pressing challenges related to energy, including when the specific measures to put into practice such commitments that still have to go into effect. These commitments include objectives that support renewable energy and Energy Efficiency, and programs relative to the decrease or freezing of the participation of nuclear energy, the promises made by the nations to reduce the emissions of greenhouse effect gasses, which have been officially communicated through the Cancun Agreement, and the initiatives adopted by the G-20 to eliminate inefficient subsidies to fossil fuels that promote excessive consumption.

Finally, Scenario 450 establishes an energy panorama that strives to reach the objective of limiting the increase of average world temperature to two degrees centigrade (2 °C), in comparison with pre-industrial levels. According to climate experts, to be able to reach this objective it is necessary to limit the long-term concentration of greenhouse effect gasses in the atmosphere to around 450 parts per million of carbon dioxide equivalent. To be able to achieve this scenario implies a stricter political action to fully apply the Cancun Agreements.

The Cancun Agreements were established during the United Nations Conference on Climate Change, on December 11, 2010 and constitute the basis for the greatest collective effort by the countries of the world to reduce emission, being mutually accountable to each other, with national plans officially registered at the international level. These agreements include the largest package of assistance ever agreed to between several governments so that the developing nations can face climate change. This package includes financing, technology and support for the development of capacity of those countries with the purpose of covering their urgent needs for adaptation to climate change, and to accelerate their plans for the adoption of sustainable paths leading to economies with low rates of emissions that can also resist the negative impacts of climate change (UNFCCC, 2013).

In spite of these agreements, there exist great difficulties and high costs that do not permit a faithful compliance with the ambitious climate objectives that have been determined, for which reason there is a very high uncertainty relative to climate policy. In spite of the fact that it is probable that several governments will take a firm political action to face a growing energy insecurity, local contamination, climate change and other problems related to energy, the policies that effectively will be put into motion during the coming years, will no doubt be different than the agreements reached in Cancun. On the one hand, some governments may decide to adopt energy measures to put into practice their present commitments that is to say that they can adopt goals that are stricter and harden their environmental legislation. On the other hand, it is also probable that other governments will not be able to put into practice the policies that are necessary to even satisfy their present commitments, that is, they will continue with weak environmental legislation, in an attempt to satisfy as a minimum their demand for energy, independent of the fact that this may be forthcoming from contaminating energy resources.

In this context, energy prospective must take into account the possible paths that each country may take relative to its environmental legislation.

III.6.3. Indicators

Indicators are parameters used for measurement that generally integrate more than one basic variable that characterizes an event, through simple mathematical formulations, expanding the meaning of the variables that comprise it and permitting an easier understanding of the causes, behavior and results of an activity (IAEA 2005).

A large part of energy information especially that relative to certain social and environmental indicators, are very clear measures of progress. If concentrations of environmental contaminants show lower values than those previously measured, this constitutes a clear measure of progress and an indication that very probably the policies and plans implemented in these areas have contributed to that improvement.

However, this is not always the case with economic information. If the intensity of the use of energy in the sector of agriculture increases, this may be due to a high degree of automation or because a structural change in agriculture has taken place, as could be a change from one crop to another that requires more energy for its growth, harvest and processing. In those cases, changes in information must be analyzed within the context of the specific conditions of each country. When information is used in that manner, this shows the effects of political decisions and plans, and this is useful to evaluate such decisions and formulate future policies and plans.

The analysis for the interpretation of this information must be carried out within the context of the priorities of energy and sustainable development of each country. Since the characteristics of each country are unique, the results obtained in one country should not necessarily be taken as a reference for comparison with another country that presents different conditions. For this reason, in general there is no way to establish threshold values or ranges in the values of indicators that are not valid for different countries. A large part of the material presented in this chapter represents a tool that permits a continuous observation of the energy progress of each country and to define strategies that may lead to a sustainable energy future.

Within the activities for the preparation of energy policies and plans there are certain topics that are difficult to quantify or that are of a more qualitative nature, but that must be considered in the process of decision making and in the formulation of energy policies that are transcendental for countries. Many of these non-quantifiable aspects are within the institutional dimension of sustainable development.

In this section, two sets of indicators are set forth, the so-called sustainable development indicators that are categorized in three dimensions of development: social, environmental and of an economic dimension; and complementary indicators that occupy a special section.

Each set of indicators expresses the consequences of the production and use of energy. In a joint manner, these indicators offer a clear panorama of the complete system, including the interaction between the various dimensions of sustainable development, as well as showing the long-term implications of present decisions and behaviors. Changes in time in the value of the indicator show the progress or lack thereof towards the objective of achieving sustainable development. The same value of energy may not mean the same thing for different countries. The meaning will depend on the level of development of each country, the nature of its economy, its geographic conditions, the availability of energy resources, etc. Therefore, it is necessary to proceed with caution when these indicators are used to compare the situation of two or more countries and their energy resources. However, instead of depending on abstract and complicated analysis, planners and decision makers, and persons or organizations that prepare energy policies will have available a simple set of tools to help them to guide their decisions and monitor the results of the policies implemented.

For greater information, in Annex I-B contains a list of Indicators and the procedures for calculation.

III.7. Information Systems

III.7.1. Definition

A system is a set of interrelated elements to produce a result, comprised by the following components: *elements*, *relations* and *objective*.

Elements or parts***:*** These may be human or mechanical, tangible or intangible, static or dynamic.

Relations: These make the entire system a complex matter. The importance of relations, both for the analysis and design of the behavior of the system, is fundamental. This is frequently seen in the scope of organizations. There are companies or organizations that obtain successful results while others failed, in spite of the fact that they used the same persons and have the same resources, because the same elements have been used, assigning them different roles and modifying their interrelations. In the strict sense of the word, the system has been changed.

O**bjective**: Constitutes the reason of being of a system. The objective defines the system; nothing can be done in relation to a system (study it, re-design it, evaluate it, operate it, direct it, etc.) if its objective is not known.

In the specific issue of systems that are specialized in information, these could be defined as a set of human, material, financial, technologic, normative and methodological resources; organized for those who operate and make decisions in an organization, with the information necessary for the development of their activities. This type of system has the following elements, categorized as follows:

- √ **Persons**: This is the most influential component for the success or failure of information systems, it refers to the human resource involved in the life cycle of the system; analysts, developers, experts, final users, technical support.
- √ **Data:** These are quantitative or qualitative facts used to generate useful information. Data are integrated and generate information by means of procedures and tasks defined to produce knowledge, which is what finally permits taking decisions.
- √ **Tasks and procedures**: Are the activities that transform the entry of information into exit of information, and procedures that will determine the policies that govern the functioning of information systems and describe their different processes.
- √ **Resources of hardware and software:** Hardware refers to the machinery, information equipment, entry and exit devices, storage devices and communications devices. Software refers to computer programs, legible instructions provided by the hardware parts of the system to be able to operate in manners in which they produce useful information from data.

III.7.2. Information System Model

An information system carries out four basic activities: entry, storage, processing, and exit of information.

Entry of Information: The Information System takes the data that it requires to process the information. Entries can be manual or automatic. Manual entries are those that are provided in a direct manner by the user, while the automatic entries are data or information that is forthcoming or are taken from other systems or modules.

Storage of information: The information that enters the system as well as the information that is processed is stored for future use, this information is kept in permanent storage devices, usually hard discs or in structure of database or in structured files.

Processing of Information: This is the capacity of the Information System to carry out calculations in accordance with a pre-established sequence of operations. These calculations may be performed with the data recently introduced into the system or with data that are already stored. This characteristic of the systems permits the transformation of a data source into information that can be used to make decisions.

Exit of Information: This is the capacity of the Information System to deliver processed information, by means of the generation of reports and structured files that may be consumed from other informatics tools.

III.7.3. Life Cycle of Information Systems

Growth of the Organization: Analyses and knows all of the systems that form a part of the organization, as well as the future users of the Information System. An analysis is made of the business and the transactional processes to which the Information System will provide support.

Identification of problems and opportunities: The second step is to reveal the situations that the organization faces and that it can derive an advantage from, as well as those unfavorable situations or limitations that must be sorted out or taken into consideration.

Determining needs: This process is also called the definition of requirements. By means of this process it is possible to identify through some method the gathering of information (the one that is best suited for each case) that is relevant for the Information System to be set up.

Diagnosis: In this step a report is prepared that highlights positive and negative aspects of the organization. This report will comprise a part of the Information System, and will also be considered at the moment of designing the system.

Proposal: Once all of the necessary information relative to the organization is available, it is possible to prepare a formal proposal directed to the organization that contains details of: a budget, the cost-benefit relation and the presentation of the project for the development of the Information System.

Design of the system: Once the project has been approved, it is necessary to start with the preparation of the logic design of the Information System; that includes: the design of the flow of information within the system, the processes that will be carried out in the system, the dictionary of data, exit of information reports, etc. In this step it is important to select the platform where the Information

System will be supported and the programing language to be used.

Coding: With the algorithm that has already been designed, it is necessary to proceed to the re-writing of the programing language established in the previous stages that is in codes that the machine will be able to interpret and execute.

Implementation: This step consists of all of the activities required for the installation of information equipment, networks and the installation of the application (program) generated in the Coding stage.

Maintenance: Feed-back process, through which it is possible to request the correction, improvement or adaptation of the Information System that has been created to another work environment or platform. This step includes technical support.

III.8 Energy Information Systems

III.8.1 Definition

Energy Information Systems: Depending on the purpose that the information system has and of the data that it stores from a particular scheme of classification, it is possible to indicate in which specific case of the energy sector there exist energy information systems. As its name specifies, it stores information of the entire energy chain, conceived from the exploration of the resource until it reaches the final consumer. These types of systems can be classified into the following categories (see Figure III.2):

Basic System

This is the minimum system of information necessary to undertake planning and it is based on the following groups of data:

- √ SOCIAL-ECONOMIC: Such as: population, GDP among others
- √ SUPPLY - DEMAND: Final energy balance (FEB) and useful (UEB) by sources and sectors
- √ PRICES: Prices of energy sources
- √ INFRESTRUCTURE: Energy capacities and equipment by sectors

Integrated Unitary System

This is a single global national system that covers the entire energy sector of a country. It normally has 2 components:

- √ Numerical data resulting from the activities of the energy sector, generally on an annual basis (although some may be monthly or even on a daily basis), geo-referenced or not; it may be by areas, sources, activities and attributes.
- √ Information data (alfa-numerical), that comprises a sort of up-to-date energy balance with the most relevant news relative to the state of projects, studies under way, etc.

Vertical Integration System

This is a system of unitary integration + sectorial peripheral sub-systems. The latter cover an ample variety of information instruments and technologies.

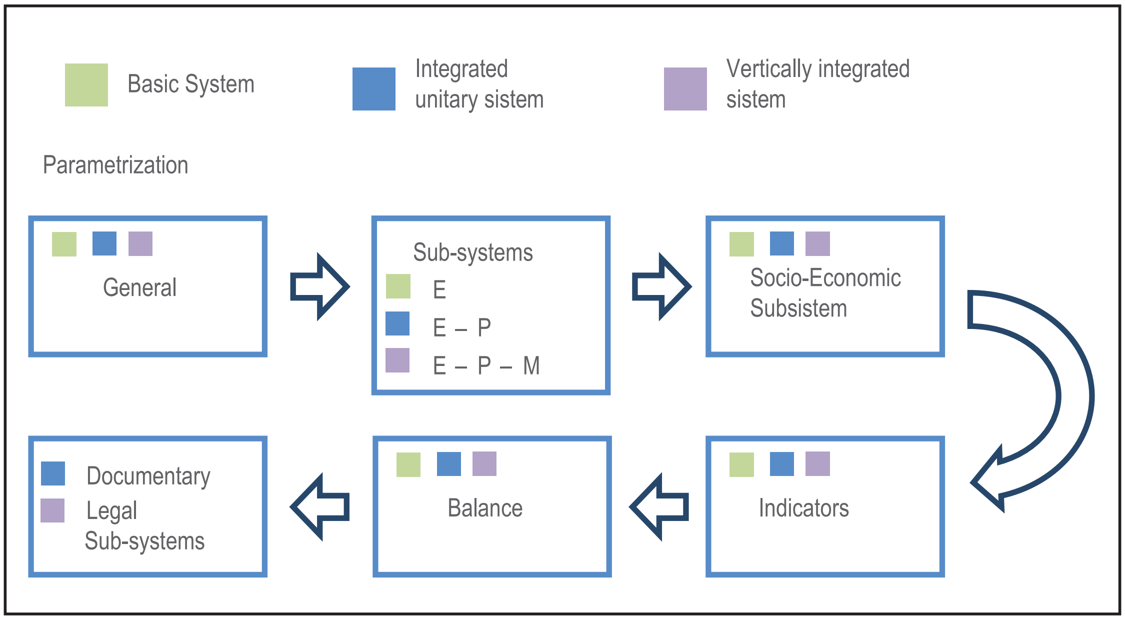
It includes all of numerical and documentary sub-systems:

- √ Statistical
- √ Prospective
- √ Global
- √ Social economic

√ Documentary

√ Legal

Figure III.2: Minimal Content Requirements in Energy Information Systems



Source: Authors.

III.8.2. Energy Information Systems in LAC

With the purpose of knowing the situation of the Member Countries of OLADE[26] regarding the management and administration of information, a survey was carried out. Derived from it, it was possible to obtain answers from 20 countries. Table 1 presents the results obtained.

Table III.1: Management of Energy Information. Situation in Latin America and the Caribbean

	Countries		
	South America	Caribbean	Central America
Data Storage			
Database	AR, BO, CO, PY	JM, DO, TT	HN
Calculation sheets	CL, AR, BO, BR, PY, PE, UY	GY, JM, DO, SR, TT	NI, HN, PA, GT, CR, SV
Physical Files	AR, BO, BR, UY	GY, JM, DO, SR	PA, HN, GT, CR
Other	BO		
Interfaces for entry of Data			
Manual	CL, AR, BO, BR, CO, PY, PE, UY	JM, DO, SR, TT	PA, HN, GT, NI, CR
Transfer from Files	AR, BO, BR, CO, PY, PE	JM, DO	PA, HN, GT, CR, SV

26 http://www.olade.org/es/quienes-somos.

Web Service	CL, AR, BO, BR, CO, PY	JM, TT	CR
Other	BO		
	Countries		
	South America	Caribbean	Central America
Presentation of reports			
Web Page	CL ,AR, BO, BR, CO, PY, PE, UY	DO, TT	PA, GT, ES, CR, HN
Physical Files	BO, PY, PE	JM, DO, SR, TT	PA, NI, HN, GT
Printed	BO, BR, CO, PY, PE	GY, JM, DO	PA, NI, HN, CR
Other	BO, UY	JM	
Platform of the System			
Client – Server	AR, PY	JM	
Web Services	AR, CO, PY	JM, TT	CR
Other	PE	JM	
Type of Database			
MS-Access		TT	
SQL	CO, PY	JM, DO	CR
ORACLE	CO		
Other		JM	
Operative System			
Windows	AR, BO, CO, PY	JM, TT	CR
Mac-OS			
Linux	AR, CO		
Other		DO	
Programing language			
.NET	CO		
JAVA	PY		CR
Language Other C	0		
Other	AR		
Communication Means			
VPN	AR, CO		
Internet wide band	AR, BO, CO, PY	DO, TT	CR
Commuted line			
Other			

Source: Authors

On the basis of the results presented in the above Table, it is concluded that the most used method to store energy information in the Region is by spreadsheets; 12 countries also use physical files and 8 countries present storage in databases.

Regarding interfaces, a 90% of the countries have manual type interfaces and a 65% by means of the transfer of files. While a 75% of the countries present their reports by means of Web pages and 65% in physical files and printed materials.

A majority of countries do not have specialized systems for energy information, however, countries that have information systems are in personal computers and only a 25% of the countries use client-server platforms and similar.

On the other hand, an 85% of the countries surveyed have areas dedicated to energy information and statistics.

In summary, office automation tools are mostly used by the Region for the treatment and administration of information. Even when some countries have databases, there are no systems that fully integrate the information from the energy sector. In order to meet this need and make it available to its Member Countries, OLADE has developed computer tools and methodologies for the management of energy statistics, which facilitates and standardizes the consolidated management of energy information, with a database that allows obtaining a dynamic energy matrix at both national and regional levels, to contribute to integration initiatives, energy planning and the promotion of quality and transparency of information.

III.8.3. Latin America and the Caribbean Energy Information System (SIELAC-OLADE)

OLADE, with the aim of promoting among its Member Countries technical cooperation, the exchange and dissemination of scientific and legal information, and the development and diffusion of technologies in energy-related activities, has developed some tools that allow the systematized administration of the most relevant information of the energy sector in Latin America and the Caribbean.

The Latin American and Caribbean Energy Information System SIELAC-OLADE is an energy information platform that allows OLADE to integrate process and disseminate the official statistical, prospective, socioeconomic, legal and documentary information of the energy sector of its 27 Member Countries. It is based on standardized methodologies and concepts that allow the consolidation of information at the national, sub-regional and regional levels. This historical database of more than 40 years facilitates the analysis of energy integration processes, regional and / or sub-regional energy planning, and the evaluation of investment opportunities and the exchange of experiences, generating a regional knowledge management program. It also has a dynamic regional energy matrix, which serves as a basis for regional, sub-regional and national studies, which allows visualizing strategies to ensure sustainability and energy security.

System Benefits:

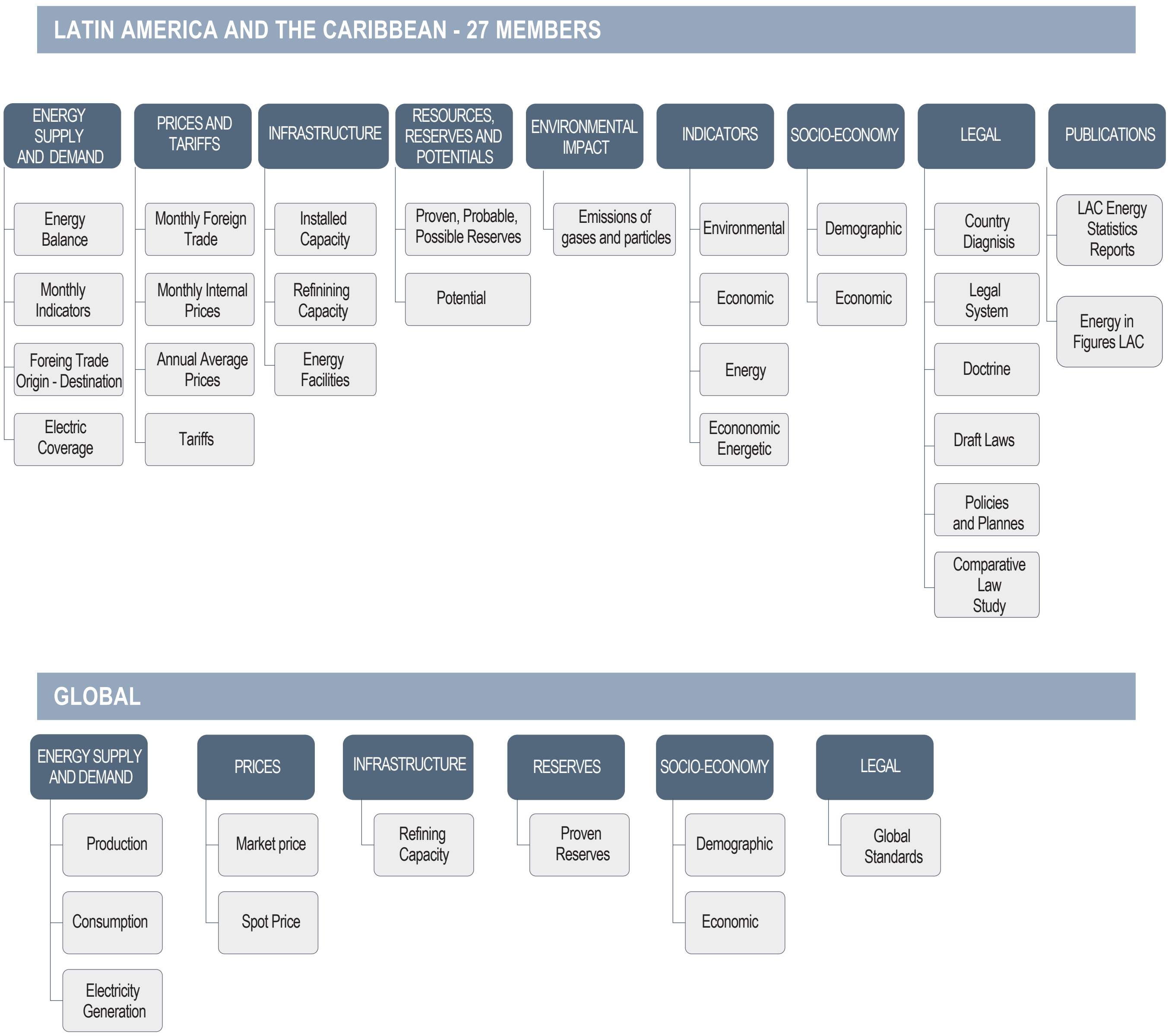
- It integrates the information of the energy chain of Latin America and the Caribbean establishing standardized criteria, guaranteeing the reliability of the results.
- It presents historical series of the most important variables of the energy sector, where trend behaviors can be established to identify the causes of changes in the composition of the energy mix, and the outlook of future behavior of the sector.
- It contains indicators combining economic and energy information reinforcing the analysis of the sector and providing best planning elements.
- Access to the legal information of the countries in the energy area, which is an important input for political, regulatory, economic, social and commercial decision-making, comparative law studies, development of framework laws for the energy sector, good practices and historical review of regulatory frameworks related to the energy sector.

The **SIELAC** is aimed primarily at the energy authorities of OLADE's Member Countries, as well as to specialists from entities related to the sector, universities, consultants and investors and in general to the global energy community that requires integrated, timely and official information on the main characteristics, and issues of the energy sector of Latin America and the Caribbean, under the same computer platform.

Content:

Given the flexibility of the SIELAC-OLADE, it can be configured under the basic system, integrated unit system and as a system of vertical integration.

Table III.2: Schematic of the energy information contained in the SIELAC-OLADE



Source: Author

National Energy Information Systems supported by OLADE

OLADE, together with its Member Countries, works to strengthen the management of energy information and makes available to the countries, the methodologies, training, technical support and specific computer software (SIE_Country). It allows the integration, processing and dissemination of statistical, forecasting, socioeconomic, legal information, supply and demand of services and documentary of the energy sector, based on standardized methodologies and concepts that allow the consolidation of information at the national level.

SIE_Country is a unique energy information system in the Region due to its easy and dynamic configuration, which allows characterizing the energy sector according to the requirements of each country. It has become the “National Energy Information System”, where each country is responsible for the administration and management of their data.

Objective

To strengthen the communication channels of the OLADE's Member Countries through computer tools that help improve the management, storage and processing capacities of the statistical, prospective, legal and documentary information of the country's energy sector, being the country which implements their "**National Energy Information System**".

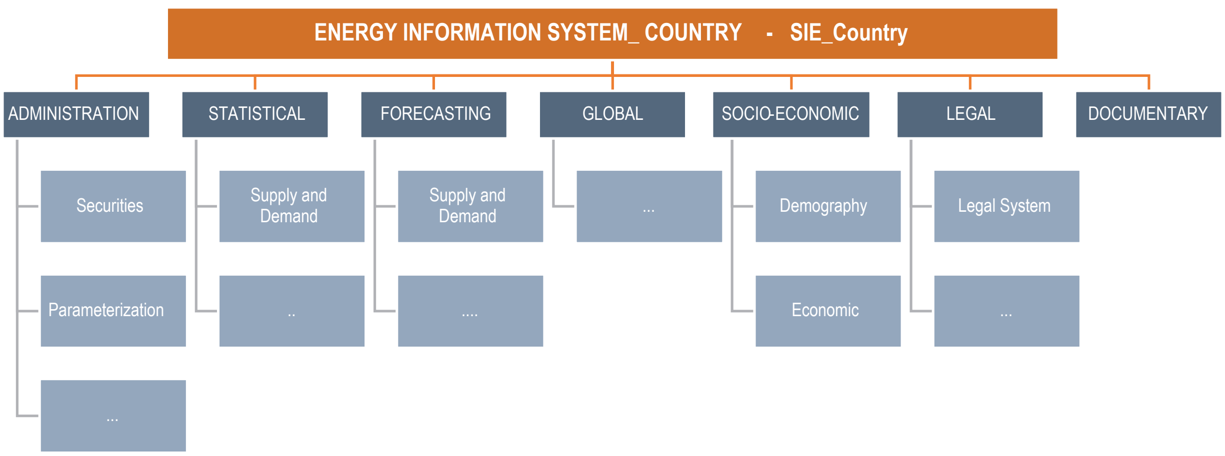
Benefits

Taking into account that the SIE_Country operates under the same computer platform of SIELAC-OLADE, it has the same benefits.

Content

The energy structure is similar to SIELAC, with the difference that the country can enable or disable activities according to the behavior of its energy matrix and its information availability.

Table III.3: Scheme SIE_Countries

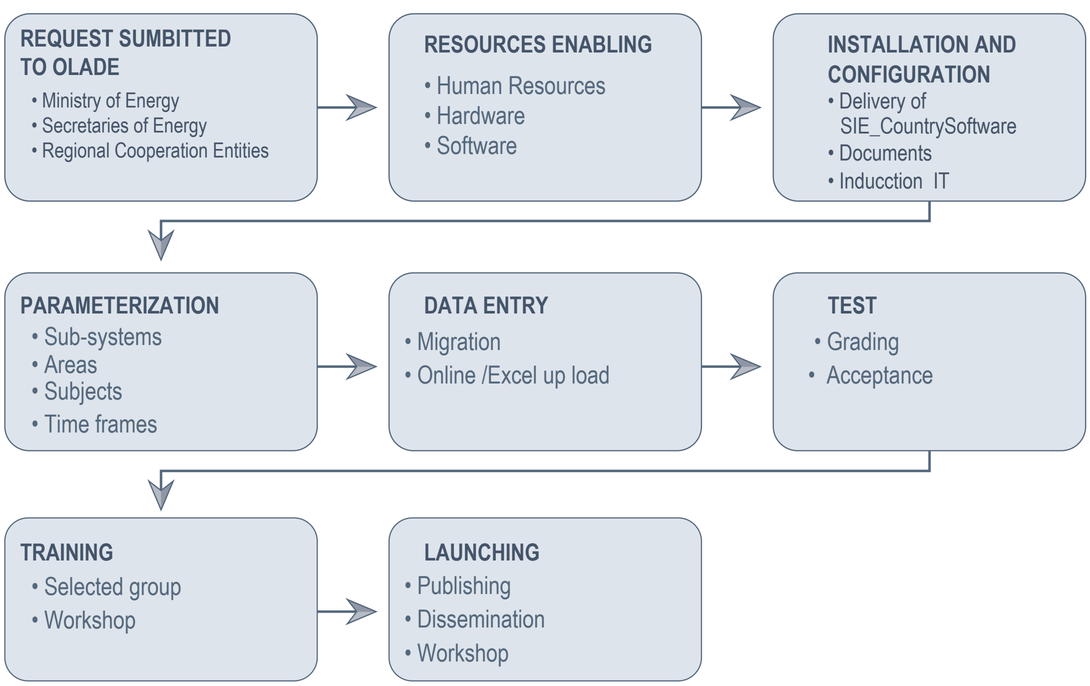


Source: Author

Implementation phases in the Countries

The OLADE's Member Countries that wish to implement the SIE_Country, as their "National Energy Information System" should have as reference the following stages:

Figure III.3: Implementation Stages of SIE_Country



Source: Authors

Human Support: Committee for Energy Information proposed for the SIER-OLADE

As mentioned in the previous paragraph, the human resource is decisive, both for the development as well as the implementation of an information system; depending on the country and its conditions of human resources that may vary according to the objectives and availability. The following is a reference for the offices and institutions in charge of the management and administration of the information regarding the minimum technical team required as well as its specific functions. For purposes of this Manual we will refer to the technical team as the Energy Information Committee, this Figure may be modified.

> The Energy Information Committee is a group of specialists of the energy sector that must have a wide and democratic scope, in which will participate representatives of the principal institutions linked or related to the energy sector, interested in interacting with the Energy Information System, providing and receiving up-to-date information.

a) Structure

The Energy Information Committee will be comprised by three types of members:

Technical Team

Comprised by the administrator of the System, an energy specialist, a legal specialist and a specialist in information sciences. These are officials designated by the Ministry or Secretariat of Energy to coordinate with OLADE or other organisms, the process for the establishment or development of SIER in each country.

Group of Coordinators

This is formed by the specialists of the Ministry or Secretariat of Energy, that belong to technical areas, entrusted with the gathering, processing and/or analysis of statistics, prospective and information on hydrocarbons, electricity, renewable sources, environment, investigation and technogical development, energy projects and installations, energy legislation and the economic aspects of energy.

Group of Advisors

This is formed by specialists that are representatives of public and private institutions, linked or related to the energy sector in their respective entities they are in charge of the gathering, preparation, and supplying analysis of statistics, prospective, technical information on facilities, environmental impact or legislation of the sector.

b) Functions

The members of the Energy Information Committee provide advice to the Administrator of the energy information system relative to the best manner of carrying out the activities proposed by OLADE to establish the characteristics, availability and requirements of information, particularly for each one of the subsectors that they represent and in general for the entire energy sector, facilitating access to information and collaboration with the entities they represent and recommending the best options regarding the operation, functionality, administration and dissemination of the System.

Administrator of the System

Acts as the Technical Secretary of the System and has the following functions:

- √ Coordinate with OLADE and the Energy Information Committee the content, scope and disaggregation of the information administered under the System.
- √ Coordinate the gathering, processing and income of information to the System.
- √ Identify the issues to be considered by the Committee.
- √ Convene and coordinate the meetings of the Committee.
- √ Maintain the System in production, guaranteeing the quality, opportunity and veracity of the information.
- √ Act as liaison between the Energy Information Committee with OLADE.
- √ Inform the rest of the Committee regarding the state and functioning of the System.
- √ Promote the dissemination of the System to the authorities of the energy sector and community.

Energy Specialist

Advice the Information Committee with respect to energy matters registered in the System and in charge of the following activities:

- √ Evaluate the integrity and representative nature of energy information that is contained in the System.
- √ Recommend to the Information Committee any improvements, adjustments, complements or new issues relative to energy that should be incorporated into the System.
- √ Promote the preparation of reports and analysis of the information in the System.

Information Technology Specialist

Provide advice to the Information Committee with respect to information technologies related to the System and also carry out the following activities:

- √ Install and keep up-to-date the action components of the System.
- √ Manage the System as an information tool.
- √ Provide technical information support to the members of the Committee as well as the users of the System.
- √ Maintain a technical information liaison with OLADE.

Legal Specialist

Advice the Information Committee with respect to legal-energy issues registered in the System, and in charge of the following activities:

- √ Evaluate the integrity and representative nature of legal energy information contained in the System.
- √ Coordinate with the legal representatives of the subsectors and energy sectors to gather, order, classify, process and systematize the entire legal order in force in the country in matters related to energy.
- √ Provide support for the improvement of procedures and methodologies for the gathering and processing of national energy standards.
- √ Promote the dissemination and exchange of information and good legislative practices in matters of energy.
- √ Recommend to the Information Committee on adjustments, complements or new legal energy issues that should be incorporated into the System.
- √ Promote the analysis of legal energy information.

Sub sectorial Coordinators

These are responsible for coordinating with the entities of the sector for the supply of information registered in the System, contributing with their experience to the entry, reviews and control of the quality of the data, preparing or participating in the analysis and diagnosis of the area of their specialization and regarding the sector in general. Collaborate with the Administrator of the System in the following activities:

- √ Provide technical support in a pre-determined energy sub-sector.
- √ Facilitate interaction between the Administrators of the System and sub sectorial Advisors.
- √ Maintain the criteria of consistency, veracity and timeliness of the information.
- √ Manage the gathering and bringing up-to-date of all subsector information.
- √ Establish the requirements that the Ministry, Secretariat or Entity has implemented in the System
- √ Define the parameterization (configuration) of the information related to its subsector.

Sub sectorial Advisors

Advise the Administrator of the System regarding the characteristics of information, content, scope and functional specifications of the System, facilitating the provision of information from each of the institutions and providing the use of the System in their entities and institutions and promoting the use of the system in their entities. In charge of the following activities:

- √ Establish an adequate procedure to assure the flow and management of statistics that are required by the System.
- √ Define the configuration of the System in accordance with the structure of the energy sector.
- √ Implement, manage and maintain the System.
- √ Establish access to the System for external users and the public in general.
- √ Advise the Statistics Committee on the definition and implementation of an adequate information structure for that country.
- √ Define the parameterization (configuration) of information related to its subsector.
- √ Facilitate access to information and obtain the collaboration of the entities that represent its members.
- √ Establish the criteria for consistency, veracity and timeliness of the information.
- √ Manage the provision and consolidation of sub-sectorial information.

CHAPTER IV

Scenario Building

KEY WORDS

Energy - planning – prospective – scenarios – Latin America and the Caribbean.

IV.1. Introduction

This chapter deals with scenarios, the concept and background of its development and application. Are pointed out the significant social, economic and environmental variables that comprise them and the relevant hypothesis that define its trajectory, in a Scheme of influence of the "top-down" type with international, regional and national aspects. Relevant variables are linked to different types of scenarios: trends type, of rupture and evolutionary.

A methodology for the construction and evaluation of scenarios is presented, in a sequential process of activities with the use of specific resources and techniques will permit producing an initial selection of not more than 6 to 8 scenarios that are "communicable", and which can be later reduced to 2 or 3. In the formulation of the reduced options, there is an exemplification of the technique for the multi-criteria evaluation of options.

Each scenario derives into emerging applications (forecasts) of the utilization of planning models or instruments that are duly examined in the respective chapters of this Manual. A multiple solution will appear, the results of which will comprise a "space of possible solutions" to be considered.

Finally, examples are offered relative to the use of scenarios in energy planning in LAC countries as well as other cases of interest. Some countries present a single scenario of planning, with alternatives established by means of analysis of sensitivities; almost all include periodic revisions, a fact that confers to such scenarios and planning a dynamic nature to its results.

IV.2. What are "Planning Scenarios?"

The concept of a "scenario" in the field of planning has at least two meanings. It is sometimes used to denominate the "results" of the prospective, other times to describe the "conditions foreseen as possible" for a certain horizon of planning that is the conditions prior to the exercise of the prospective. For purposes of this work the second of these meanings is applied.

We therefore define the scope of the concept of "Planning Scenarios", based on five essential characteristics:

- Planning scenario is the imaginative construction of the relevant structural context that will frame the energy reality under study, within a determined future horizon.
- It is a hypothetical construction, based on the hypothesis of rationally possible structural behaviors, supported by analytically consistent causal relations.
- It is a summarized and simple expression, but of a complex preparation, that reflects the two-fold purpose of becoming an element of understanding and simple use, useful for making decisions in relation to the possible future, and in turn it is also the result of a process of comprehensive analysis that is solid and robust.
- It defines possibilities and not probabilities of occurrence, permitting an analysis of the eventual consequences facing the occurrence of such possibilities.
- It is instrument of the prospective analysis that permits the reduction of uncertainties in the decision making process.

Scenarios Building is equivalent to forecasting the environment and involves acceptance of a future that includes many possible environments.

IV.2.1. Definitions in specialized literature

Scenario~~s~~ Building is equivalent to forecasting the environment and involves the acceptance that the future includes many possible environments. Planning based on trends, projections, extrapolations more or less refined of the present situation, has been largely surpassed.

Today it is admitted knowing certain basic relations of the internal functioning of a process, it is possible to imagine variants of that same process that describe a "possible future by means of an internally coherent description, using parameters or elements both quantitative as well as qualitative, including not only economic data but also technological, political, social and cultural (D. Matos, 2001)[27]".

In other words, we have available elements that make it possible to undertake a rational construction of a set of environments that are intrinsically possible. And it is emphasized that this is a matter of a *rational construction*, and which in the result will *not be the only one*, while we propose to encompass a range of possibilities, and to have ready the tools required to face them.

In the words of **Godet** (2009), "the preparation of scenarios offers many advantages: starting from a specific situation, it permits an awareness of the multiplicity of possible futures and the corresponding relativization of a simple obedience to trends; obligate a consideration of the interdependence of the elements that comprise the studied system; favor the identification of problems, relations or issues that have been ignored or voluntarily discarded since they are controversial".

Strategic planning by scenarios is centered on the future and not on the past, analyses everything that may happen, not what should or what we would like to happen. Attached at the end of this Chapter is a list of fifteen cases of documents on Energy Planning with the use of scenarios that correspond to at least ten countries of Latin America and the Caribbean, as well as several examples from other regions.

A planning scenario is the imaginative construction of a relevant structural context that will provide a frame for the energy reality under study, within a determined future horizon

Referring to the abundant bibliography on the building of planning scenarios, are mentioned those references that are considered as more illustrative.

Pierre Wack, who started with the analysis of scenarios in the strategic planning of Royal Dutch Shell in the 70's, defined scenarios as intrinsically consistent descriptions of possible futures[28].

The reports prepared by Shell state**:** "Scenarios are narrations of possible futures, with the purpose of being able to make better elections at the present"…"A scenario is a story that describes a possible future. It identifies some relevant events, the principal players with their motivations and presents their functional relations. The building and use of scenarios permits an exploration of what the future may be and the probable challenges for the people that will live in it"… The scenarios of Shell ask, "*What would happen if?"* to explore alternative points of view relative to the future and to create plausible stories regarding them. They consider long-term trends of the economy, and the demand and supply of energy, geo-political turns and social changes, as well as factors that motivate such changes. These contribute to building the visions of the future". And "…scenarios are based on intuition, but are prepared as analytical structures. There is no vision of the future under consensus, they are not predictive[29]".

Singularly illustrative is the contribution of Denes Matos[30], who by describing the technique of planning by scenarios states: "What is interesting of this technique is that the objective of a scenario~~,~~ essentially is not the determination of a forecast. Even though of course, the intention of forecasting is not entirely ignored, the objective is not the description of something we are intimately convinced that it will take place. As a matter of fact, a scenario does not even have to be `credible` or `probable` because the constant processes of change exerts a strong influence on that which at a given moment may be considered as credible or probable. The only thing that must be necessarily observed is that it is intrinsically consistent"..."A scenario is not modeled to determine what *will happen*; it is built to describe *what may happen*- beyond that which may be credible or probable to ensue".

A scenario does not even have to be ´credible´ or ´probable´. The only thing that necessarily it must be intrinsically consistent.

27 Taken from Chapter VII, "A strategy by Scenarios" of D. Matos (2001).

28 Harvard Business Review. (Sept-Oct and Nov-Dec 1985).

29 Shell (2008). Energy Scenarios in 2025 and in 2050.

30 Chapter VII. A Strategy for scenarios.

Other references explain in simple terms, that scenarios refer to a “illustrative set of paths” that point out “how the future can be presented” and that “…scenarios are different from forecasts in that they explore a range of possible results when facing uncertainties; while forecasts try to identify the most probable path and to estimate uncertainty” (Ghanadan and Koomey 2005)[31].

On its part for IDEE/FB, the technique for using “scenarios” constitutes an “instrument for prospective that permits a reduction of the degree of uncertainty during the process of making decisions”. It also “constitutes a coherent image of the state of a determined system at certain points in the future”, and that “the construction of scenarios must be directed by the objective that has been set forth with the prospective analysis that is being undertaken[32]”.

IV.3. Background and historic evolution

IV.3.1. Strategic scenarios

Background of the development and application of scenarios for military uses and their later evolution towards strategic planning in economic, political and environmental organizations and institutions

The building of planning scenarios arises from the use of strategic planning methods applied by several organizations to formulate their long-term plans[33]. In a certain measure this has arisen from the generalization and adaptation of methods used by military intelligence services.

Originally, the method consisted in that a group of analysts generated simulation games to be used by persons concerned with political decision-making. These simulations combined known facts about the future, such as demographic, geographic, military, political, industrial and mining reserves information with possible alternatives in social, technological, economic, environmental, educational, political and aesthetic trends, as well as key directives.

In its economic applications, the planning of scenarios ceases to emphasize the confrontational game between opponents –military approach – and is more directed to considering natural variables. Shell considers the planning of scenarios as dynamic blocks of thoughts regarding the exogenous parts of the universe under analysis (energy variables), prior to the formulation of specific strategies.

In a certain manner, planning of scenarios involves, aspects of “systemic thought”[34] that refer to an acknowledgement that many factors may be combined in different manners that sometimes result in surprising futures (including, non-linear feedback links). The method also permits the inclusion of factors that are difficult to formalize, such as new perceptions regarding the future, accentuated changes in the values established, technological innovations or unexpected regulations.

IV.3.2. Scenarios in energy planning or prospective.

Background of the development and application of planning and studies on energy prospective. The case of Shell and others can be highlighted. The “single scenario”.

The introduction and use of scenarios in planning is generalized, beginning with the definition of public policies in matters of climate change and energy efficiency (Ghanadan and Koomey 2005). It has its origin in the use of Strategic Management, in which they have been used since the 60’s.

The use of scenarios is an integral part of the “focus of final use” in planning and consequently is not a recent novelty in energy analysis. M. Jefferson (2000) presents a brief description of the efforts of the World Council on Energy (WCE)[35] o decipher the future demand of energy and to describe the scenarios used in a determined number of studies. In a study of 1978, the Council convened policies and actions to assure a sustainable future. Up to 1989, were used two scenarios – of high growth and of a medium evolution. Since 1993, a new scenario was added, directed towards ecologic preservation, which after 1998 was expanded up to six scenarios – three of high growth, one of a middle term and two that were ecologically oriented. The integrated set of scenarios presents a range of possible results of a rational nature and forecasts of energy and environmental indicators up to the year of 2100. Shell has also actively

31 Bibliographic quotes by Ghanadan and Kooney and de Leydon have been taken from Bhattacharyya, S. (2011) pages 119 and following.

32 IDEE/FB (2009).

33 Scenario planning, también llamado scenario thinking (imaginación de escenarios) ó scenario analysis (estudio de escenarios).

34 Senge, P (2005): “El pensamiento sistémico es el que se da en un sistema de varios subsistemas o elementos interrelacionados. Intenta comprender su funcionamiento y resolver los problemas que presentan sus propiedades. El pensamiento sistémico es un marco conceptual, un nuevo contexto que se ha desarrollado en los últimos setenta años que facilita la claridad y modificación de patrones”.

35 Michael Jefferson, Deputy Secretary General, World Energy Council.

used it to apply the techniques that define scenarios for its planning and strategic direction.[36] Shell produced its first study on scenarios in 1992 that was followed by several studies, with the last being prepared in 2013. Among the studies with possible global energy scenarios, mention must also be made, among others, of those of the EIA of the United States, Exxon Mobil and British Petroleum.[37]

The robust nature of the approach of the use of scenarios consists in the ability to explicitly capture structural changes, taking into account sudden changes in the trends of development

Observing the experience of energy planning along a half century, it could be stated that, during the first decades, many planners have used the technique of scenarios, surely without perceiving it, in its most rudimentary version: the single scenario. Of course this should not be understood as if planning has made a passive acceptance of trend behaviors. To the contrary, the essential purpose of planning has always been the design of policies and strategies to reach the desired trajectory, in line with the objectives planned.

IV.4. Significant variables and hypothesis

In energy scenarios, exogenous variables may be considered external provisions to the sector, that although being a part of the scenarios, they comprise a type of exogenous parameters. These may be quantitative, as population, GDP, prices; or qualitative, as technology, penetration of new sources, rational use, etc.

In view of the nature of the above-mentioned exogenous variables, it is possible to appreciate that these should of course integrate any energy scenario, and there is the trend of considering these as within that scope.

Let us consider the case of world population and how it should be incorporated into the building of scenarios. During decades, the world analyzed and discussed the possibility of the fear of over-population in such dramatic terms as the probable result of widespread hunger, and its eventual influence on the world market of energy that was never included in the agenda.

There is a great change in the “population” variable in the world scenario that is not demographic but rather economic. Economic and social changes verified in China, India, and in the entire BRIC group have an impact as if suddenly the world population –is demanding food, raw materials and of course energy- has increased in the last few years by a fifth. Of course, this great change can also be analyzed from the point of view of GDP, provided that this great change can also be analyzed from the point of the GDP, and that it takes into account regional singularities and associated elasticity.

Other elements that are substantial for the building of scenarios are “prices”, “technology” and the penetration of new sources. This is not a simple relation, for example, it is not possible to recognize that important technological changes are a consequence of higher prices or that these produce the impact that such forecasts were announcing. Although we must not ignore the importance of prices, a retrospective of the last century and a half would seem to indicate that technology has followed a reasonably independent path than that of energy sources and their prices. In the link technological development-penetration of primary energy sources, it would seem that the cause-effect relation goes from the first to the second and not on an inverted basis. Neither have the prices of energy shown a significant importance on technological development and the processes for substitution between sources. If we analyze the process of substitution in that period, there is evidence that the “quality of the source” and technological development have been two of the gravitating variables. The most inexpensive forms of sources are not the ones that have substituted the more expensive ones, as well as the variable of “depletion” has had little importance.

From the demand point of view, although most persons are convinced of the intrinsic benefit of the rational use of energy, to a large measure it is its price what has brought about these practices, norms in the market and generated the appearance of important energy savings inventions, from solar heaters to hybrid automobiles. Although these incorporations face much more complex barriers than the mere convenience of prices, it is a matter that should be considered.

IV.4.1. Systems and their relations

In the formulation of social and economic scenarios for a country, should be considered systemic plans within which they must be included

36 Han sido ex -planificadores de Shell quienes difundieron públicamente sus prácticas (Ghanadan y Koomey 2005).

37 EIA (Annual Energy Outlook, 2013); ExxonMobil (2013) y BP (2013).

In general terms, economic, social and political events that occur in systems of greater scope (the world economic system and the regional political-economic system) have a significant influence on the social and economic system and even the political one of a country [38]. It is relevant to mention here some concepts in relation to causality that frame the process, known as “top-down”:

- It is essential to identify the unidirectional causal relation or of interdependence between systems “since this defines a certain type of hierarchy in the formulation of the hypothesis contained in them”.
- “The more open that the social economic space is, the greater will be the importance of exogenous impacts forthcoming from the impacts of greater hierarchy”.
- “In essence, the globalization process of the world economy represents a greater opening of national economies to the action of large conglomerates of corporations and financial flow movements within the context of very weak regulations on markets”.
- “The formation of blocks, under the form of free trade agreements, customs unions or common markets, largely induced as an answer to that globalization process, creates additional instances of expansion of the degree of opening of national social and economic systems”.
- “In consequence, the importance of exogenous types of impacts upon the systems of lesser hierarchy has been growing considerably”.
- The attempt to include a scenario that portrays the evolution of systems “also responds to endogenous changes of different degrees of significance. Precisely these types of changes can permit certain degrees of freedom in the design of hypotheses to be included in the scenarios that portray national systems, with respect to those of the international levels (regional or global)” [39].

IV.4.2. Relevant hypotheses of the world context

In accordance with that statement, the hypotheses used in scenarios that refer to the world level must include two types of aspects. The first refers to certain global question relative to the organization and functioning of the world economic system (principal characteristics of the predominant modalities for accumulation, distinctive characteristics in large regions, etc.). The second type of aspects, formulated in a coherent manner with the previous aspect, is related to those particular questions that more directly affect the country or region considered (possibilities of access to international financial markets, investment currents, access to the markets that provide certain goods and services, etc.).

It is essential to identify the unidirectional causality relation or of interdependence between systems, since this defines a certain type of hierarchy in the formulation of the hypothesis therein contained

This way, in the preparation of scenarios, it will be necessary to qualitatively analyze different possibilities with respect to the world context, formulating hypothesis relative to:

- Degree of globalization and relevance of regional blocks (including some references of a geopolitical nature: single or multi-polarity, potential of conflicts between blocks);
- Degree of interregional competition and solidarity (articulation) intra-blocks;
- Principal activities that will lead the accumulation process at the world scale and outstanding characteristics of technological changes and the organization that predominates in work processes;
- Rhythm of growth by large regions and the vertical and horizontal expansion of markets;
- Liquidity level of international financial markets and the degree of access to credit on the part of semi-industrialized and/ or lesser development countries of their national financial markets;
- Affluence of direct investments to the abovementioned countries and specification of the principal areas of these investments;

38 IDEE/FB (2009).

39 Ídem

- Degree of access to exports of the social economic system considered (national and regional) to the corresponding international markets;
- Evolution of international agreements with relation to the preservation of the global environment, in particular, restrictions to the trade of goods derived from such agreements.

IV.4.3. Hypotheses relative to the regional space

In a coherent manner with the hypotheses relative to the world context, it is necessary to advance with the additional specifications that refer to the regional environment (Latin America and the Caribbean and the regional blocks to which they belong[40]), corresponding to the country under consideration. As in the previous case, the hypothesis relative to this level must include both those general aspects that may have incidence upon the global macro-economic evolution as well as specific energy questions:

- *Evolution of the degree and the forms of integr*ation at the regional or sub-regional level; intensity of competition and the existence of solidary articulations;
- Type of strategic alliances with other blocks;
- Degree of compatibility of macro-economic and sectorial policies within the block for integration;
- Level of cooperation at the level of activities of investigation and technological development;
- Degree of penetration of multinational conglomerates in the economies of the regional block;
- Types of activities in which the action of those conglomerates is predominant;
- Type of predominating sectorial complementarities;
- Degree of sub-sector and entrepreneurial integration and improvements in competitiveness of regional productive activities;
- Rhythms of economic growth and of population in the countries that comprise the sub-regional block;
- Evolution of social asymmetries and the rhythm of horizontal expansion of certain mass markets (example, of food);
- Specific environmental conditions in the regional sc*ope.*

IV.4.4. Hypotheses of a national system

Hypotheses at the national level~~,~~ will include the following dimensions: global economic and energetic, social, demographic and environmental including its spatial aspects. As well as assumptions relative to public policies and the strategies of national and multinational stakeholders within the analyzed world and regional contexts. Regarding the above-mentioned dimensions, hypotheses will refer to general aspects such as the followings:

<u>Economic, global and sectorial dimension</u>: Characterization of the predominant modalities of accumulation, indicating the insertion in the world and regional levels, considering the trans-nationalization of productive activities and the role of foreign investments; Degree of access to international financing and the evolution of the margin of foreign indebtedness; Global economic growth and the responsibility relative to internal and external markets; Sectorial growth pattern: principal activities and degrees of integration at the national, regional and world levels; Evolution of exports and imports, their sectorial composition and principal markets; Participation and expansion of small and medium size companies and their future possibilities; Spatial patterns of economic growth; Principal corridors or areas of integration with the countries that belong to the regional block.

<u>Social dimension</u>: Evolution of the average income of the population; Unemployment and sub-employment levels; degree of precariousness in employment; Evolution of social asymmetries: distribution of income; poverty and marginality; degree of access to basic services and particularly, to the different levels of formal education.

40 OLADE member countries integrate different regional and / or supraregional blocks and initiatives whose development and perspective can have a significant impact on the analysis of the scenarios. Some active blocks and initiatives are mentioned: NAFTA TLCAN (North American Free Trade Agreement or TLCAN in spanish), ALBA (Alianza Bolivariana para los Pueblos de Nuestra América), MCCA (Mercado Común Centro Americano), CARICOM (Comunidad del Caribe), SICA (Sistema de Integración Centroamericano), MERCOSUR (Mercado Común del Sur), CAN (Comunidad Andina de Naciones o Pacto Andino), UNASUR (Unión de Naciones Sudamericanas), Alianza del Pacífico, ALADI (Asociación Latinoamericana de Integración), G3 (México y Colombia), CAFTA (EEUU, Centroamérica y R. Dominicana), MESOAMÉRICA (México, Colombia, Centroamérica y R. Dominicana) y PETROCARIBE.

<u>Geographic dimension</u>: Global population growth; Evolution of patterns and levels of urbanization; spatial distribution and direction of internal migrations; Movement of populations in the block(s) of regional integration.

<u>Environmental dimension</u>: Degree and modality of adhesion of the country to international agreements on the environment; National policy referred to the preservation of natural heritage resources and the impacts upon the local environment; Rational nature of productive stakeholders in relation to the environmental impacts of their activities.

IV.4.5. Significant variables

> *For the definition of the hypotheses that comprised the scenarios, in the presented spaces and dimensions, the most significant variables will be applied (exogenous variables) that provide a more adequate reflection of the phenomena that are to be represented*

These variables may be quantitative at the global or local scale or qualitative. There is no pretense of trying to establish a closed list, but in any case it is possible to identify some that are considered important, and to group them in families.

a) Global Quantitative Variables:

- √ Population
- √ Global economic growth
- √ Energy Consumption
- √ Participation of renewable sources in the global energy supply
- √ …

In view of the different dynamic nature that is frequently shown by these variables, it is advisable to open these into two sub-groups, corresponding to developed and emerging countries. Other significant quantitative variables are:

- √ International prices of oil and substitutes (volatility)
- √ Range of international interest rates (volatility)
- √ Needs of global investments in the energy sector
- √ …

b) Local Quantitative Variables:

- √ Population, with diverse regional openings
- √ Regional/local economic growth. Gross Domestic Product and per capita, opening by sectors
- √ Elasticity / price and elasticity / incomes from energy consumption
- √ Investment costs per product unit, according to sources
- √ …

c) Quantitative Variables of Global/Local Relationships:

- √ External commercial opening and principal export markets
- √ Integration in regional blocks
- √ Participation of imported energy in the total of offer
- √ External financial opening
- √ …

d) Global Qualitative Variables:

- √ Hypothesis of regional conflicts that affect energy sources or supply routes
- √ Hypothesis of internal conflicts within larger countries
- √ Hypothesis of global conflicts
- √ …

e) Technological Qualitative Variables:

√ Having an impact on demand:

- Implementation or Evolution of Efficient Use Policies
- Penetration of low consumption/LED lighting
- Penetration of hybrid or electric automobiles
- …

√ Having an impact on supply:

- Changes in wind or solar technologies
- Dissemination of techniques of fracking on shale oil and shale gas
- Mass development of offshore deposits
- …

f) Environmental Qualitative Variables:

√ Implementation or evolution of policies relative to air, water, soil pollution

√ Theoretical and practical adhesion to policies on greenhouse gasses

√ Social acceptance or conflict regarding hydroelectric or nuclear facilities

√ Acceptance or conflict regarding the change of landscapes, in lines of HT, windmills and others

√ …

As has been indicated, this is not a closed list of variables. It is an illustrative list, and for that reason and in a deliberate manner we leave an available point at the end of each enumeration. It is always possible that other variables may be considered.

However, care must be taken that a scenario is not necessarily enriched by the accumulation of more and more variables. The selection of these must be in an appropriate relation to the relevance with the matters to be investigated and with the dimension and scope of those proposed.[41]

Is enlightening about this issue the document published by the National Grid Co. responsible for the planning, sizing and transport of electricity and gas in Great Britain[42], *"The UK Future Energy Scenarios Document"* in which are presented three scenarios with a projection to 2030. Three scenarios basically prepared on only five variables: economic environment, oil prices, developments in the heating market –emphasis on heat pumps - developments in transport –emphasis on electric vehicles- and electricity, focused on high efficiency technologies and the management of demand (*demand-side management*).[43]

IV.4.6. Selection of variables

In the preceding paragraphs we have presented hypotheses to be formulated for the construction of future scenarios and a relatively long list of exogenous variables, which is still susceptible of being completed. We have also warned that the multiplicity of variables is not a virtue in itself. The quantity and type of variables to be used to build scenarios need an indispensable prior definition, although not necessarily irreversible. It requires theoretical knowledge and experience regarding the functioning of the sector or subsector that is the object of planning and the environment and its interrelations. This is why the following section states that the team in charge of constructing scenarios must be formed by specialists. The selection of variables is essentially an identification of the forces that may have impacts upon the sector.[44]

The selection of variables must be related to the hypothesis of the world context, the regional space and that of the national system.

41 In the next section (IV.4.6), the criteria for selecting those variables that may be relevant for the study of future scenarios are presented. This is complemented by the analysis of the relevant variables that some countries have considered in their scenarios studies, which is developed in the section "Planning scenarios in LAC".

42 The NGC is a privately held company with the functions of planning, dimensioning and operating national gas and electricity networks in the United Kingdom, subject to the control of the OFGEM (British regulator) to whom it submits its plans for approval.

43 National Grid Company (2011).

44 Castaño Duque, G.A. (University of Colombia, Manizales) speaks of "scrutiny of the environment", aiming above all to identify "discontinuities".

An initial selection of variables must be associated with the international insertion of the country in energy matters. If it is an importer or exporter of energy, if it is a part of multinational economic blocks, if it has in force agreements or binational treaties, if it is an importer or exporter of capital and if it can be influenced by certain hypotheses of international conflict, are all elements of judgment that will provide advice relative to the importance of granting global qualitative or quantitative variables, as well as those of the world-regional-local relationships.

A second approach is related to the evolution of the internal productive apparatus, and here the great macroeconomic variables play a role, those that refer to the expected growth of GDP, its de-aggregation by sectors, urbanization, income distribution, income elasticity of the demand for energy.

Of course, within an ample conception, practically all variables that we have listed as an example and perhaps even more are susceptible of having an impact on the energy sector. But it is also true that those of special interest are the ones that have a significant incidence upon energy demands and supplies and which may set forth problems of discontinuities.

The third criteria applied for selection, addresses processes of a political nature in the widest sense of the term. In this group we find qualitative social, environmental and technologic variables. We refer to the manner in which society and the government must process demands in matters of environmental care and the manner in which they must promote or make difficult the insertion of technologies. Within this group have also a value of reference the level or degree of those variables referred to the efficiency of implementation of energy policies adopted by the country. Depending also in this case on the different realities of each country, it is possible to determine which of the variables related to these issues have the aptitude of producing a significant impact or even a rupture.

IV.4.7. Variables and Scenarios

> *The evolution or behavior that was attributed as a hypothesis to different variables, may give as a result scenarios of continuity, rupture or evolution (Fig. V.1)*

This characterization of scenarios as of continuity, rupture or evolution, should not be understood as a recommendation in the sense of necessarily adopting scenarios included in one of the three groups. It is simply a classification of the scenarios that may result from the adoption of certain hypotheses that refer to the future behavior of different variables.

We consider as **"scenarios of continuity"** those that can be built by means of a reasonable projection of present trends. Certain discontinuities may exist in them, but these are not able to touch significant variables.

Looking to the past, one of the extended periods of continuity recognized in the XX Century is without doubt that which followed the Second World War. Within this framework, for example, the closing of the Suez Canal after the Six-Day War (1967) no doubt affected the considerable flows of the transport of fuels by sea, but did not constitute a rupture. However, the events that followed the Yom Kippur War (1973), which became a great world oil crisis, absolutely meant the end of an era. At least in that which refers to energy.

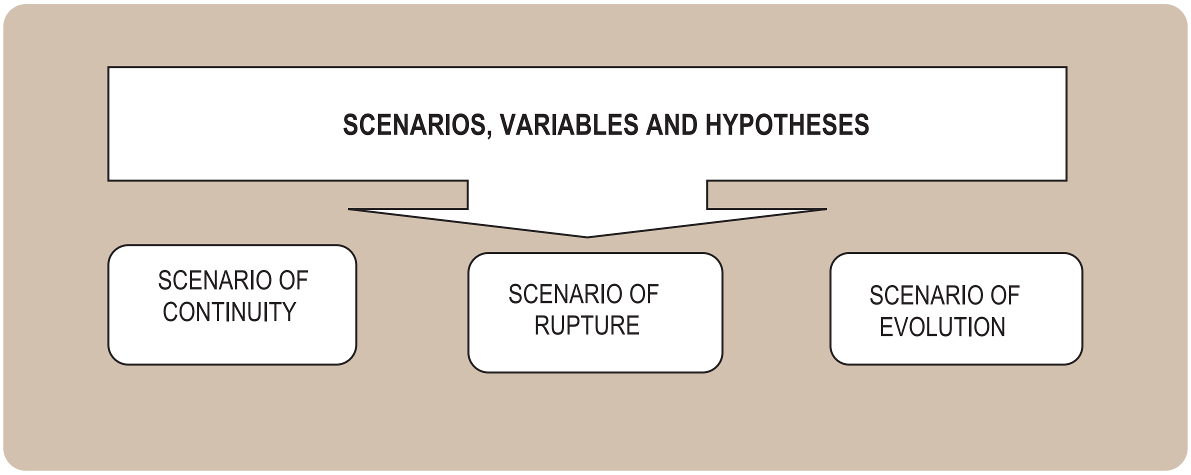
Of course, a scenario of continuity does not assure viability: for example, if during the coming decades, the Chinese society would adopt a profile of energy consumption similar to that of the United States, including the quantity of automobiles per one thousand inhabitants, the energy requirement would exceed any possibility. Another well-known example would be to suppose an undefined expansion of the supply of biofuels, without considering how this would affect the world supply of food. In these scenarios, the claim of continuity itself, sooner or later will add to some type of rupture.

What we call a **"scenario of rupture"** is that which assumes a lack of continuity of one or more of the significant variables.

For example: a scenario of rupture could include a hypothesis of an internal political conflict in China that would derive into a significant economic de-acceleration, or a weakening in demographic control. What impact would this have on the GDP in China, on its productivity, on the global demand for food, in the world generation of savings, in the capital markets? How could it affect the demand of products and revenues from LAC exports? On the world and LAC demands for energy?

A rupture is not necessarily a negative concept. An eventual discovery of hydrocarbons in a non-producing country would not be considered as bad news. In the medium term, it may modify important variables, such as the participation of imported energy in the supply, and produce a lowering of the average energy cost in that country. It could also mean the abandonment of renewable energy policies or projects, in detriment of environmental care.

Figure IV.1: Characterization of the different types of scenarios based on hypotheses relative to the evolution of variables



Source: Authors.

On the other hand, the notions of continuity or rupture also change in time. A case in point illustrates the statement of Denes Martos that we have quoted in previous pages: "As a matter of fact, a scenario does not even have to be "credible" or "probable" because the constant processes of change operate very intensely upon that which at a certain moment had been considered as credible or probable."

If in 1990, a scenario would have been built, that for example would have included a net fall in gasoline consumption in the United States market, or the rise of this country as a relevant exporter of petroleum and gas, this would have meant the assumption of bold rupture hypotheses with respect to the secular trend. At present, both are trends that exist and which have been incorporated in the official projections of the United States for the period 2013-2040, and the different scenarios in this respect only have quantitative differences. [45]

Likewise, without considering as "of rupture", if some of the perspectives that are based on historically atypical performances, could establish the profile of scenarios highlighted for the projection of relevant variables in the energy planning of LAC. We call them **"scenarios of evolution"**.

These three types of scenarios are now described with their respective definitions. Although to be able to illustrate them, we have chosen cases of continuity and of rupture at the global level and a scenario of evolution at the regional level, it is clear that these are examples, corresponding to which we can mention others at the global as well as regional levels, including the national level of different countries in the region.

IV.4.8. Variables and Implementation

Chapter II of this Manual deals with the "Planning Process", in the section that analyzes the problems of implementation that may arise during the application of an energy plan, mentions among other things, those derived from unforeseen alterations in the global economic and financial contexts or the positioning of a country with respect to these, with an impact on the execution of planning.

These global economic and financial variables have been summarized in this Chapter at the level of the growth of global GDP and by regions, at the level of energy product prices (petroleum) and of rates of interest. The problem that appears in prospective studies of these variables (particularly the price of petroleum and rate of interest) is more focused on volatility that may be present, a matter that makes forecasts difficult.

But due to the complex relation between these variables and the demand and availability of energy resources, as well as the feedback between them, it is convenient to mediatize the impact of these variables in future scenarios through an analysis of the treatment given by international organizations that carry out specialized diagnosis and forecasts on energy mentioned in Chapter II[46]. The problems for the implementation of energy plans derived from unforeseen alterations of these variables, is dealt in the referred Chapter.

45 US EIA/DOE (2013).

46 EIA of the DOE, EE.UU; WEC; CEPAL; ARPEL and the Shell global scenarios, Exxon Mobil and BP.

IV.5. Methodology for the building and evaluation of scenarios

"The only truly valuable thing is intuition" [Albert Einstein].
Building scenarios is the only methodic, rational and fundamental use of intuition.

The process for the building and evaluation of scenarios, involves a sequence of activities, the use of resources and a set of techniques, that are not the only or exclusive ones, but that are illustrated in this Manual by means of the presentation of those that are considered as mostly used or frequently referred to in specialized literature.

Almost from their origin, in the decades of the 70s and 80s, efforts directed to design what is today known as the techniques of scenarios, started distinguishing between two categories, one of which revealed a closer link to business strategies, and the other more appropriate for the study and treatment of social processes.

A very useful systematization of the path travelled by these studies~~,~~ was presented by Antezana (2012) who distinguishes the following methods for the building of scenarios:

- **"Logics of construction with high formalization** (associated to quantitative analysis methods)" that tends to "obtain scenarios for which it is possible to estimate the probability of occurrence, in addition to quantitatively formalizing (or modeling) the logic or the interaction of the events that determine it." The labors of Godet are representative of this category.

- **"Logics of intuitive construction"**, where scenarios "usually arise from the consultation with experts associated with quantitative and qualitative methods of information." These methods appeared following the well-known experience of Shell, and are historically associated with the work of Peter Schwartz.

Godet (2009) begins with the description of his method by distinguishing two types of scenarios. The so called exploratory, that "describe, based on a present situation and of the dominating trends, a series of events that lead in a logic manner (necessary) to a possible future". He then adds that an exploratory scenario "could have trends, in which case it is based on the strong inertias or trends of the system studied" or also "could be based on sudden changes in relation to the trend scenario, to explore contrasting hypotheses that are placed in the limit of what is possible.

In turn, regulatory scenarios or of anticipation "do not start on a present situation, but rather from the image of a desirable future, described on the basis of a determined set of objectives, and describe a path that links the future with the present."

In the Godet method, the preparation of scenarios has three phases:

- Phase 1) Construct the base. "Consists in preparing a set of representations of the present state of the system, formed by different elements of the environment of the organization. It is the expression of a series of interrelated variables. Its construction depends on the delimitation of the system, of the determination of the essential variables and of the analysis of the strategy of its stakeholders".

- Phase 2) "Explore the field of what's possible and reduce uncertainty: After identifying the key variables and analyzing the sets of stakeholders, it is possible to point out possible futures starting with a list of hypotheses that reflect, for example, the maintenance or end of a trend".

- Phase 3) "Prepare scenarios: In this phase, scenarios are still in an embryonic state, since they are limited to sets of hypotheses that have been materialized or not. It then corresponds to describe the path that leads from the present situation to that of the final images. This part of the work is referred to as the "diachronic phase".

"The images of future trends that are contrasted are then constructed, describing them with the greatest possible detail; and also described is the transition from the present situation to the possible and desirable future situations (Licha, 2002)".

To the above described methodological process should be added that the availability of information respect to the mentioned variables is a key aspect for scenario building. From the strength, availability and consistency of statistics both energetic as well as socio-economic depends mainly the success of the building and the evolution of scenarios.

In accordance with their business school orientation, the method described by Godet dedicates a great deal of attention to the situation of the company, its position with respect to competitors and the awareness of its personnel through so-called "prospective workshops". It uses techniques destined to provide a quantitative support to the different steps, and grants importance to the possibility of attributing probabilities to hypotheses and events ("probability of scenarios").

The techniques of scenarios distinguishes two areas, one that is better linked to business strategies, and the other that is more appropriate for the study and treatment of social processes. This Manual focuses on the methodology of intuitive construction, more compatible with the problems of energy planning.

The techniques of scenarios called "of intuitive construction" are based on the ideas and practices recommended by Peter Schwartz, continuator of Pierre Wack at Shell. These techniques recognize the flexibility that is necessary to be able to adapt to diverse objectives and contexts, but without forgetting that there is a set of minimum rules that must be respected to assure the reliability of the method.

The mentioned document from Antezana 2012 – an illustrative example of the technique based on this method – starts by presenting two prior conditions:

- √ *Diversity – of disciplines, sectors, cultures, specializations – of those intervening.*
- √ *Information, what means the prior availability of sectorial studies, opinions of experts, opinion surveys and other backgrounds.*

Once these initial conditions are present, five steps are described:

1. *Determine the focus of such scenarios: the team must be able to discuss from different perspectives, until it is able to determine the principal focus. Following that it must determine the time horizon of the scenarios.*

2. *Brainstorming of particular factors: destined to identify representative factors of "the general trends or forces of change that can configure different realities to the future."*

3. *Distinguish between structural trends and factors of rupture: understanding that the first comprise the context –example, globalization- and the second could turn out to be the effect of decisions taken by particular stakeholders.*

4. *Identify the logic of the scenarios: the team must reach a consensus regarding "the critical factors that represent the most relevant uncertainties" and later make explicit the different possible states of critical variables retained. The combination of the different states of variables describes a series of possible situations that are qualitatively different in the future, each one of which constitutes the skeleton of a scenario.*

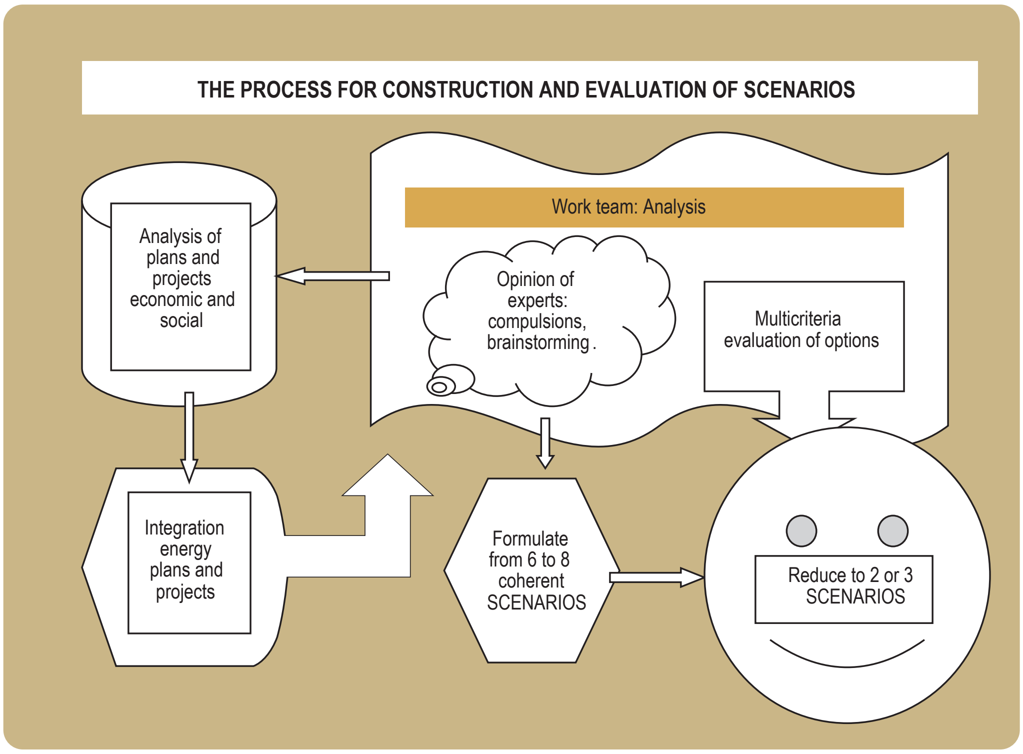
5. *Fill-in and draft the scenarios: construct the narrative of scenarios, describing how they go "from the present towards the future that has been delineated".*

The author adds that scenarios must be susceptible to evaluation in accordance with the criteria of plausibility, differentiation and internal consistency.

The methodology for the building of scenarios that we will be developed in the following pages, is inscribed within the calls for intuitive construction, more compatible with the framework of problems of energy planning - essentially socio-economic – than the techniques directed to business strategies in the world of business.

A summarized scheme of this process appears in the following graph.

Figure IV.2: Components of the process for the construction of scenarios



Source: Authors.

The start of the process resides in bringing together the necessary resources, and on the basis of these, to establish the basic definitions that will make it possible to advance with the activities.

IV.5.1. The "Project Team"

Undoubtedly, the process of scenario building is a collective task, and of teamwork. Perhaps because the the technique of scenarios was first used with military strategic objectives, in the scope of corporations that had generous budgets, the preparation of scenarios is usually considered as an effort that requires numerous work teams and large-scale resources. However, the information available does not confirm this assumption.

Of course, the volume of information that must be processed to establish the scenarios has to keep a relation with resources and the time available, and usually both are limited. As in any other project, it is desirable that a group of specialists fully dedicate themselves to the task. If the purpose and the resources are ample, the project team can also do it, but in any case there must exist an "executive management" of not more than six or seven persons, and one of them must be invested as the "project leader".

IV.5.2. Basic definitions

Even though the central core of the task consists in gathering and processing wisdom and imagination from different sources, some definitions must be adopted before starting.

√ Work Plan

The first refers to the working method –which may be that advised by this Manual - and later its application, that depends on resources and time. Taking into consideration these three essential elements –method, resources and time – it is possible and necessary to establish a Work Plan.

√ Time period for scenarios

It is necessary to define it according the time horizon for energy planning of this Manual.

There seems to exist an agreement that in scenarios building it always refers to the long-term, and the notion of long-term always conveys the time that is necessary to modify the installed productive capacity. In matters of energy, it must be recognized that in many cases the time required for a project from the start of studies until it goes into production is close to ten years. Although the purpose may be, for example, a five-year period of planning, the scenario in which this evolves must cover a span of time of not less than ten years, and literature published on the issue is full of scenarios with a span of thirty or more years.

To illustrate this, the time span (in years) will later be mentioned[47], under which planning scenarios are built in different countries of LAC and in the world.

IV.5.3. Integration of plans

Economic social and environmental plans and projects

It is evident that the construction of scenarios destined to energy planning cannot be independent of the vision that the country itself –or the region- is officially undertaking as strategic or macroeconomic programs. And it is also obvious that such programs should exist and be endowed with a reasonable credibility, the task would be facilitated by the possibility that certain variables could be transformed into data, at least for some of the scenarios. This implies that it would be necessary to analyze economic, social and environmental plans and projects and fit into them the hypotheses regarding the variables to consider.

> *The building of scenarios destined to energy planning cannot be independent of the vision of the country itself –or of the region – that is officially undertaking it as strategic or macro-economic programs.*

It may be the case that such strategic or macro-economic programs are not available, or that they are on the way to exist but do not reach us on time[48]. This apparently grants us a greater degree of freedom, but also leaves zones of uncertainty and possible conflict with political decision makers

Integration of energy plans and projects

Energy plans and projects should also be considered. A central question is to consider the challenges, broadly and for the temporal horizon selected, which are estimated that the energy system under study and the plans established for that effect.[49] will face.

Many countries or organizations have already identified and established the matters that will guide their energy policies and quite often, the qualitative and quantitative goals that they intend to achieve.

At global level and in general terms, some authors consider as challenges for the energy sector the following[50]:

- Reliability of supply that has drawn public attention and debates during the last years. While those countries that dispose of energy are interested in their future prospective, those that lack it make efforts to have access to reliable energy services, affordable and adequate.
- The access of population to energy has been identified as the principal challenge to be able to reach global sustainable development.
- Notwithstanding this, there are clear signs of the permanence of non-sustainable practices: an unprecedented growth in energy demand in new regions, running counter to that of the traditional centers of demand; globalization of wasteful consumption patterns; concentration of the supply in politically unstable regions; concerns regarding the financial solvency of public supply companies, and other.
- Also relevant are the challenges relative to governance, reform and restructuring of the energy sector and environmental concerns.

47 This is illustrated in the section "Planning scenarios in LAC" is illustrated in this regard.

48 The experience of the region seems to indicate that energy planners have always been among the most enthusiastic, so that sectorial plans are often enlightened even when national plans do not exist where they should theoretically be inserted.

49 In this regard, see the development made in Chapter II.

50 Bhattacharyya, S. (2011)

This complex set of challenges is that which delineates the future of the energy sector and the path on which its activities will be organized and developed. In consequence, in the dynamic world in which deep political, social, economic, technologic and even ideological changes take place, it is inevitable to also expect changes in energy scenarios.

For example, specifically for Europe[51], the European Commission through its General Direction for Energy, established objective guidelines "20% - 20% - 20%" for the decade 2010-2020. These imply the achievement of:

- √ 20% of reduction in CO_2 emissions in relation to 1990.
- √ Reach a 20% of participation of renewable energies by 2020.
- √ Increase by 20% Energy Efficiency by 2020.

In this case, the goal-parameters to be reached are in relation with projections based on possible scenarios of evolution. It considers three scenarios: a) one with the historic trend (*business as usual*); b) one based on the results of already established policies of change; and c) a scenario with additional political efforts to achieve the objectives "20-20-20". In this latter case, derived from the magnitude and nature of additional and necessary normative and regulatory changes.

The energy challenges to be faced by the LAC countries and consequent guidelines for strategic action to face them, have already been defined many times and have been expressed in official documents of different legal-administrative hierarchies.[52]

In the event that this is not so, or even being so, it is convenient to review them – for the purposes of the planning exercise that the country wishes to be undertaken-, the sequence of identification of the present situation, of the trend and challenges to the energy system under study, will constitute the initial instances of the planning process[53] and will represent an input for the construction of scenarios.

IV.6. Techniques for the construction of scenarios

The process of scenarios building that is illustrated in Fig. IV.2, once that it has defined the "work team" and has analyzed the economic and social plans and projects (in their most ample meaning) and the energy products, requires a set of operative techniques for the development of the task.

The work team must be imbued with the notion and characteristics of the scenarios to be built, of the significant variables to consider and the hypotheses regarding its future development, and to have a work plan and time horizons duly defined.
It will continue with the application of the techniques that permit to configure the scenarios and to evaluate them. These techniques may be varied and their election will depend on multiple factors that are issues beyond the scope of this Manual. Notwithstanding this, here are presented those that are considered as more direct and recommendable due to their generalized use.

IV.6.1. Opinions of experts

Almost all of the literature on scenarios building recommends that in the first place it is necessary to request the opinion of experts. It may be conceived that in this part of the investigation that status is bestowed because it is the source from which the most attractive contributions are expected. It may also be useful to approach it from the beginning, because it can take a considerable amount of time.

In order to gather the opinions of experts we can basically use four techniques: the certification, the survey, the interview and "*brainstorming*". These techniques are often combined with each other

<u>Certification</u>: Consists in requesting that a group of experts selected simply on the basis of their public or academic recognition, answer a written questionnaire relative to the possible evolution of some or all of the selected variables.

This is the simplest method, and if the questionnaire is designed in such a way that it may be answered with a brief amount of dedication, there will be good possibilities of obtaining a high percentage of answers.

However its simplicity is also one of the principal weaknesses of this technique. A contribution that requires little effort will also mean less commitment and will be provided with a certain lightness or misapprehension in opinions. This inconvenience could be solved from the elaboration of different questionnaires depending on the specific areas of the experts.

51 Market Observatory for Energy. European Commission. Directorate – General for Energy. Key Figures.June 2011.

52 Chapter II is exemplified by planning documents and / or definition of energy policy guidelines for countries or regions in the OLADE area: Argentina, Uruguay and Colombia.

53 See Chapter II of this Manual.

Survey: Essentially, it also a submittal of a list of questions to a universe of experts. However, to be recognized as a “survey” it should have a statistical rigor, it must classify those surveyed according to some criteria – specialization, academic degree, country or region of residence, public or private activity, age or other- designing samples and processing the results. It is a more costly technique and provides different types of results, more quantitative than qualitative; but it cannot be denied that in any scope, a well carried out survey adds a sort of additional respectability to the conclusions.

The opinions of experts can be gathered by means of certification, survey, interviews or “brainstorming”

Interviews: The practice of carrying out personal interviews with determined experts, although it will always be guided by a previously prepared questionnaire, in a certain manner is a special case of the technique of certification. It is clear that it is necessary to limit the number of chosen experts whose contribution is of special interest, and that interest may have arisen from well-known backgrounds, or of the answers provided by a previous certification. The interview implies a greater degree of involvement of the expert, even more so when this is done on a face-to-face basis, although it may also be carried out at distance. In view that this leads to more extensive reflections, and to questions and clarifications, it can be expected that it will provide a greater wealth of results.

Brainstorming: This is the technique most frequently associated with planning by scenarios, and from which it is usually expected will appear the primary design of the useful scenarios that will later be refined up to the final selection. It means an invitation to a debate for one or more groups of experts inviting them to openly and freely express their respective visions, based on their experiences, investigations or simple intuitions. Participants must be willing to participate in a creative discussion –not a succession of monologues – and freely present their opinions and thoughts. One of the merits attributed to *brainstorming* is the exposure of different ideas that normally generate other ideas, and the greatest advantage will be derived from the aptitude for collecting and organizing all such ideas. For this purpose, the traditional technique known as “Shell” proposes the gathering of opinions in self-adhesive cards that can be placed on a wall in the room where the debate goes on, organizing them according to certain criteria and changing their places as advised by the discussion, until the selected wall is expressed in a sort of chart or map that will be able to anticipate, at least in a preliminary manner, its conclusions. More modern forms, including the use of electronic means may now be used instead of the classic “adhesive yellow cards”, but the useful result will always rise from the wealth of opinions and the capacity to be able to organize them.

IV.6.2. Construction of a first set of manageable scenarios

It is obvious that the gathering of multiple opinions regarding the possible evolution of a set that could contain twenty or thirty variables with their hypotheses –which in the literature of scenarios are referred to as “drivers”-, could provide as a result an almost infinite quantity of scenarios. Here we face one of the most delicate steps of the process.

With the information gathered in the preceding steps, the project team is in condition of producing a set of partial scenarios, organized around what would seem to be the most important variables. Experience – of already several decades – relative to the use of the technique of scenarios, indicates that it is possible and convenient to obtain a first selection of not more than 6 to 8 scenarios.

It is possible and convenient to obtain an initial selection of not more than six to eight scenarios. An important condition is that each scenario must be communicable.

An important condition is that each scenario must be “communicable”: in the first place, this means that it has to be fully explained by means of a simple and brief presentation, both in verbal as well as written form. Figures, charts and graphs are valid auxiliaries for this task. The variables must be properly identified –important detail- and assumptions must be explicitly stated as invariables. If there is a scenario that cannot be easily understood by persons who have not participated in its construction, the question must be asked if this is due only to the form of presentation, or if it contains some inconsistency.

IV.6.3. Simulation and control of consistency

There is no theoretical basis to determine that the building process must conclude with the presentation of two or three scenarios. It is only experience that almost always indicates, that those responsible for taking decisions in the planning process decide to retain this number.

In this instance, the project team must avail itself of an iterative procedure, in which there is a simulation of the evolution of variables with special attention to the links between them. This task will produce –not devoid of a debate, at times intense- a reduction of scenarios, in part by accumulation of partially compatible scenarios, and in part by elimination of those that reveal as being inconsistent. The use of econometric models may be appropriate for this stage[54], especially in that which refers to the links between qualitative

54 This is the eventual use of econometric models to examine the internal consistency of some scenarios. These are not models that are mentioned in Chapter VII of this Manual as planning tools.

variables. However, its use must always be coupled to the warning that quantifiable variables do not intervene in the construction of scenarios since only quantifiable variables are permitted. Certain scenarios may be discarded since from the macroeconomic point of view they are inconsistent (including social and environmental issues), however this does not assure that the remaining ones can be considered as eligible.

At the end of this stage, it is convenient that the project team can submit its conclusions to discussion with the groups of immediate "users", understanding by this those who are responsible at the political level and who will at some time approve the instruments resulting from the planning, and also to the technical teams that will be in charge of preparing these plans, based on the selected scenarios. In this instance, the eventual participation of the members at the political level will be useful if it is possible to involve them at an early stage in the framework of planning and that they may contribute with their ideas and appreciations, forming part of the working group and not only in the exercise of administrative power.

This instance of debate is appropriate to generate a double enrichment: the project team can receive original contributions from persons interested and informed on the issue of energy planning, who are motivated by the challenge of viewing future possible scenarios; and at the same time, those who will work on succeeding stages, and those that will adopt the decisions at a maximum level, will have the opportunity of familiarizing themselves within the vision of the future that will frame their tasks.

Again, communicational technique plays an important role. The members of the project team must remember at all times that they are going to address a group that has not lived with nor participated in most of their discussions, that do not use the specific vocabulary on a daily basis, and that mentally could be located at a great distance of the framework of problems that have been discussed within the team. They must also consider that at least part of their audience does not have the time or inclination to read extensive documents. It is recommended that texts be of easy reading, interesting presentation and the intelligent use of Figures, Tables and Graphs, be used in all cases.

IV.6.4. Formulation of reduced and comprehensive options

It is advisable that the project team concludes its work with two or three scenarios that present future visions upon which the development of a strategy is recommended.

Since this is a matter of energy planning, the scenarios that have been obtained must permit the preparation of plans and their alternatives, making possible the adaptation of strategic decisions for the sector, and not only in function of external events, impossible to control by national decisions. Also in function of political decisions to which the planners can attribute costs.
Foreign episodes may also introduce substantial changes in several variables –for example: in the long-term price of oil –exceeds any internal political will. Other changes may originate in domestic decisions –example: government policies relative to the emission of greenhouse gasses or nuclear energy. In one or another case it is very probable that we may be facing a change of scenario, if the steps have not been observed on a timely basis as advised by the technique, this may bring about changes in plans, without the planners being surprised by a situation that surpasses them.

The construction of two or three scenarios does not necessarily lead to establishing a hierarchy. Specialized literature even suggests to "baptizing" scenarios with neutral names, avoiding qualifications such as "high – low", or "desirable – alternative". However there is the possibility that the project team is virtually under the obligation to select a scenario as its first recommendation, or which would provide an initial strength to strategic decisions.

In some cases the option is to select two; a basic scenario, with trends, and an alternative one that is superior, example: if certain decisions on efficient use are adopted or renewable energy advances are achieved.

The characteristic that is most recommendable between various scenarios, is that they can be contrasted, what means that they are clearly differentiate and identifiable among each other. And that this contrast and differentiation clearly appears in their respective "name" or denomination.

IV.6.5. Multi-criteria evaluation of options

This technique consists in the ex-ante evaluation of a set of conditions allocating bands of veracity to different parameters to infer possibilities of occurrence to determined events. These constitute an operation of reduction that when applied to a Matrix of options, selects the most probable scenarios among many of the possible ones.[55]

Multi-criteria evaluation is a process of a certain complexity that may be presented as a succession of steps, each one subject to certain norms or method. In essence, an effort is made to express in a quantitative order, the appreciations and preferences of a group of persons regarding previously built scenarios.

55 OLADE. " Call for contracting consultancies to develop the Energy Planning Manual - Chapter V: Construction of Scenarios". Year 2013.

This technique, one of those possible, has been taken from the European Commission and consists of a four step procedure applicable to the evaluation and selection of scenarios for energy planning[56].

Multi-criteria evaluation strives to express in a quantitative order, the appreciations and preferences of a group of persons relative to a set of scenarios previously constructed.

The four steps of multi-criteria evaluation are:

- √ Step 1: Conformation of the Evaluating Group or Groups
- √ Step 2: Selection of the Evaluation criteria
- √ Step 3: Weighting
- √ Step 4: Application of criteria

In **Annex II -A *"Multi-criteria for the Evaluation of Options"*** in this Chapter, the content of this technique is developed in detail and examples are provided of its implementation.

IV.7. Relation between Scenarios and Forecasts

"Quantitative forecasts are organized under the form of provisional solutions or profiles. A traditional scheme of alternatives (generally expressed with the three prong high-medium-low) is being accepted in more recent times as a more modern concept that conceives forecasts as an application and whose argument is a set of parameters that belong to a given scenario, which generates solutions or profiles based on a certain set of exogenous variables; and which in turn constitute a space, the space for solutions.[57]"

Therefore, the path travelled for the construction and evaluation of scenarios will not lead to a single vision of the future.

If there is more than one possible vision for the future, how are these differentiated among themselves? Or more properly stated, which is the one that could have an incidence upon the evolution of the energy sector, so that the future will appear closer to one scenario instead of another one? Of course, this will depend on the parameters adopted and of the behavior of exogenous variables.

For the purpose of an example, let us assume that starting from the construction of multiple scenarios, three have been selected that in general terms could be characterized by the behavior of three variables.

A "base scenario" could present a relative stability in the long-term price of oil and substitutes, a slow and deliberate penetration of new sources of supply, and a growth associated to the process of urbanization and industrialization, with an elasticity-income of slightly higher than one.

A scenario thus described could be considered as one of "the trend", that is apparently free of ruptures. Although it is necessary to caution, that it could also harbor developments, such as an increase in the participation of non-conventional hydrocarbons in the world supply that acts as a reinsurance of stable prices.

Based on this scenario, the model or models of planning to be used would produce a certain set of solutions that –in very broad terms- would describe a package of projects that are capable of satisfying that demand, with characteristics of a local optimum.

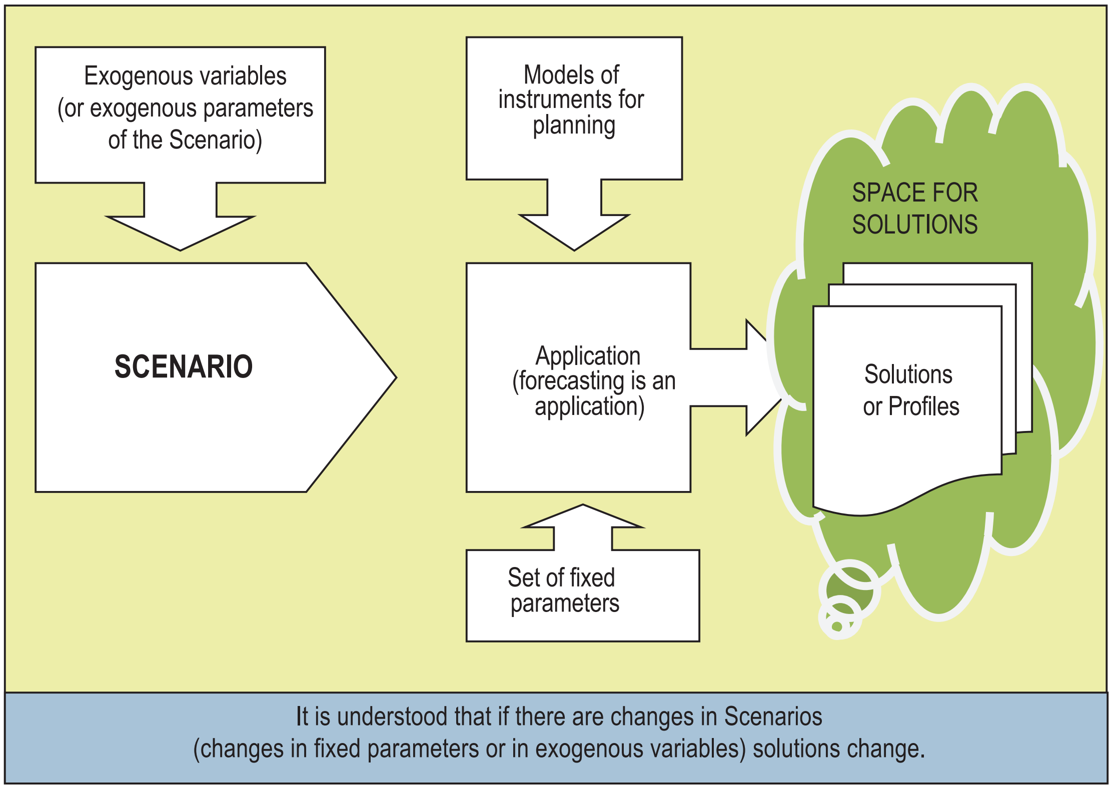
Continuing with our example, a second scenario could be characterized by a sustained downward trend in fossil fuels prices. This of course would affect the rhythm of penetration of new sources, and could impact on the demand due to the effect of price.

Of course, this type of scenario would lead to a set of different solutions, and such differences would be deeply influenced by the situation in which the country finds itself with respect to the supply of hydrocarbons, whether it is surplus, deficit or balanced.

56 The description of the method follows the recommendations of the European Commission "Evaluation".

57 OLADE. "Call for contracting consultancies to develop the Energy Planning Manual - Chapter V: Construction of Scenarios". Year 2013.

Figure IV.3: Space for possible solutions



Source: Authors.

There could also be a third scenario –always as an example- in which a sustained policy for efficient use – associated to environmental or macro-economic causes- impacts on the growth of demand. The package of projects contained in the set of solutions would have another content and costs.

Notice should be taken that on an initial view, it is not possible to determine as "the most desirable" any of the three scenarios. Changes in the variables that have been mentioned as an example~~,~~ would have a different impact according to the structural condition of the country in question, and also according to its situation as an exporter or importer of energy products. Changes in the international price of hydrocarbons could be favorable or otherwise. And it always seems to be desirable to have a sustained policy for efficient use, but we must recognize its limits in the competitive nature of the goods exported by such a country. This is only a simple example based on the behavior of a few variables.

IV.7.1. Space of solutions

The purpose of scenario building is not simply to identify the most probable or the most desirable one, but to the contrary, an effort is made to have available the tools that permit us to face, from planning, an array of possible situations, having rational answers to each one of them.

Each one of the three scenarios of our example will derive into applications (forecasts) that emerge from the use of planning instruments and the use of fixed parameters described in the respective Chapters of this Manual.

In the described sense, the different scenarios will not present a single solution but rather a multiple one, the possible results of which must be considered as a continuous "space of solutions" within which must be introduced all possible situations to be taken into consideration on the part of the instances of political decision to which are addressed these planning studies, and within them, the scenarios that this Chapter deals with.

It is possible to present another case[58], if there are two scenarios "well contrasted" that are two well-differentiated images of the future, and in them are to be found the sets of decisions relative to supply that respectively are forthcoming from common elements. Then the investment decisions, of which both sets form a part of, are referred to as "robust decisions", and are the ones that stakeholders would adopt under any case. In this event, an awareness of that set on the part of the involved stakeholders, considerably reduces the degree of uncertainty in the decision making process.

58 IDEE/FB/SEI (2009).

Different scenarios will not present a single unequivocal solution but rather of a multiple nature, a "space of solutions" that is continuous within which will be introduced the possible situations to be taken into consideration on the part of political decision instances.

Finally, as a summary, a call is made to again consider the thought of the already quoted author Matos, D.[59]; in a phrase that possibly expresses the essence of the scenarios technique:

> *"The most transcendental consequence of setting aside the excluding search for a single correct quantitative answer is that, with it, the future ceases to be a single-dimensional possibility. The essence of the forecast consists in the capacity of being able to exactly describe a complex situation that will take place (or will not take place) in the future. To the contrary, a forecast by means of scenarios, describes an array of events or situations that are coherently foreseeable – at most – a statistical appreciation relative to the probability of its occurrence. Thus, the future that rises from a set of scenarios is essentially multidimensional and the logic of the model is normally expressed by means of a series of conditional affirmations in the style of "if **X**, then **Y**; but if **W**, then **Z**".*

IV.7.2. Multi or single-dimensional exposure

Alternatively, the employment and exposure of a set of scenarios in parallel, some countries present the applications of their planning based on a single or "assumed" scenario" – although prepared with different degrees of alternatives y sensibilities – complemented with periodic revisions that confer a dynamic character to it.[60]

In these cases the concept of the "space of solutions" is still valid, since although implicitly stated it is the multidimensional vision of the future and the conditional nature of results, although the form of exposure awards priority to the emphasis of a single dimensional type, that is projected to the planning horizon, but which like what happens in certain multidimensional presentations, is reviewed periodically with a certain frequency.

The sequential and periodic review of planning implies the study and re-preparation of the scenarios and consequent applications, in a process that enables constructive techniques, and to strengthen and consolidate its results.

In the following section, the use of planning scenarios in LAC and in other instances is presented and studied, that deals on those characteristics in other instances, and these characteristics will be examined.

IV.8. Planning Scenarios in LAC

This section illustrates some examples of the use and treatment of "Scenarios" in energy planning in the Member Countries of OLADE and also in other countries or organizations of interest. Some of the examples are not truly planning exercises, but rather constitute visions of future energy scenarios at the global or local scale.[61]

Although all of the cases analyzed incorporate the technique of "scenario building" to frame their planning projections, two types of characteristics referred to at the end of the preceding section become evident.

One type is that of the "scenarios in parallel", that reflects the technique predominantly presented in this Chapter that consists in considering a determined future horizon, a set of possible alternatives for explanatory variables, establishing what we have already defined as a "space of solutions" for the different applications, even though when almost always and due to simplicity, one scenario is highlighted among them, such as that of base, of trend, middle or of reference.

Another type of implementation is that of an "assumed scenario", that consists in adopting a single path for explanatory variables, even under the admission of variations, alternatives and sensitivity analysis, but without being expressed as such as an alternative scenario.

59 Matos, D. (2011). CHAPTER VII. Una Estrategia por escenarios.

60 In the next section of this chapter, the planning examples from Mexico, Brazil and Spain are analyzed, which respond to the presentation feature indicated here. Also the case of Exxon Mobil, which is not properly planning but a vision for the future of the global energy market, with a unique scenario assumed.

61 AGEERA, CEPAL, EIA, Shell, ExxonMobil.

Both methods are constructed in a similar manner and are enriched when they carry out a continuous process of temporal and periodic revision (every year or several years), because they strengthen the constructive technique, provide feedback and consolidate their results.[62]

Organization of the energy sector has a lot to do within one or the other method. An energy sector with dominance of the State and vertical structures doesn't appear the same way as in a sector under market economy with more and more diverse stakeholders.

The case of "assumed scenarios" is more frequent in the presence of predominant energy stakeholders of the State whose plans already consider projective as well as official scenarios, while in the technique of "parallel scenarios" it is possible to observe a more diverse conformation in markets. Continuing with a review in time, both methods are valid although the technique of "parallel scenarios" presents more clearly the alternative margins towards possible future scenarios. But in the last instance, the difference lies in a matter of presentation, derived from the characteristics of each country and of its energy reality.

The number of scenarios per study is basically between two or three, with particular alternatives and considerations, especially when possible technological variations are introduced to cover energy supply

In the charts included in **Annex II-B "Planning Scenarios in LAC and others"** the examples analyzed are illustrated and refer to consulted documents.

Regarding the temporary term, cases depicted in the charts include future scenarios for a period of not less than 8 and not more than 40 years, with an average of 20 and a median of 15 years.

Between 8 years and 15/20 years are the studies of evolution of power systems and networks (gas and electricity) that comfortably includes the time necessary to foresee and execute investments for their expansion. Terms adjusted to 8/10 years refer to power systems and networks, whose usual investment projects could also be included within those terms. Longer terms correspond to long-term studies in a more international perspective, as are the cases of EIA (USA), ExxonMobil and Shell and also with a more mercantile planning vision, as is the case of NGC.

The number of scenarios per study basically falls between two or three scenarios, with particular alternatives and considerations, especially when there is the introduction of possible technological variations to cover energy supply. In such cases, the number of possibilities studied and evaluated may reach several dozens, but the final result concludes by being summarized and few variants.

Among the variables considered to define scenarios, there is a predominance of those that determine the expected level of demand. All studies start from projective studies that express trends or a determined continuity and introduce quantitative variations emerging from different circumstances. Thus, there is a predominance of estimates for a greater or lesser demand than that of the trend. And to this, in many cases it is necessary to add, the possible future effect of the introduction of policies and regulations that have the purpose of reducing the emission of greenhouse gasses, and lead to a more rational and efficient use of energy and a greater penetration of renewable energies.

Technological variables, as alternatives of coverage of future demand, expand the possibilities and in many cases makes scenarios much more complex, especially for less diversified and smaller size energy systems, in which the alternative of new technologies has a relatively greater impact than in more diversified and encompassing systems alternatives. [63]

62 The EIA, which presents scenarios in "parallel", reelabor in the opportunity to publish each year its "Energy Outlook". And in the "Issues in focus" section, compare the assumptions you use each year against those of the previous two years. For its part, the EPE of Brazil, which presents "assumed" scenarios, also modifies annually some of the parameters or assumptions. A similar case is that of Mexico, as shown in the respective table. Exxon Mobil also presents an "assumed scenario" that periodically re-elaborates.

63 Of the analyzed, it is especially the case of the CA countries.

CHAPTER V

Prospective

KEY WORDS

Prospective, planning, models, demand, supply, resources.

V.1. Introduction

The main objective of this Chapter consists in characterizing the development process of energy prospective, information required, tools to be used and possible alternative approaches.

Throughout this chapter are described and analyzed the necessary elements required to carry out the prospective, offering a description that begins with the demand for energy, passing through its supply and the resources, additionally describing the principal technological aspects that may influence an energy plan and concluding with the description of those aspects linked to the investments prospective.

In that which refers to the demand prospective, a description is offered of the information required to prepare it (either based on the information limited to energy balances or that resulting from studies in the field that reveal consumption in terms of sources and uses). Regarding the supply, various approaches are described that permit determining the future supply to satisfy demand, using for this purpose simulation and/or optimization models, and in addition presenting the weaknesses and strengths of each approach. The principal techniques used to estimate resources and reserves of the different energy products are later analyzed and described and there is also an evaluation of the changes in technology considered in an energy plan affecting demand and supply. Finally, are described the principal criteria that must be considered in the preparation of an investment plan referred to an energy plan.

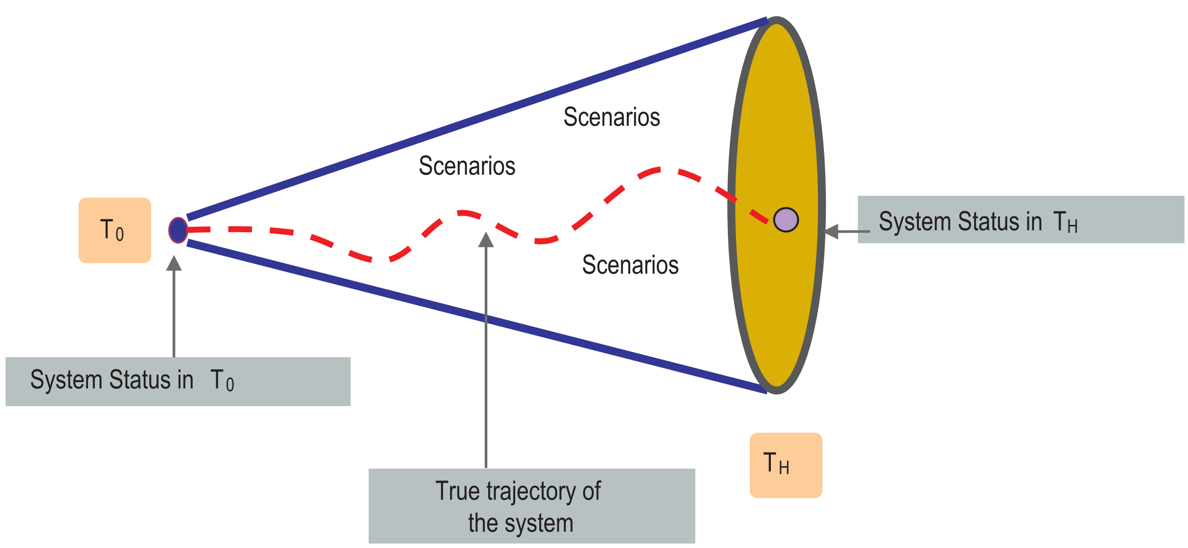
The points of the chapter respond to the logical sequence of the planning process, starting it with the analysis of the methodological approach, describing the planning process of demand, going through that of supply and reaching to that of resources.

V.2. Characterization of the Prospective

V.2.1 The prospective analysis

The prospective analysis is meant to be an operation which allows realizing an exploration of the future. Graphically it can be imagined like a solid cone, whose vertexes represent the position of the system in the present moment (T_0) and its extension reaches up to the foresight's horizon (T_H). The cone's diameter is expanding, when passing from T_0 to T_H, as the variation of the possible situations which the system can assume are increasing.

Figure V.1: Formulation of Scenarios



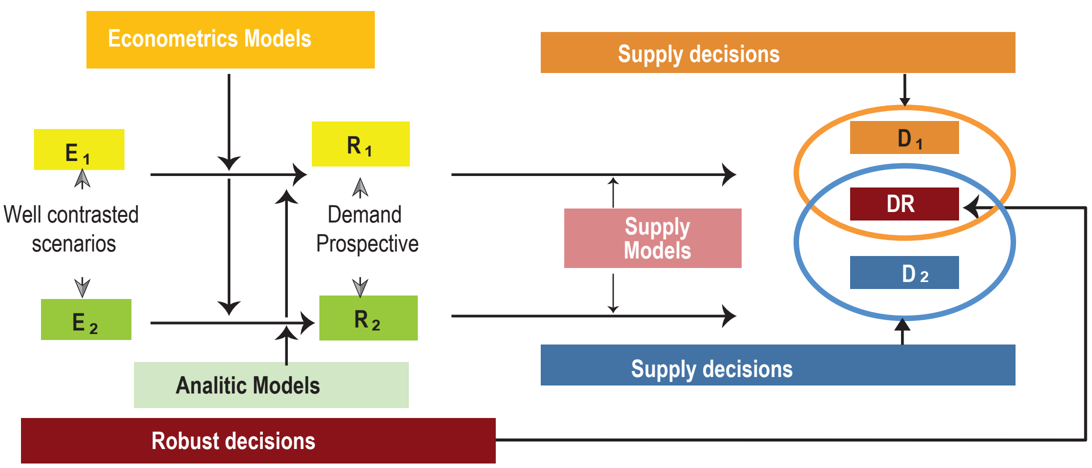
Source: Authors based on "The construction of Socio-economic Scenarios for Energy Prospective", Fundación Bariloche, 2013a.

Thus, the idea of prospective analysis supposes the formulation of a variety of scenarios that represent well-contrasted evolutions (which in Figure V.1 are covering the external surface of the cone), so that in its interior they "contain" the real trajectory of the system with high plausibility.

This would suppose the formulation of an infinite number of scenarios, something that in practice would be impossible to carry out. Of course this in only a matter of a conceptual illustration that attempts to indicate that it is necessary that the set of scenarios that are formulated must be of a properly contrasted variety (represent situations and trajectories that are qualitatively different) so that they may contain a plausibility of the real trajectory of the system.

In Figure V.2 is presented a scheme that refers to the prospective analysis for energy planning or energy policy. As may be observed, two scenarios have been presented (socio-economic and energetic) E1 and E2, properly contrasted (a greater variety could be formulated); and based on them the energy demand or requirements are determined R1 (corresponding to E1) and R2 (corresponding E2) using econometric or analytical models (for example model LEAP or MAED).

Figure V.2: Robust decisions



Source: Authors on the base of "Construction of Social-economic Scenarios for Energy Prospective", Fundación Bariloche, 2013ª.

Through the use of supply models (of optimization or of simulation or the combination of both) investment decisions are determined, (D1 and D2) permitting to supply the requirements that correspond to each scenario. It is highly probable that sets D1 and D2 will have a not empty intersection, since DR (robust decision) are the elements of this intersection.

Proceeding in this manner, the prospective analysis will allow the location of robust decisions that are the ones that would be taken, whichever scenario is verified in reality.

This conceptual development permits the affirmation that the principal purpose of the prospective analysis is to reduce the degree of uncertainty in the decision making process.

V.2.2. Methods, and models and information of Prospective Scenarios for the Prospective

As indicated in Figure V.2, the prospective of energy demand or requirements can be carried out with the use of econometric models or through the use of analytical models. As far as supplying, optimization or simulation models are concerned, as will be seen hereafter, a pragmatic attitude must be developed from this toolbox. That is not to prefer the prospective methods by adopting a dogmatic vision, even though we must highlight the advantages and limitations posed by the use of the different models.

In the first place, reference is made to demand or requirement prospective models. As stated, this task may be started by means of econometric or analytical approaches. A question that must be initially examined is linked to the time available to carry out this job, since this is an aspect that significantly conditions the election of the focus and the model, considering the information required for its implementation.

In that regard it can be anticipated that analytical models require a considerable amount of information, both those which refers to the starting point of the prospective process and the scenarios on which it is based to prepare the trajectories for the future. The gathering of such information implies the availability of time and therefore the methodological approach to be applied. In summary, if a prospective exercise is required in a very short time, this will determine that the option is reduced to the election of econometric methods, understanding that its use will principally demand the time series of a limited group of dependent variables (object of the prospective) and explanatory (which must form part of the scenarios). This is one of the aspects that must be pointed out in the list of advantages and inconveniences of one and the other methodological approach.

However, admitting that the time available for the execution of the process of Energy Policy and Planning is longer, at least more than one year, or that the system of economic and energy information contains sufficient details (in terms of the variables that correspond to both scopes), it is of interest to discuss under which conditions are formulated the election of the two methodological approaches set forth, on the basis of the advantages and limitations that each focus presents, in addition to those previously mentioned.

Econometric approaches are coherent with the neoclassical theory tradition that has been characterized at the beginning of this section, and therefore coherent with its epistemological characteristics. Therefore it is coherent with the theory of demand resulting from it. It is that the demand for an energy source in a specific consumption sector will be in function of the consumer's income (or alternatively of the level of activity if it would refer to a productive sector) and of the relative prices of the sources and technologies available for utilization. In the case of residential demand it is necessary to add to this list some indicators of the income distribution. In essence, have to be taken into account the neoclassical theories of consumer's behavior and of production (demand of the productive resources that comprise the function of production) always admitting the own optimizing conduct of stakeholders within this theoretical approach.

For example, in case it refers to the market demand of residential consumers of source **j**, the demand function would be an expression of the following type:

$$D_j = \mathrm{f}\left(P_j, P_{aj}, P_s, Y_m, DY\right) (1)$$

Where:

D_j : Market demand for source j
P_j : Market price of source j
P_{aj} : Price index of the artifacts of use of source j (price of complementary goods)
P_s : prices of a substitute source
Y_m : Average income of consumers
DY: Indicator of income distribution

Expression (1) translates what indicates the economic theory derived from the aggregation of decisions taken by consumers to obtain market demand, with its determining variables. However, the specific application of this theory implies that other demand determinants, acknowledge the characteristics of the system under study. In the case of the demand for energy this will deal with variables related to demographic, environmental or relative to the supply coverage of the source under study.-Therefore, expression (1) will adopt the following form:

$$\mathrm{Dj} = \mathrm{f}\left(\mathrm{P}_j, \mathrm{P}_{aj}, \mathrm{P}_s, \mathrm{Y}_m, \mathrm{DY}, \mathrm{Z}_1, \mathrm{Z}_2, \ldots, \mathrm{Z}_n\right) (2)$$

where variables Z_i represent other determining factors of the demand of energy source j, in addition to those previously indicated.

The first stage in the application of the econometric approach presupposes the specification of source f, of the variables in a compatible manner with the information available and of the random characteristics of error in the equation (mean, variance and of other parameters of its distribution). Regarding the form of the function, economic theory does not provide indications beyond the recognition of the adoption of a potential form (linearized in logarithmic terms) that will imply that there is an implicit admittance of the dependent variable that will have a constant elasticity with respect to each one of its arguments and that the adoption of a lineal form will imply that those elasticities must be variables with the level of the variables considered.

Once that all decision have been taken relative to the specification, the econometric approach continues with the stage of estimation of the adopted model's parameters. Without going into the details of the econometric technique, a task that escapes the scope of this chapter of the manual, it corresponds to discuss the principal advantage of the use of this methodological approach as well as its **most outbound limitations.**

The first limitation of the econometric approach is the characteristic of transferring to the future the past structural features of the system. This property of the approach establishes a strong inflexibility to represent structural changes.

In second place, the econometric approach has strong limitations to represent the substitution process among energy sources. Taking into account what has been stated, when relying on the neoclassical theory of demand, the substitution processes are represented by means of the relative prices of those sources that presupposes that all of the energy sources are disputing the supply of energy services are traded in the formal markets. This means that all sources of direct appropriation on the part of the consumer are excluded.

On the other hand, this methodological approach does not permit to represent the penetration of sources that were not present in the past, a matter that limits the challenge in the market of energy services to the sources that were traditionally supplied.

In summary, and for these reasons, the use of the econometric approach to carry out the prospective task within the formulation of energy policy and planning, that in general terms, implies the presence of structural changes that this approach presents serious difficulties to be able to represent.

In contrast, the application of the econometric approach presents some **advantages** among which we can highlight, the already mentioned one regarding the possibility of being implemented in a very short term, due to the limited information required by its application, both as that which refers to the past as that relative to the formulation of scenarios.

For its part, the use of **analytical approaches**[64] is characterized precisely by being based on a structural approach, what attempts to establish a difference among the sets of consumers in function of a set of space-environmental, socio-spatial stakeholders, energy supply conditions and social conditions. This way, the application of those methods presupposes the identification of more or less ample groups of consumer sets that present reasonably similar characteristics regarding to their requirements, both what respects their present conditions as their dynamic behavior towards the future. These groups, which are generally denominated as **Homogeneous Modules**, have components that change throughout the period of the prospective.

Among the **advantages** of this methodological approach we can mention:

- √ Its flexibility to represent structural changes, a matter that is facilitated by the adoption of a systemic representation, linked to sources and technologies of use.
- √ This flexibility permits simulating strategies of a determined proposal for energy policy and thus to be able to evaluate its impacts.
- √ This is a simple and transparent approach that assures the physical coherence of the system.

With relation to its **limitations** it is necessary to point out:

- √ The amount of information required by its full implementation, both as that related to the starting point of prospective as that which refers to the scenarios.
- √ Does not assure economic consistency.

Down below will be inserted some considerations with regards to the methods used in **supply planning**.[65] As has been schematized in Figure V.2, linked to each prospective requirements a certain set of supply decisions in the plan should correspond to them. To carry out this task two principal types of approaches can be used: those for **optimization** and those for **simulation**.

The varied **optimization models** that are used for energy planning may be referred to either represent planning an energy productive chain or the whole set of the energy system incorporating links with other and different chains that comprise this system pretending to find solutions that are more “efficient” on the basis of certain criteria defined by the planner. These criteria may be captured in a certain **“objective function”**. It is more frequent that such optimization models use the technique of **linear programing** that in the main problem permits the deduction of *efficient* solutions regarding quantities and the dual problem that supposedly contains the *marginal values of efficiency*.

Limits to optimization approaches. The planner should care not to assign to dual variables the interpretation of “efficiency prices” that correspond to the optimal of Pareto, ignoring that in both cases they are partial optimal results and therefore cannot have these attributes, beyond the fact that the use of models for linear programing implicitly supposes the existence of a perfect competition as a kind of market, what turns out to be contradictory with the specific characteristics of real markets. In addition, it is important to point out that usually decision making processes are of a multi-objective nature and even when there exists abundant literature regarding this type of optimization technique, Sawaragi (1985), its practical application to large size systems is very complex and requires the political decision of the planner.

S**imulation models** do not present these theoretical limitations and possess the flexibility to be able to represent different supply scenarios.

64 This issue will be discussed in greater depth in point 3 of this Chapter.

65 This issue will be discussed in greater depth in point 4 of this Chapter.

In consequence, in the measure of what is possible, it seems recommendable to have the joint use of both methodological approaches, based on the knowledge of the advantages and inconveniences that each one presents.

V.3. Simplified approach: Prospective of energy balance

It is usual to find situations in the countries of our region where resources are not available, there is no specialized staff or time to carry out the prospective and energy planning task or where the necessary information to make a deeper analysis of energy requirements and supply are not available. In other cases, the energy prospective studies serve as the basis to evaluate the effects of environmental policies, as is the case of proposals for the mitigation of greenhouse gasses. In these cases, it is possible to take advantage of the use of the prospective of energy balances that basically consists of making a projection of the desired period, necessarily on a long-term basis, of all the variables that comprise the energy balance of the country.

The prospective of energy balances is a typical case of the application of simulation models, that provides the advantages of considering the evolution of the energy system as such, that corresponds to the conception of the energy balance, a matter that assures the general balance of the projections of the different energy variables.

Scope and limitations of the balance prospective. The variables projected by this method are:

- Final consumption (or of net energy) by sectors
- Final consumption by sources
- Imports and exports by source
- National production of secondary sources in transformation centers
- Production of primary energy

When considering as a base the information from the energy balance, each of its elements is known with a high degree of aggregation. Therefore, by means of the balance prospective it will not be possible to evaluate with due precision the effects of measures of energy policy directed to a certain group of consumers or to the promotion of certain technologies, to mention only a few examples.

Necessary Information and explanatory variables. It is evident that the information is based on the national energy balance, prepared with the methodology proper of the country under study. It is necessary to have available balances for the base year of the projections and for a historic series of 10-to 15 years. The availability of the historic series is fundamental to be able to observe the evolution of the structure of the energy system in the past; and in addition, to be able to evaluate if the modifications proposed for the future maintain a certain degree of coherence.

In the balance prospective, are used as principal explanatory variables for energy requirements the followings according to the consumption sector:

Sector	Variable
Residential	Number of homes or population
Commercial, Services and Public	Sectorial value added
Industry	Sectorial value added
Transport	GDP, vehicle fleet
Agro, Fishing and Mining	Sectorial value added
Construction and Others	Sectorial value added
Non Energy Consumption	GDP

Therefore there must be available information for the base year, of these explanatory variables of energy consumption and thus be able to obtain *energy intensities or specific consumption* (consumption of final energy per unit of explanatory variable). There also must be a prospective or projection of these variables during the entire period of energy projection considered.

Within the final energy consumption, the two principal actions of energy policy refer to the substitution of energy sources and the penetration of new ones and to the energy savings by means of increases in energy efficiency or conservation practices. Information must be available regarding plans or measures that have been programmed in these two areas.

For the prospective of energy offer or supply information must be gathered relative to sub-sectorial energy plans; particularly those that refer to the expansion of electricity offer, to the capacity of refinement and treatment of natural gas and mineral coal, to cite only the principal existing centers of transformation in the countries of the region. For the projection of the supply of the remaining renewable sources, such as: firewood, charcoal, biomass residues, biofuels and solar, has to be used on one part the analysis of the historic series of balances and, on the other, regarding new sources, the specialists or institutions entrusted with their promotion, as is the case of biofuels or solar energy. In order to determine the levels of activity of the national transformation centers, it is necessary to previously determine or establish hypotheses relative to energy exchanges to the exterior: import and export flows both to the countries of the region as well as the extra-regional ones.

Prospective of consumption and energy supply. The prospective process begins with a projection of energy consumption in each one of the sectors considered in the energy balance. In the first instance, there is a projection of final total consumptions of the sector, multiplying in the time the energy intensities (or specific consumptions) by the values projected that correspond to the explanatory variable. At the same time there is the need to make a **projection of energy intensities**: it is expected that these coefficients will decrease in time as a consequence of technological change, the use of more efficient artifacts and equipment and additional measures for energy savings or conservation that is related to the changes in the habits of energy consumption. As a reference it is possible to use analytical prospective, where these changes are analyzed in greater depth, in general provide reductions in energy intensities in the order of 10 to 20% in the values of the horizon year (normally 20 years) respect to the base year. However, it is convenient to analyze the case in which energy intensities tend to increase as a consequence of a more equitable distribution of household incomes, or a greater development of energy-intensive activities as in some basic industries. The final result must compensate these increases with the reductions due to greater efficiency in the use of energy.

The next step is the analysis of **the substitution processes** between energy sources of each sector of final consumption. The result of this analysis is the projection of the structures of final consumption by sources (percentage participation) in each sector, and for this we must take into account the evolutions of those participations in the past, information provided by the historic series of balances. Also must be considered the long-term historic evolution, but more particularly the changes observed during the last five years. Continually we must consider the policies presently in force regarding the penetration of sources, which could be the overcrowding of a conventional source such as natural gas, a greater penetration of LPG in rural areas, or the penetration of new sources.

Once the process of the consumption projection has concluded, it is possible to begin projecting the energy supply or offer.

In the first place it is necessary to project the secondary sources, which are produced in secondary transformation centers[66]: beginning by the projection of electricity supply. That is so, because for the production of electricity it may require, for example, fuel oil or diesel produced in a refinery; that is why refineries must be projected once the projection of electricity has been completed. Then, there must be a projection of the electricity balance, where variables to be determined are imports, exports and losses in transport and distribution. Following this, the remaining result depicts the needs of national electricity production.

The following step is the projection of electricity generation, in view of the simplified method of the balance prospective optimization or equilibrium models that are normally used by electricity planners will not be applied as mentioned later in this chapter. The evolution of the power generation park will then be projected taking into account the desired evolution of generation in percentage terms by type of plant and source of intermediate consumption. Improvements will be assumed in the efficiency of the electric power stations and self-producers, in particular in conventional thermal power stations.

Then there will be a projection of the remaining secondary sources, taking into account the planning of those that require another secondary source for its production, as the mentioned typical case of electricity. Projecting the balance of each secondary source, we will obtain as a result the needs of national production in gas treatment plants, refineries, bunkers, distilleries, coke ovens/blast furnaces, etc.

The following is a projection of the self-consumption of the energy sector. Normally, energy balances record their own consumptions in a partial manner, and only the consumptions of sources produced in the transformation centers. For example, generally are not revealed the consumptions of electricity in refineries or in oil fields, which can be of considerable magnitudes. Self-consumptions are projected with the evolution of the variables associated to them, for example, production in electric power plants, the crude oil that is processed in refineries, natural gas injected into the head of gas pipelines, etc. These self-consumptions lead to an increase

66 Referred to as centers of primary transformation are those that only transform primary sources (refineries, natural gas treatment centers, coal yards, alcohol distilleries, etc.), and secondary transformation centers that transform primary and secondary sources (electric power stations, self-producers, petrochemical plants, blast furnaces, coke ovens, etc.).

of production requirements in transformation centers, in turn increasing self-consumption. Normally, with two or three interactions a reasonable equilibrium is reached.

Once that the expansion of all primary and secondary transformation centers, has been projected, the conditions are given to project the balances of each primary source. The principal variables to be defined are imports and exports of primary sources, and then the result is a determination of the needs for production of primary sources, both renewable and non-renewable. In this latter case, taking into account the relation reserves/production projected of the base year, the final result will be the determination of the needs to incorporate reserves during the entire period of projection.

V.4. Demand prospective: analytic approach

Consumers are grouped in homogeneous groups, that is: a set of consumers grouped on the basis of similar social, economic, environmental, technologic and cultural conditions; supplied or not by determined energy sources; and of which a similar behavior is expected when facing variations in the determinants of energy consumption. It is then indicated that energy consumption of each homogeneous module is analyzed at the level of uses and sources. This permits a direct relation of energy requirements to human needs, both productive of wellbeing. It permits a better evaluation of the substitution processes between energy and the impacts of the efficient use of energy.

Finally, mention is made of the analytical methods of the requirement (or demand) prospective permitting an impact evaluation of the measures of energy policy when these are focalized on determined situations that must be improved.

V.4.1. Prospective

The analytic approach has the strength of an analysis that could be performed on the basis of a bottom-up focus for the application of which there must exist information on demand, disaggregated at the level of a homogeneous group of consumers, also called homogeneous modules (example: high, medium and low income homes). For each one of these, energy consumption matrixes by sources and uses must be available, as well as the average efficiency of the used artifacts. With this information the planner is able to analyze for each homogeneous group of consumers the impact of a measure of this type (labeling of refrigerators), being able to also estimate their effectiveness and/or type of incentives that should be implemented in each group, so that the measure is successful.

The technique of demand prospective that follows these criteria is also called a prospective by analytical methods. This approach permits analyzing the impact of structural changes that are meant to be towards the future, such as: substitution processes between energy products, inclusion of new supply, improvements in energy efficiency, among others.

As presented in point V.6, of this chapter, throughout history, the penetration of the technologies of final use in the demand has been much more dynamic than that registered in the technologies of energy supply. However, the models and information available privilege the modeling of offer vis-à-vis that of demand. This is why the energy planner must favor the search for and systematization of the base information that will allow the representation with an adequate level of detail of who, how and with what technology final users consume energy, in order to be able to develop the prospective of energy demand, on a well-informed base.

To have access to this information, there are at least three possible alternatives. The first consists in having access to qualified informants, who normally are sectorial experts, and who on the basis of knowledge and experience can provide general guidelines to be able to open the energy demand at the level of the different uses and sources of energy by user category.

The second alternative, consists in in using secondary information obtained in some type of national or regional survey, (for example population and housing census, permanent home survey, economic census, etc.), that permits the identification of consumptions by sources and uses generating a proxy of consumptions by consumer at a source and use level (example: based on permanent home surveys it is possible to obtain data relative to equipment and the energy sources with which families cook, access to the power grid, etc.).

The third alternative consists in the preparation of primary information, based on the development of sectorial surveys that permit the identification of energy consumptions by source and use at the level of each consumption sector and subsector, considering also the homogeneous groups that comprise it.

These field raids, depending on the extension and complexity of the country, normally take several months of work for their development, permitting the determination for a specific year, of the source and use matrixes that will be later used in analytical models (LEAP or MAED type), for the development of the demand prospective, based on the links between economy and energy.

Various countries in the region have progressed in the elaboration of useful energy balances. Even if the information which can be extracted from useful energy balances cannot necessarily cover all requirements of an analytic prospective, it is without doubt a source of information of extraordinary value which will make the planner’s job easier. Other information which could be found actually in the countries in the region is the one related to indicators of energy efficiency, which also will contribute to the process of demand prospective.

Stated demand prospective, begins with the preparation of base information (sectorial energy balances, or detailed information obtained by means of one of the three alternatives previously mentioned). In turn, it is necessary to develop socio-economic scenarios, that present the evolution of explanatory variables that break down in detail the energy consumption of each sector, as well as the preparation of energy scenarios, raising issues of structural changes or historic trends, relative to the penetration of fuels, improvements in efficiencies of artifacts or variations in energy intensities, among other aspects. The building of these scenarios has been treated in the previous chapter.

With the purpose to operationalize the methodology for the prospective of future energy requirements, and within it with what types of sources and technologies these will be materialized (analysis of substitutions), the complex process is separated into two aspects: on one hand all of what leads directly to the level of satisfaction of the energy needs of users (homes, commerce and services, industries, agriculture and livestock, transport, etc.) and on the other, the election of consumers among the different options of sources and technologies that are presented to them. We highlight the fact that this separation is only a methodological question, to be able to provide a detail of the effects of determining factors of energy consumption over each one.

The process of the prospective of future energy requirements has to consider all the aspects that contribute to improve the level of satisfaction of the final users’ energy needs and the election of consumers between different source and technology options which are offered to them.

The evolution of the level of satisfaction of human needs that require–energy consumption implies a definition of useful energy consumptions[67] by home – specific consumption or energy intensity – in time and, especially (as previously announced), the disaggregation of that consumption by uses[68].

The analysis of substitutions rises from the structure (participation) of technologies and sources used in useful energy consumption of each use in the base or present year and provides as a result the evolution of said structure during the period of projection.

The results of both processes are then integrated, and also consider the evolution foreseen in the other determinants of energy consumption in households, provide the projections of energy consumptions, net and useful, by sources and uses.

Additionally, it is necessary to estimate, based on the results of the projections, the total expenditure on energy in homes for the future and to compare it with the evolution of the income forecast. This may result in an increase in the participation in the energy expenditure, which may place in doubt the viability of the results obtained; while to the contrary, a relative decrease in the energy expenditure implies an improvement in the situation of-households that may have been an objective of the energy policy.

Finally, if the process of energy planning is of a comprehensive nature, the results of the projections for the different homogeneous modules are added, to thus obtain the total energy consumptions by sources of the sector, region and country, and thus be able to continue to the energy supply analysis.

V.4.2. Residential Sector

In this sector, the recommended opening (which depends on available information) is established on the basis of the disaggregation of consumption in a first level referred to the urban and rural areas. Access to modern energy sources and the quality of service is very different in urban areas with respect to rural areas, and therefore the matrixes of sources and uses will be likewise.

67 Useful Energy: this is obtained by multiplying net energy consumption of an artifact with the average performance of said technology.

68 Present terminology of the concept of the use of energy products has been modified fore energy services, to refer to its final uses.

A second level of opening takes place considering the income levels of homes. It is evident that in a low income home there will be access to different sources of energy and equipment with respect to a high-income home. This implies different matrixes of sources and uses as well as artifacts with varying performances, when facing signals of an energy policy (example: changes in lighting fixtures), the level of response for each type of consumer will be different according to the income level of the household.

Additionally, it may be required to divide a given country by regions according to its bio-geographic characteristics, mainly if it is a huge country implying extreme latitudes with very diverse climates (example: Argentina, Peru, Brazil, etc.).

The following schematizes the proposed basic opening:

- √ Residential Sector
    - Urban
    - Rural
        - High Income
        - Medium Income
        - Low Income

The uses of energy in the Residential sector must be de-aggregated, at least in the following categories:

- √ Illumination
- √ Cooking
- √ Water Heating
- √ Heating
- √ Food Conservation
- √ Ventilation and Air Conditioning
- √ Water Pumping
- √ Other Artifacts

At the level of the explanatory variables of this sector, it's the number of homes by homogeneous group of consumption the normally used variable. For the base year of the prospective, it will be necessary to identify energy consumptions by use in each household, expressed as energy intensities (example: kilocalories of net energy or useful energy consumed by each home in cooking with firewood burning stoves). In socio-economic scenarios has to be consigned the evolution of homes in each homogeneous group, based on economy-energy links (with the use of elasticities for example), it will be necessary to determine the evolution of energy intensities, and on the basis of the energy scenario to establish the evolution of the performance of artifacts and the possible process for substitutions (example: consumers that migrate from firewood stoves to others that use LPG).

With all these elements, and with the assistance of analytical models such as LEAP or MAED, it is possible to configure with them the matrixes of sources and uses for the base year and with them, together with the hypotheses of scenarios, it will be possible to undertake the prospective of energy demand of that sector.

V.4.3. Commercial, Services and Public Sector

This sector includes the activities classified in sections E, and from G to U, of the International Standard Industrial Classification of All Economic Activities (ISIC, Rev. 4) of United Nations. From section H, Transport and Storage, are only included the energy consumptions of offices, deposits, ports, airports, support activities, etc.; but are not included the energy consumptions of different vehicles according to the road, air, railroad or fluvial/maritime modes, since these consumptions are included in the Transport sector properly considered.

In the disaggregation by homogeneous consumer modules of the Commercial, Services and Public sectors, according to the geography of the country it may be required to have an opening by regions in case of very large countries and with regions having very different climates. This is due to the importance of energy consumption for air-conditioning (heating and refrigeration) and for water heating of this sector, similar to that of the Residential sector.

Beyond the regional opening, the first disaggregation that must be made is that of consumers by subsectors, according to the type of activity and taking as a base the classification of ISIC. The number of subsectors and activities included in each one of them will depend on the country. Normally with 6 to 8 subsectors it is sufficient, for example:

- √ Commercial, Services and Public Sector
  - Wholesale and Retail Commerce
  - Hotels and Restaurants
  - Teaching
  - Health and Social Assistance
  - Public Administration and Defense
  - Water and Sanitation
  - Other Services
  - Public Lighting

Additionally, if the intention is to work with a greater level of analysis, each subsector can be stratified by size of establishments into large, medium and small; and an additional opening could be made, if these are managed publicly or privately.

The categories of uses (energy services) to be used in the Commercial, Services and Public sectors are:

- √ Illumination
- √ Cooking
- √ Heating Water
- √ Heating
- √ Food Conservation
- √ Ventilation and Air Conditioning
- √ Water Pumping
- √ Internal Transport
- √ Other Uses

The principal explanatory consumption variable of useful energy of the sector is the activity level. This can be approximated through the aggregate value of each subsector, the gross value of production or the personnel employed. These are the variables commonly used; however in certain subsectors it is possible to use variables of a more physical type, such as: number of rooms and dinners in Hotels and Restaurants, students registered in Teaching, number of beds in Health, population that has the service of Water and Sanitation and Public Lighting. For the base year, it will be necessary to calculate the specific useful consumptions or useful energy intensities per use, that which is the consumption per unit of activity level.

Then, for the prospective study, we must consider the substitution or competition processes between sources and technologies for each use of energy. In this sector, normally the principal substitutions take place in water heating for sanitary uses, heating and cooking. In water heating we can mention~~,~~ together with the competition with traditional sources, the use of solar energy; in heating, the diffusion of the heat pump effect in air-conditioning units; and, in cooking we must bear in mind that an important part of energy consumption that takes place in Restaurants, the election of the source follows cultural patterns.

In the field of energy efficiency, the preponderance of electricity consumption in the sector indicates that the measures to receive priority must be directed, without being excluding, to the incorporation of efficient lamps and artifacts, techniques of efficient management in lighting, both on public as on private level, temperature control in refrigerated rooms and improvements in envelopes of buildings. Measures directed to fuel savings must also be considered in accordance with the characteristics of energy supply of the country.

V.4.4. Manufacturing Sector

The Manufacturing Industry sector corresponds to the activities of Section C of ISIC Rev. 4.

Energy consumptions in Industry depend on the type of good produced, the technology applied and the configuration of the different productive plants in those cases of processes of a greater complexity. Consumptions that depend on the weather generally do not have a great incidence in the total consumption of energy in Industry, for which reason it is not necessary to make a regionalization to determine homogeneous modules. However, said regionalization is undertaken to maintain coherence with the rest of sectors to carry out the planning of supply.

In the first place, the definition of the homogeneous modules is carried out in terms, and function of the good produced by grouping the different manufacturing activities into 10-12 subsectors, depending on the industrial productive structure of the country, for example:

- √ Manufacturing Sector
    - Food
    - Beverages and Tabaco
    - Textile and Leather
    - Paper
    - Wood
    - Chemistry, Rubber and Plastics
    - Non-Metallic Products
    - Metals
    - Machinery and Equipment
    - Other Manufactures

Not included within Manufacturing is Division 19 of the ISIC, manufacture of coke and refined petroleum products, since these activities are included within the consumption that corresponds to the energy sector.

Energy consumption in blast furnaces of the iron and steel industry and coke ovens are separated from the rest of consumptions of the Manufacturing sector and are included as intermediate consumption in the transformation centers~~,~~ coke and blast furnaces and as own consumption of the energy sector. In a similar manner, the consumption of hydrocarbons of Group 201, production of basic chemical substances, as raw material for obtaining plastics and other products under the denomination of petrochemicals may be considered as inputs of the center for transformation of Petrochemical Plants.

After having made this grouping by subsectors, the establishments can be stratified by size into large, medium and small; and later it may be necessary to disaggregate some subsectors according to their production technology when they have highly differentiated specific consumptions, for example, cement production through the wet or dry methods, cellulose production by mechanical or chemical means, iron and steel industries that are integrated or process by direct reduction.

The categories of use in the Manufacturing sector are:

- √ Illumination
- √ Steam
- √ Direct Heat
- √ Driving Force
- √ Process Cold
- √ Internal Transport
- √ Electrochemical Processes
- √ Non Productive Uses

The principal explanatory variable of useful energy consumption of the Manufacturing sector is the level of activity, and the ideal is to relate useful energy consumption with each use of physical production within each homogeneous module, however generally within a subsector different goods are produced and for this reason another variable should be used such as added value, gross value of production or the number of employees.

Substitutions among sources principally take place in the use of stream and direct heat. It is necessary to consider in the analysis the particular nature of those industries that produce energy residues, such as bagasse, black liquor, sawdust, shells, etc., which have a low or nil cost for the industrialist and~~,~~ additionally have a renewable nature.

In order to direct the activities of Energy Efficiency in the Manufacturing sector it is necessary to consider as a base, in case of having them available, energy audits or diagnosis performed in industries. Care must be taken in the expansion of these results to the corresponding industrial branch, since such diagnosis generally do not have a high degree of statistical representation and a direct extrapolation may produce important biases. The most usual measures of efficiency in the sector are the incorporation of efficient engines, variable speed drives, combustion regulation, improvements in insulations and the incorporation of cogeneration systems, among others.

V.4.5. Transport Sector

This is one of the most complex sectors to be studied, not only in Latin America, but also at the world level. In general the statistics available in the countries of the Region are incomplete, non-systematic and out-of-date. In the case of road transport, in many countries there are no databases that unify the registries of the vehicle fleet, that provide details of such elementary variables as the active vehicle fleet by type (example: cars, 4x4 pick-ups, busses, trucks of less than 2 tons, motorcycles, etc.), the type of engine that propels such units (example: automobiles with Otto cycle and Diesel engines, moved by LPG, etc.), the age of the vehicle, engine capacity, etc. These are basic variables for the application of the prospective methods of road transport.

In the case of other means of locomotion (air, fluvial, maritime, railroad, metro, etc.), it is normal to have access to base information, in view of the fact that there are few providers of such services and drawing on their knowledge it is possible to determine the fleet, energy intensities and on the basis of explanatory variables such as GDP, the added value of certain sectors that are associated to the means of transport (example: the railroad dedicated to the transport of grains in countries that have a strong agricultural activity, unfailingly will have as an explanatory variable the added value of the agricultural and livestock sector), it is possible to carry out the prospective of energy demand of such means.

Returning to the case of road transport, a well-disseminated method for the prospective of energy demand is the denominated VKR, where consumption by means of locomotion is obtained by multiplying the following parameters:

V = number of vehicles (active fleet), by

K = average number of kilometers travelled per year per vehicle, by

R = specific consumption in liters / 100 km.

Therefore, the expression used for the estimation of consumption of the road mode is the following:

$$Net\ Energy\ Consumption\ C, m, M = (Vx\ K\ x\ R)\ m, M\ (3)$$

C = Category: passenger or cargo

m = Means: Automobiles, Busses, Motorcycles, Trucks, etc.

M = Type of engine: naphtha engine, diesel engine, and LPG engine

V = Fleet or Number of vehicles with an engine M, expressed in units

K = Kilometers travelled by year

R = Specific consumption, expressed in liters/ 100 kilometers

To be able to carry out this task, in the first place we require a database that can provide the data relative to the vehicle fleet, discriminating by type of engine, kilometers travelled per year and specific consumptions.

As will be indicated later on, countries have normally databases of vehicle registries, but they do not include information on the type of engine nor specific consumptions and very often it is not clearly specified if the fleet therein consigned is net of yearly withdrawals. That is why it is necessary to carry out a cleaning of the databases provided by the institutions in charge of maintaining such registers, in order to re-categorize the different vehicles within the means of locomotion to be analyzed. Once this task is completed, it is possible to know the nature of the fleet in circulation for a specific year, classifying it under some criteria, as for example those presented next:

- √ Transport Sector
  - Road
    - Passengers
      - Car
      - 4x4 Pick-up
      - Taxi
      - Motorcycle
      - Bus
    - Cargo
      - Pick-up truck
      - Small truck
      - Large truck
      - Tracto-trailer

Once the fleet has been determined, there are two alternatives to gain access to the information that refers to specific consumptions and the average distances travelled per year.

One of them consists in the search for this information through specialized bibliography, principally in that which refers to specific consumptions. This information together with the assistance that can be provided by a sector expert, it will be possible to determine said consumptions, considering in turn, the particular characteristics of the fleet under analysis, such as average age, brand and model of predominant vehicle, fuel quality, etc. With this type of approach, the last variable to be determined is the average distance travelled by vehicle per year. Usually, this is the closing variable, against which it is necessary to adjust the consumption of each type of category of the means of locomotion, in order to obtain the total consumption of the transport sector, which has been calibrated with respect to fuel sales that are contained in the national energy balance.

The other alternative consists in the preparation of surveys, which are usually carried out in service stations where fuels are sold. On the basis of field operations it is possible to determine the average distances travelled per year, with simple question such as: what is the time in months or in kilometers that you make oil changes in the engine of your vehicle. The specific consumption (kilometers travelled per liter of fuel), may also be asked, but not in all cases drivers keep a record of this performance. As in the previous case, estimates of consumption by means of locomotion, once these have been aggregated must coincide with the sales of fuels that appear in the energy balance.

For other means of road transport that are not private (such as bus or truck fleets), access can be made to the principal companies of the sector to request data relative to the fleet and annual distances travelled and/or the statistics of the country itself that are registered in its annual reports.

To carry out the energy prospective of the transport sector, based on the approach herein presented, it is necessary to have the evolution of the vehicle fleet (which usually is estimated on the basis of econometric models, that link the evolution of the GDP/ inhabitant and the inhabitants per vehicle with the fleet; example: the function S-shaped of Gompertz that links the fleet with GDP/per capita).

After considering the evolution of the fleet, we analyze the penetration of the different types of engines that compete within each means of locomotion. For this it will be necessary to analyze the possibility of the penetration of engines of LPG, natural gas, flex-fuel, electric, etc., either with specific percentages of penetration (a consequence of policy objectives) or with the assistance of substitution models.

Finally, we must establish a hypothesis relative to the evolution of the kilometers travelled by type of vehicle. For this we will consider aspects of a socio-economic nature (for example if it estimated that there will be a modernization of the vehicle fleet, it is very probable that the average distance travelled will increase) and/or the impacts in the development of mass locomotion means (for example the expansion of the metro, or cargo trains) may have on the average yearly distances travelled, due to transfers of passenger and/or tons of cargo between means of locomotion.

Based on the consideration of all these variables and their evolution, we can apply analytical methods that permit carrying out the energy demand prospective of said sector.

V.4.6. Agriculture and Livestock Sector

The configuration of the Agriculture and Livestock sector for the purposes of the Prospective of its energy consumptions, this is the definition of the homogeneous modules, must take into account the regions of different bio-geographic characteristics since these determine the types of the most appropriate types of crops, the productivity of soils and applicable technologies, which in consequence have an incidence upon energy requirements. A second level of disaggregation corresponds to the type of crop or agriculture or livestock product. In this sense, such disaggregation may be:

- √ Agriculture and Livestock Sector
  - Temporary crops
  - Permanent crops
  - Cattle
  - Poultry
  - Forestsery
  - Other agriculture and livestock activities

In turn, according to the production levels of each product type it may be convenient to further disaggregate those subsectors, referring to a specific crop or product: soybeans, corn, wheat, sunflower cotton, beef cattle, dairy cattle, etc. Or to disaggregate by production technology (conventional planting and direct planting), by size of exploitation, if it is commercial or subsistence production, etc.; who are the stakeholders that have an incidence on energy requirements. The disaggregation that is finally adopted will depend on the country and of the objectives and scope of the prospective study.

Different energy use in the sector may be grouped under the following categories:

- √ Illumination
- √ Tractors and agricultural machinery
- √ Fixed machinery
- √ Irrigation and water pumping
- √ Heat
- √ Process cold

The principal explanatory variable of energy consumptions of the sector is the surface under cultivation and the number of heads of cattle.

Normally, the principal source consumed in the sector is Diesel fuel, used by tractors and the different self-propelled machineries for the performance of agricultural tasks. This limits the scope of application of Energy Efficiency and substitution measures between energy sources.

V.4.7. Other sectors

These include Fishing, Mining and Construction. Generally these sectors tend to have a lesser weight of energy consumption in countries, and often such energy consumptions are not identified in energy balances. In case that these sectors have important energy consumptions and/or such consumptions are discriminated, a prospective should be undertaken on a similar manner of the remaining sectors.

In Fishing, it may be necessary to discriminate those subsectors of artisanal and industrial fishing. In the first case, the explanatory variable may be the fishing fleet; and for industrial fishing the tons of capture. Energy uses may be classified in: Propulsion, Heat, Cold and Other uses.

In Mining, disaggregation in homogeneous modules may be carried out according to the type of mineral according to the production levels of each type. The explanatory variable is the production in tons of the mineral. Uses may be classified in fixed and mobile machinery.

The Construction sector can be considered without disaggregation. However, if a more detailed energy prospective is desired and there is available information for the base year, it is possible to disaggregate it into the following subsectors: Architectural Works, Road Works, Works of Infrastructure and industrial Plants. The explanatory variables are the surface built, the length of roads or the manner of investment, according to each case. Uses may be classified in: Illumination, Mobile and Fixed Machinery, and Process Heat.

V.5. Planning of the principal energy sources

V.5.1. Planning in the Electric Sector

Electrical planning consists in defining the course of the electric subsector relative to the works necessary for expansion, modification of the matrix of primary resources, combination of technologies, measures to manage demand in such a way as to comply with a satisfactory evolution in terms of providing services, a robust nature of decisions before possible scenarios and minimum costs, but also taking into account restrictions that are determined as priority, independently of being valued.

It is observed that electrical planning is a central issue within global energy planning, since it is deeply intertwined to the remaining links of the energy chain, particularly to the hydrocarbons sector, principally highlighting natural gas. To this we must add that the electric sector is more complex due to the multiplicity of primary inputs that can be plausibly used, their variability, diverse technologies and the necessary immediacy between demand and supply without a real possibility of storage.

It is pointed out that the conjunction of the stated aspects gave rise (and makes it almost unavoidable) to the use of models to simulate the behavior and evolution of possible alternative plans and evaluate them in their multiple dimensions. The modeling of an electric system provides important advantages to elucidate the most adequate planning, but it faces limitations when quantifying all of the aspects involved and therefore to assure the convenience of one solution facing another. Notwithstanding which, the exercise of isolating specific solutions, evaluating them (even though partially) and contrasting them, is essential for the decision making process, under the considerations previously undertaken. The limitations mentioned could be manifested more incidentally in the case of the electrical system depending on the structural complexity of these systems.

Principal characteristics of the electric system

One of the most accepted definitions of the Electric System is that of the Institute of Electrical and Electronics Engineer (IEEE), which states: This is a network formed by electric generating units, loads or consumptions and power transmission lines, including the associated equipment, electrically or mechanically connected to the network.

In practice, it is not very common that electric power plants can be installed in the vicinity of all important consumptions.

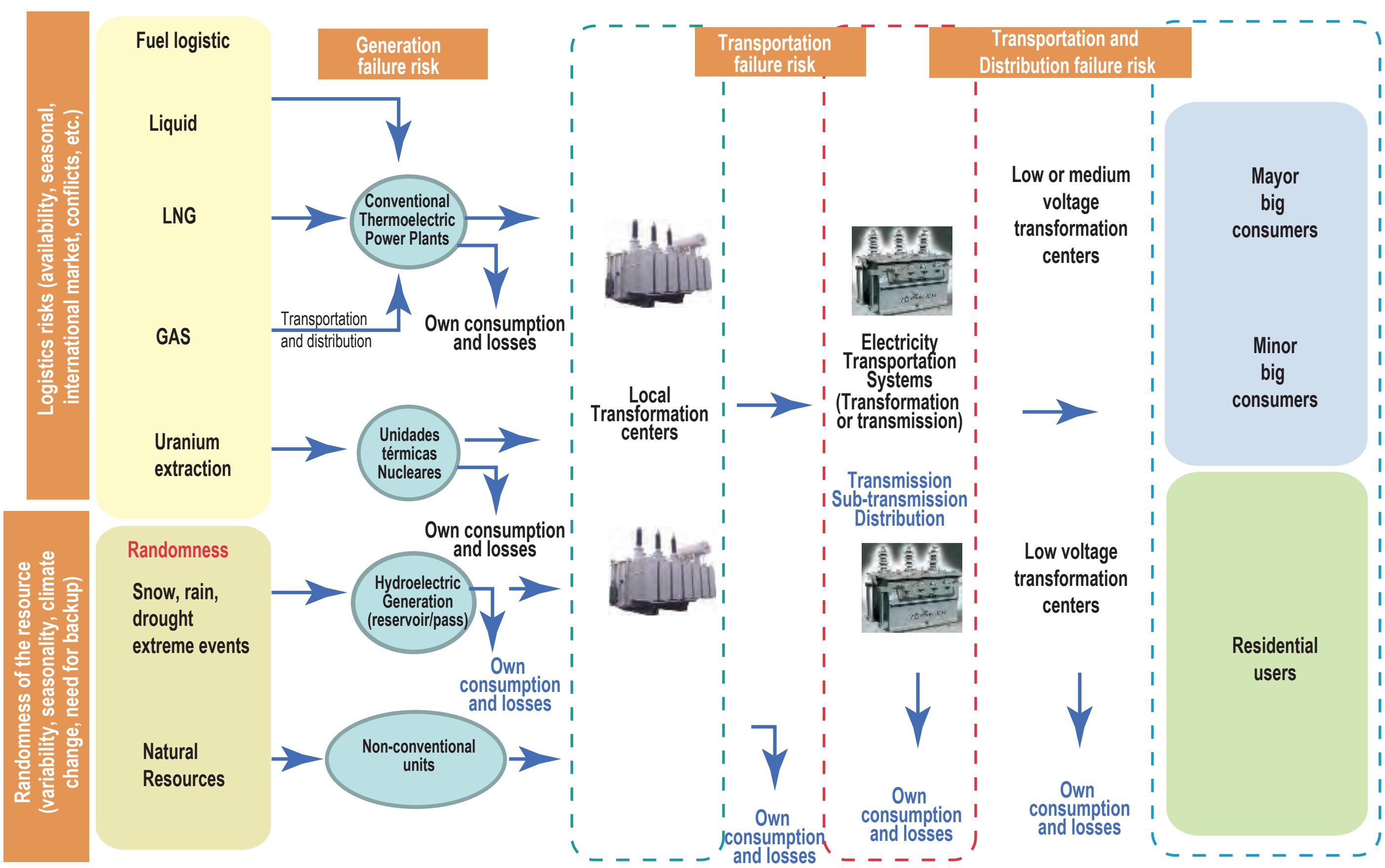
This fact obligates the construction of electric unions more or less important between electric plants and centers of consumption, unions that have slowly given rise to growingly more complex grids.

The clearest form of establishing the difference in an electric system is through the function carried out in its different stages, since this determines the quantities of power and energy that it must deliver, and as a consequence of that, the tension that should be used and the restrictions that will be imposed on its operation. From this point of view we can distinguish the following:

a) Power Plants, in which certain energy is transformed (thermal, hydraulic, etc.) into electric energy.
b) Transmission Networks, take the energy from the power plants to the region where the consumption is located.
c) Distribution Networks that directly supply consumptions.
d) Consumption

The following scheme illustrates the links that comprise a traditional electric network. Associated to the type of generation we can also observe potential risks of failure at different levels of self-consumptions and losses. After generation comes transmission and distribution, with their own risks, self-consumptions and associated losses; and finally to conclude with the chain are the different consumers. We can also see that between links there are the necessary transformation centers that raise or lower tension, to the corresponding levels. Thus we are able to observe the complexity of the structure, which additionally presents functional characteristics, markedly different with respect to other energy sources.

Figure V.3: The chain for electricity production



Source: Authors.

A peculiarity that rises in case of electricity is the need of providing attention to instantaneous, daily and seasonally fluctuations of demand, having to coordinate the periods for the maintenance of the machinery, daily recovery order and fine regulation of the amount of electricity produced to equal demand. This instantaneous follow-up, coordinated and timed necessarily demands the existence of a reserve of generation that is ready to cover any inconveniences.

Both the functioning as well as the diagramming of the electric chain are fractioned by ~~a~~ demand. This is highly relevant, since electricity is a secondary energy product that requires an electric transformation plant to be produced. Production of electricity based on the use of thermal machines transforms heat into electricity, a thermodynamic feature that reduces performance since heat is the most degraded form of energy, and in which the world average does not exceed 40%. The direct implication is a strong waste of energy in the case of using electricity with thermal purposes, if such electricity came from that origin. The actions of Demand Management in the case of electricity could be summarized in an effort to attenuate the hourly and seasonal demand fluctuation that implies important investments with a low degree of average annual use, as well as reducing the levels of energy and power consumption. In almost all of the electric systems of the world there exists an important installed power (in the area of 25-30%) that is used only a few hours each day, what is known as peak hours of the system, that generally corresponds to one or two hours after sunset.

Regarding the demand fluctuation, we must add the natural variability of some of the primary resources used in generation, which although as has been mentioned they do not occupy a very relevant place in the world level, in certain electric systems, they are fundamental and/or majority. Such is the case of a large part of countries in South America, in which hydrogenation participates in a very relevant manner in the electric Matrix.

This simplified presentation of electricity and its characteristics, permits us to clearly identify that planning encounters two well differentiated instances:

1) *that which respects the operation of the existing park with the implicit restriction of instantaneously satisfying the demand (instance denominated dispatch of loads) and performing it in the economically most convenient way or at minimum cost, although it may seem excessive to assume that all the costs are quantifiable and valuable; and*

2) *that associated with the expansion of the generating system thinking of the future growth of demand, in its future modification (spontaneous or induced), in the provision of primary resources as well as the direction of energy policy as a whole. This second type of problems has a clearly different horizon, since the decisions involved imply terms that are not less than 2 or 3 years, for the simplest works and in many cases reach 8-10 years for larger and more complex works, as is the case of hydroelectric or nuclear power plants. Starting today, expansion is also associated to the problems of the assessment of resources or determination of costs.*

Electricity generation, as well on a smaller scale its transmission and distribution do note escape the analysis of the contaminating industry that may produce negative effects both on the ecosystem where they operate, as well as on a global level, generating GHG emissions (greenhouse gasses). The mitigation costs of environmental impacts (local and global), will increase investment and operating costs of projects. In turn, and as the rest of the economic sectors the electric sector is vulnerable to Climate Change. Climate scenarios are alerting about these issues and must be studied and considered in sectorial planning, including within the scenarios of the availability of resources.

Under these premises and with the detailed characteristics and peculiarities, are presented hereafter the most relevant guidelines associated to sectorial planning.

Objectives and guidelines of electro-energy planning

Expansion of an electric system and selection of investments~~,~~ demand~~s~~ important efforts in any country, whether there exists or not a national or sectorial plan. It is evident that if there is no national development plan, it is difficult to prepare an energy plan. It is also a complex matter to prepare a plan for the electric sector without an energy plan. This is due to the lack of information, and in consequence the risk of committing very serious mistakes and absence of coordination.

The importance of connecting electric planning with that of energy is based on: avoid a duplication of efforts, consistency of the assumptions of important independent variables, and to improve the understanding of the hypotheses of growth and development. Problems related to financing and the use of resources, are also common aspects between the planning of energy and that of electricity. Any country must coordinate the requirements of availability of funds for the different areas of the economy. The availability of hydrocarbons for electricity generation, and/or the uses of water that compete with electricity generation, are relevant aspects to coordinate. **Fundación Bariloche** (2006).

Historically, there has been an association of the concept of "optimum" with economic efficiency, and the process of electric planning was reduced to arriving to the minimum cost supply alternative. However, social and economic planning and particularly that of energy may have additional objectives to economic efficiency, such as that of avoiding an excessive dependence on foreign resources, to control the impact on the balance of payments, guarantee employment levels, not degrade the environment, etc. These considerations transform the problem in an issue that requires ~~a~~ necessarily a multi-objective resolution in which must be used socially agreed weighting factors to assess each one of the issues. There lies a conceptual impossibility of optimizing a function with several variables, when there does not exist an unambiguous weighting of such variables.

Modeling of an electric system implies, necessarily the consideration with a certain degree of detail of those aspects that have a greater relevance in the selection of the equipment and in the realization of simplifying assumptions with respect to the remaining ones, considering the factors that may have an effect on the operation of the system, and in turn give it a greater degree of complexity. It is important to highlight that there is no "recipe" to determine what aspects are fundamental and which are secondary. This essentially depends on the system under study (degree of integration of the system, distances between consumption centers, degree of use of the hydroelectric potential, existence of a dry hydrological season, etc.).

In general we observe that certain factors that affect **the operation conditions of a system are:**

- √ *Variations in the load curve.*
- √ *Changes in the fuel prices.*
- √ *Coming into operation of new generation units.*
- √ *New installations in the transport network.*
- √ *Failures / Shutdowns of generators or transport*

And the complexity of the analysis depends among other factors of:

- √ *The random nature of demand, hydrolicity, unavailability, etc.*
- √ *Quality of the pretended service.*
- √ *Operation restrictions of hydroelectric generation.*
- √ *Operatiing restrictions of the transmission system.*
- √ *Transport costs.*
- √ *Fuel availability.*

This situation makes it necessary to have a combined use of models for simulation and optimization as tools that collaborate in the determination of projects[69], and their programming during the planning period.

Even with these considerations, it is important to highlight that **whatever might be the elected mathematical model, it must be the conceptual representation of a process or a system that permits by means of different hypotheses to analyze the nature, understand its functioning and set forth explanations of the results obtained in the framework of the general objectives proposed**. In case of an electric system, whatever might be the chosen planning model, in general a process of analysis is presented (for a sufficiently long period that will take into consideration a future development of the system), that includes several stages, among which the followings deserve special mention:

- √ *Knowledge of the initial situation of the sector (balance and configuration[70] of the electric system);*
- √ *Demand forecasts at global and sectorial levels (based on the annual or seasonal load durations) for each system, and hypotheses for the evolution of losses and the management of demand;*

69 There is an optimization of the generation park that satisfies the demand market at a minimum cost and that complies with the criteria of reliability, reserve and safety in the electric system.

70 Although it is not always possible to model a spatial solution that is acceptable, that could be obtained by setting forth the representation of each one of the regions and considering the exchange of flows of power and energy between said regions.

- √ *Prospective of supply (different plans for expansion[71]), including a Public Service (Isolated and Interconnected) and self-production, considering: uncertainties, restrictions/availabilities, the situation of fuels, location and opportunity of temporary entries/exits;*
- √ *Hypotheses of exchanges in power and energy between regions;*
- √ *Hypotheses and needs for reserves;*
- √ *Economic evaluation, by means of cost analysis of costs (of investment and costs for operation and maintenance) and*
- √ *Prospective of the necessary investments and financing.*

It is important to highlight that this process implies undertaking an analysis for medium and long-term horizons to be able to plan the operation of the electric system. As a first step, therefore is applied usually a deterministic methodology that covers the electric balance of the system, at least with maximum and minimum alternatives. Additionally, dispatches are made to verify if the objectives of service quality are met, or others for example: availability levels, import levels, etc. Also are carried out to evaluate the operative performance to see how the system faces the resulting conditions of unavailability, as well as the possible scenarios that adopt the variables or objectives set forth by the planner.

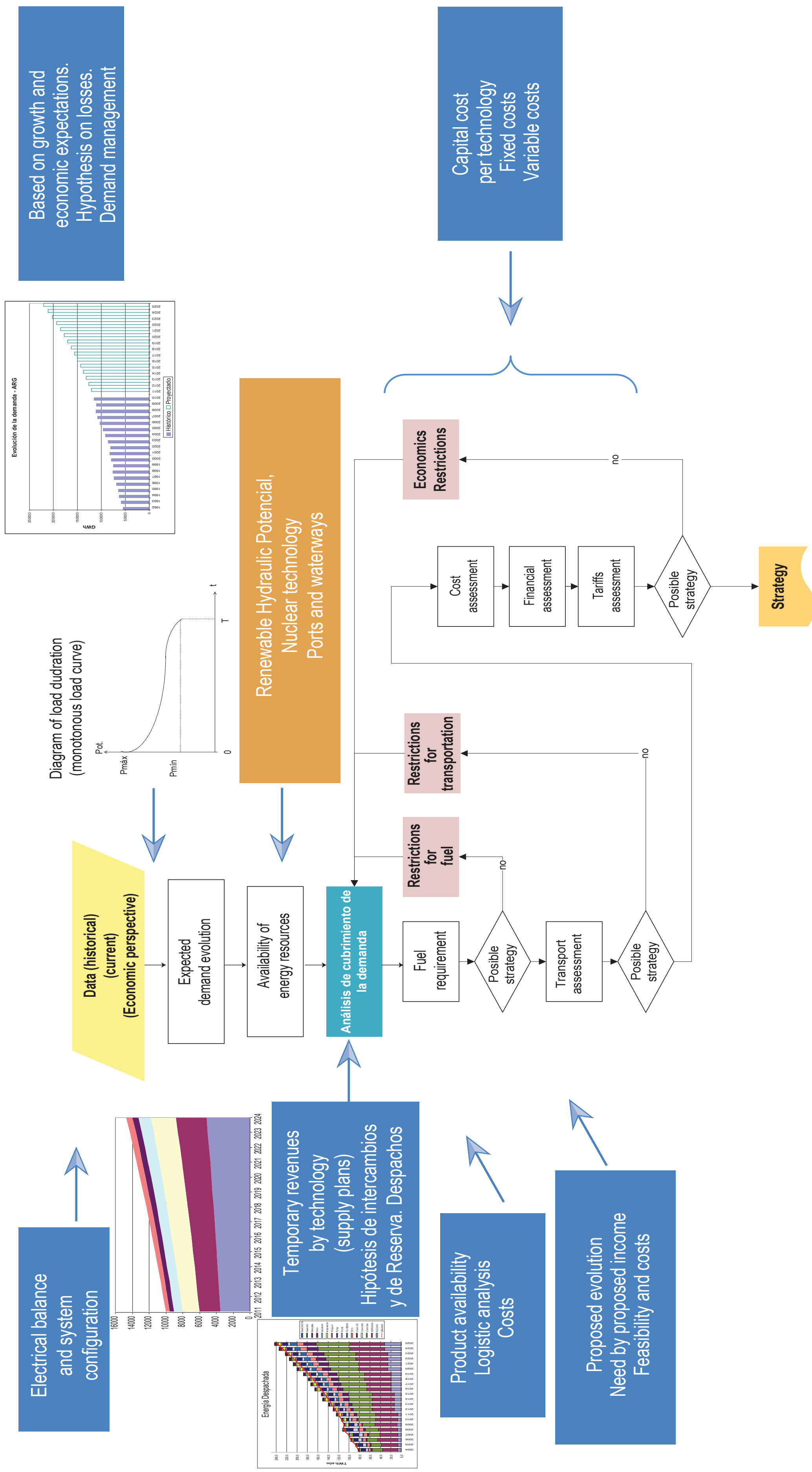
The following figure V.4 illustrates the aforementioned stages.

As a result of the already mentioned planning process, it would be possible to obtain an accepted solution with the following results:

- *i) A definition of the convenience of new power stations, the opportunity of their entry into service, equipment level and their evolution during the period of analysis. In the case of pumping stations, it also defines their peak energy.*
- *ii) Definition of the need of new thermal power stations and their locations the opportunity of installation, the most convenient level of installed power and their annual generation.*
- *iii) Definition of the best utilization of existing power stations, both thermal and hydraulic and the convenience of substituting existing equipment (withdrawal program).*
- *iv) Definition of the convenience of interconnections between systems and power and energy levels between regions (in the models that those apply).*
- *v) Sensitity analysis on within which margin of cost variation the optimum solution obtained is not altered.*
- *vi) Costs of power and energy for each region; and others.*

71 Catalogue of candidate projects, defined according to identification, evaluation and feasibility of project studies with information on the costs of construction and operation (national and international sources).

Figure V.4: General Scheme of Electric Planning



Source: Authors based on Fundación Bariloche, 2006, op. cit. .

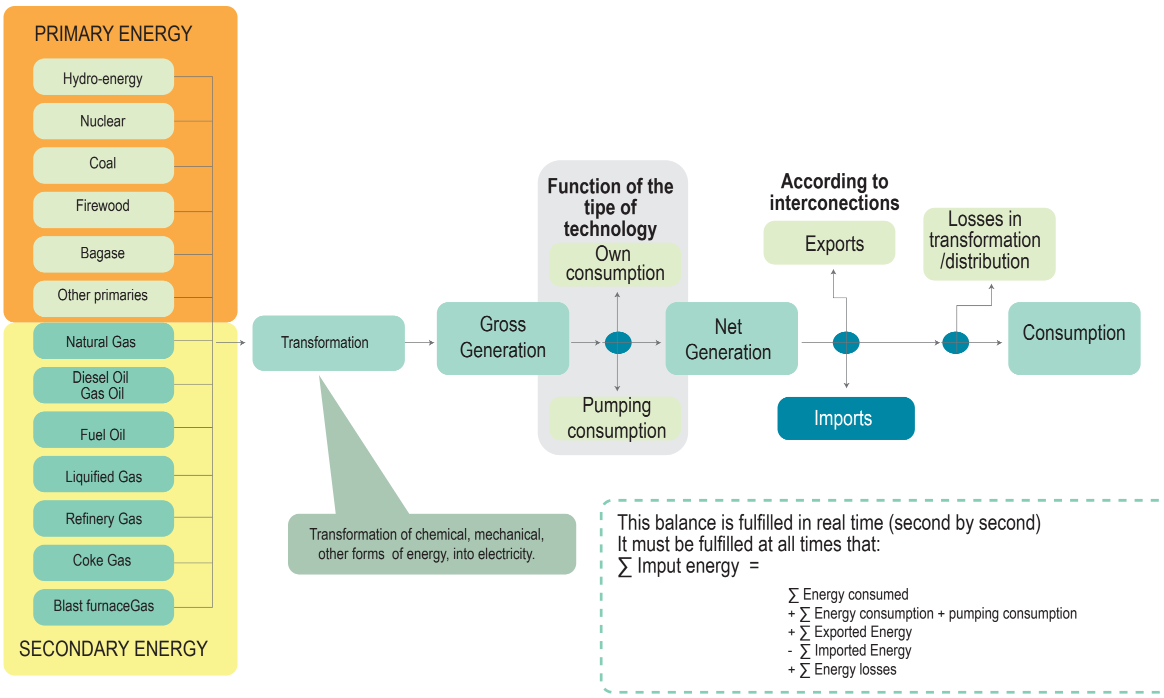
Starting Point: the electric balance

As will be later explained, it is a relevant matter for the planner, to have knowledge of the starting point of the sector.

On the other hand, according to the use given to the balance, it is possible to register instantaneous data, annual values or longer periods.

In the following scheme we can observe the different components of a simplified electric system in which have been included the energy flows produced by primary and secondary energies used for electric generation, up to consumption.

Figure V.5: Electric balance



Source: Authors.

The proper electric balance, starts from a gross generation; for its production it requires a part of electric energy that oscillates between 0.5% and 3% of the gross energy generated (according to the technology of generation), and that is called self-consumption. If from that gross generation we deduct the self-consumption (less the consumption for pumping), we obtain a net generation that is taken as a positive side in the balance. For exchanges such as transactions of energy purchases-sales (import-export) from the system to other systems (regional, national, or self-production) must be considered the signs leading to a balance. If purchases predominate, the net result is positive. If to net generation we add (or subtract) the balance of exchanges, we obtain the energy sent to the grid. If from the energy sent to the grid we subtract sales (or consumptions, or invoicing), we obtain transmission and distribution losses (in total varying approximately between 7% and 24% of gross generation). The formats and level of detail of an electric balance can differ from one country to another depending on the complexity of the system.

A simple planning exercise considers the undertaking of an electric balance, per projected year including the different hypotheses proposed.

An example of an Electric Balance

In the following chart an Electric Energy Balance is presented, that corresponds to the Total of Argentina (Wholesale Market) for the year 2003. Sors (2003). It represents a finished example that includes the energy flows that make up the national system, as well as the sub-systems that comprise it. Observe from left to right that the electric supply comes from Public Service and Self-generation. The Public Service is supplied from the Argentinian Interconnected System of Interconnection, which in turn was formed at that time by the Wholesale Electric Market and the Patagonia Electric Market (which later were definitely integrated). If we specifically analyze the WEM, we observe that its offer that was formed by the generation Dispatched by Cammesa[72], the Non Dispatched by Cammesa (generators that sold to Cammesa), the generation of the TermoAndes power station, the energy received from self-producers and Imports. On the other hand there was energy extracted from the WEM, for: Export, for the MEMSP, and for Pumping. In this case, the difference between the offer of the WEM, and the Net Demand of the WEM is to be found at the losses of transmission and sub-transmission. To reach the level of final consumption, it would be necessary yet to subtract losses from distribution.

Total energy balance - Units: GWh - Year 2003 (1)

Public Service	Incorporated to the national grid system	Wholesale Electrical Market WEM	Generation Dispatched by CAMESA	74.366		
			Generation not Dispatched by CAMESA	609		
			Generation TermoAndes	1.903		
			Received from Self-Production	184		
			Imports	7.578		
			Exports	-2.543		
			Sent to Public Service Wholesale Market	-58	Distros Transformation Losses	1.791
			Pumping	-47	High voltage losses (Model)	1.847
			Sub Total	**81.992**	**Net WEM Demand**	**78.355**
		Self-Producers WEM	Generation Dispatched by CAMESA	4.213		
			Received from Wholesale Electrical Market	58		
			Received from Self-Production	430	High voltage losses (Model)	195
			Sub Total	**4.701**	**Net Self-Producers WEM demand**	**4.506**
	Descentralized		Generation	670		
			Received from Self-Production	104		
			Sub Total	**774**	**Net Descentralized Demand**	**751**
			Total	**87.467**		**79.857**
Self-Production			Generation	**8.136**		
			Input to the Wholesale electrical market	-184		
			Input to the Self-Producers Wholesale electrical market	-430		
			Input to descentralized systems	-104	**Final Self-producer's / SP-WEM demand**	**1.837**
			Sub Total	**7.417**	**Rest of the demand**	**5.358**
Total				**94.885**		**87.052**

Electricity demand

Characteristics of demand

In general distribution companies carry out detailed studies (at an hourly level for each transforming station, level of tension, etc.), of electric demand in their area to prepare tariff charts and anticipate investments. When added these sectorial consumptions the total energy invoiced by type of user, and the responsibility of each user in the total load curve can be determined (especially during peak hours of demand). These estimates are possible with the assistance of several indicators that permit us to characterize electric demands. The different techniques that are used to estimate the sectorial demand have been presented in point V.3.

In first place we have the **demand factor** that measures the relation between the maximum of consumption of a user in a certain time interval and its total capacity connected to public service. This indicator is of great importance in the determination of the power rating of sub-stations, secondary conductors, determination of tariffs, etc.

Certain users may have demand factors in the order of 6080%, as is the case of residential users of middle income, while those of lower income may exceed them and yet be lower than those of high income. On the other hand, weather variations, the variation

72 Compañía Administradora del Mercado Eléctrico SA.

of natural illumination, isolated events both of a daily or seasonal nature, have a great influence on demand factors of commercial establishments. An example of a low demand factor is represented by places for public shows that have a great number of illumination projectors that practically are not used in a simultaneous manner.

Another indicator of demand characterization is that which represents **diversity**. In effect since not all the loads from different users are presented in a simultaneous manner, the total load in each instant will be lesser than the sum of individual capacities affected by the demand factor. The **diversity factor** is the relation between the maximum simultaneous load and the sum of the maximum demands corresponding to the set of considered users.

In the planning process, the study of demand goes through two principal stages: the Determination of initial loads, and the Projection of loads.

Determination of initial loads

To comply with this stage, we start from the determination of energy demand at the level of each user category (residential, commercial, industrial, etc.). If possible, it is important to relate the database of invoicing with the database of the elements of the distribution network (lines, Transformation Centers TC, etc.)[73]

To these invoiced energy demands we add the low-tension losses. These losses can be divided in: Technical losses: basically due to heat losses ~~by~~ as a result of the Joule effect in the grid, and Non-technical losses: due to the stealing of energy. Affecting the demands for invoiced energy by loss factors, we obtain the energy demands at the level of each sector. OLADE (1990).

From the database of invoicing it is also possible to obtain the number of users for each user category and to calculate the average consumption by user. Based on energy demands we obtain the power demands for each user category by means of the load factors and finally we obtain total demand, applying the diversity factors among the different user categories.

The use of load and diversity factors by each user category can be replaced with the determination of the typical load curves. The determination of both the load factors and curves require undertaking measurement campaigns at different points of the grid, such as, bars of Transformation Centers, electric supply for large users in medium and low tension and small user in low tension. With the typical load curves per type of user, the number of users per category it is possible to determine their total hourly consumption per year, and the duration of annual loads of the electric system under study, which is the principal tool for the planning of energy supply.

Projection of loads

The Projection of Electricity Demand depends, in a simplified manner, on the following factors: economic development, technological changes, demographic growth, incorporation of new users (electro-intensive), and of the vertical and horizontal growth (spatial) of electricity demand.

When projecting loads to the future it is necessary to take into account two aspects of the demand growth:

i) **The demand growth within the electrified zone**. This is due to the growth of the number of users in areas that have not been covered (interstitial growth) and the growth of the average consumption per user.

ii) **Expansion of the electrified area** through the appearance of new residential zones or the establishment of new industries.

The criteria for the projection of energy demand in the electrified area will depend on the user category:

√ **Reduced demands in low tension**: will be projected the number of users and the average consumption per user.

√ **Middle demands with power contracting**: will be projected the number of users, the average contracted power per user and the average factor of utilization. This factor, being the relation between the power demanded and the contracted power.

√ **Large demands**: for large users, it is convenient to make a projection of the contracted power and the factor of utilization for each one of them.

Projecting the loss factors and the load and diversity factors or load curves per user category, we will obtain the power demands for each projected year.

73 In reality, this comparison is important for detailed planning of distribution or to undertake tariff reviews.

For the treatment of expansion of the electrified area, we must start from one or several specific projects of a residential or industrial nature.

To project demand, we can use different Models as depicted in item V.3. On a summarized basis they can be classified in the followings: short-term Models: normally dependent on the day of the week, on the demand of previous days, temperature (econometric Models and neuronal networks). Short-term projections are the ones that are used for programming daily operation. Long-term Models: for trends or analysis per sector (residential, industrial, commercial, etc.), also require a projection of GDP, population, electrification, income level, price of electricity, etc. Long-term projections are used for the selection of equipment. Econometric models with explanatory variables of forecasts may be used. Prices may also be included in them.

With these models it is possible to~~,~~ obtain total (or sectorial) projections of the annual energy demand. With the load factor of the base year, to which are applied the hypotheses of future variation, it is possible to determine the projected Maximum Load demand. Next are incorporated hypotheses of evolution of losses and the incorporation of efficiency measures and/or management of demand.

Efficiency and demand management

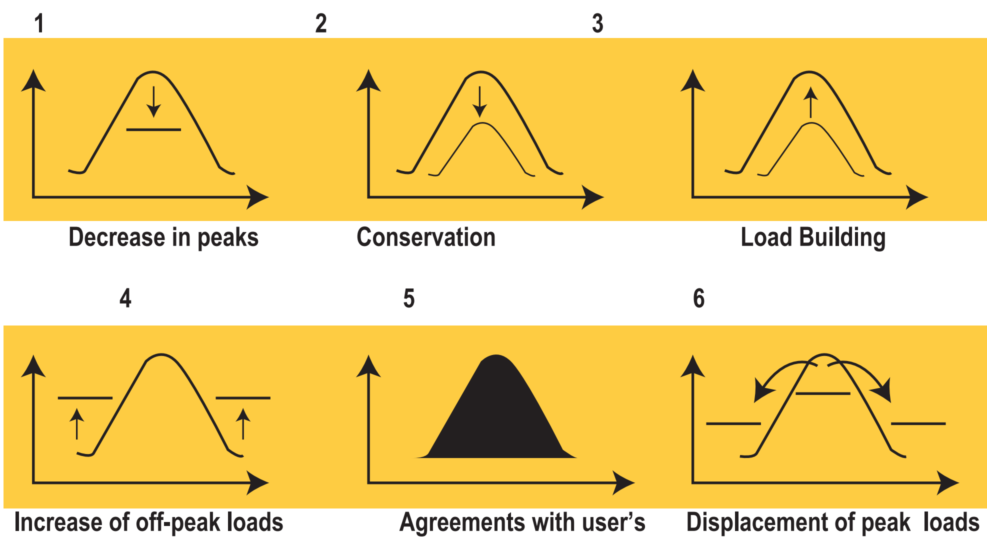
Within the hypotheses of future evolution of demand, it is possible to find the actions meant to reduce consumption. They are comprised by two large groups, (see Figure V.6) load management, that is decreasing or redistributing peaks of daily or seasonal consumption (1, 3, 4 and 5), and Energy Efficiency (2), that is the reduction of electricity consumption in a permanent manner.

In order to be able to develop actions leading to the control or management of demand, it is necessary to have a deep knowledge of the modalities of hourly consumption refered to the level and structure of consumption by uses. Carrying out pilot surveys that include a gathering of consumption habits and the ownership of household appliances, complemented with hourly consumption measurements, permit obtaining disaggregated load curves per use or appliance.

This way it is possible to determine where it is convenient to center saving~~s~~ efforts, and among others, what tariff policies should be implemented, considering that: hourly demand curve depends on existing prices (and their relation with the incomes of users), price signals permit directing demand in a better way, and price policies are used to optimize supply conditions.

In general, mechanisms for demand control or management may be classified in three principal groups: those based on time (price signals per hourly use 1, 4, 6); those based on incentives and power shortages (total power supply or use are suspended, and the user receives some type of compensation), and reliability programs, in which the users accept to become "reserves" in the system as for example. "Interruptible loads" (5). Tariffs, incentives, or direct intervention~~,~~ are the instruments that facilitate these mechanisms.

Figure V.6: Schemes for the management of demand



References
1. Decrease of peaks: a reduction of the load during the period of maximum demand
2. Conservation: a reduction of loads, during the hours of the day
3. Strategic Growth: Growth of loads in the day. May be driven by: economic development, Electrification, Incorporation of electric heating systems, etc.
4. Increase of off-peak loads: an improvement in the load factor of the system by means of the incorporation of loads in periods of low demand:
5. Agreements with users: refers to programs to alter energy consumption of clients. May be flexible and/or interruptible loads (interruptible demand)
6. Displacement of peak loads: Displacement of the general load that does not substantially alter the sales of electricity. May be based on the use of air-conditioning equipment, deferred irrigation, etc.

Source: Puga, Nicolás, 1994. Introduction to the Administration of Demand. Comprehensive Planning of Resources and Load Management. Executive Workshop. Buenos Aires, Argentina 6-8 June, 1994.

Respecting electric energy savings in a permanent manner through the use of high technology equipment and installations, we can mention the following examples: use of efficient illumination, automatic air-conditioning systems, variable speed drives for engines, use of insulating materials and constructive systems that reduce energy losses.

Finally, the planner who proposes the implementation of efficiency measures must be aware that there are important barriers for their implementation, among them special mention deserve the followings: lack of political decision, lack of an adequate legislation to promote them, lack of knowledge and awareness of the problem on the part of society, and the existence of perverse subsidy schemes for the sustainability of the electric system.

The measures for efficiency and demand management are absolutely essential from the planner`s point of view since it is not that person´s task to run after the demand, equipping all that it requires, but rather to guarantee supply, both by actions concerning supply as well as signals towards demand. The only manner to evaluate in depth the measure of demand management is to verify its implications in the future expansion of the system.

Supply of electricity

Short and long-term

From the point of view of the planner, the elements that correspond to the analysis of the supply bring together issues that require a different temporal approach. The planner must be aware of and manage elements of dispatch, being this the coordination and ordering of the instantaneous production of electricity. Although the nature of dispatch problems is rather complex due to the amount of simultaneous restrictions that have to be addressed, from the optic of the planner these may be approached in a simplified manner, using average values and approximations which are not admissible at the time of coordinating the operation of the system in real time. In a long-term vision, these simplifications relative to the operation are compensated and averages represent the aptitude of a certain expanding plan. This allows us to compare one plan with another one, but not only to evaluate that each one of them meets the necessary requirements to become an admissible plan, but also to be able to prepare their “performance indicators” and compare them.

For this reason, electric planning combines considerations regarding variables that belong to the short-term or of operation, such as the necessary margin of reserve of the system, availability of fuels, covering of demand according to the moment in time, hour, week or month (in function of the detail of information and the scope of evaluation), as well as the different proposals for expansion, which are eminently long-term matters. Here it is assumed that the concept of long-term refers to the possibility of achieving a structural change in relevant state variables that are those variables upon which the planner may decide on its future scenario proposal. Thus, the evolution of the generating park meeting the established operational requirements may affect the present generation structure, may change the degree of dependence on the primary resources used, may decrease the intrinsic variability of generation, may modify the environmental impact of generation and may also determine the cost structure.

There are different models applicable to electric planning that take into account these temporary questions and this focus, although not all include the treatment of the electric sector as an integral piece of the energy system, some deal with it in an isolated manner, with the bias that this implies. Additionally, there are other models to assist in the process of electric planning that are based on the optimization of a single function of economic merit, generally the minimization of the total cost. This implies assuming the methodological possibility of quantifying and determining values of all of its aspects. This matter will be retaken in the section of tools for electric planning.

Reserve margin

The definition of Reserve Margin is relevant for the planner, and it is the addition of installed capacity[74] over the maximum annual demand of envisaged power. In general, this maximum annual demand appears in single hour in the year and generally continues growing through the years, in function of economic growth.

The need of having a reserve margin resides in the different uncertainties an electric system is facing, from the impossibility of exactly predicting the demand, going through variability (or unavailability) of some resources necessary for generation, up to the foreseen unavailability (or not) of certain units, unfavorable impacts of climatic events (tornados, torrential rains, etc.), etc.[75].

Generation parks, mainly of the thermal type, face an uncertainty associated to non-planned damages, which in general, can be minimized with preventive or programmed maintenance. Each generating unit has associated to it a probability of failure, directly proportional to its age and with some correlation due to the type of technology. On the basis of this probability of failure, an estimate can be made for an appropriate reserve. However, beyond this type of more exact data (often required by the planning models) it is common to use as criteria, the idea of having available a determined percentage of reserve according to some historic parameter or to have a reserve that at least exceeds the power of the largest piece of equipment in the system.

When the generation park is hydrothermal, with an important hydroelectric component, the reserve margin is more strongly linked to the hydraulic variability in itself, than to unexpected failures that may appear in the generating units. This particular feature is accentuated in hydroelectric power stations that do not have a storage capacity or regulation, which makes the electric system much more vulnerable. Reserve margins of the systems with an important hydroelectric participation must consider the energy and power guaranteed (or secure) offered by hydroelectric power stations. This has a probability of occurrence of 95% of the time. That is adopting a maximum security of supply.

Under these considerations we can conclude that:

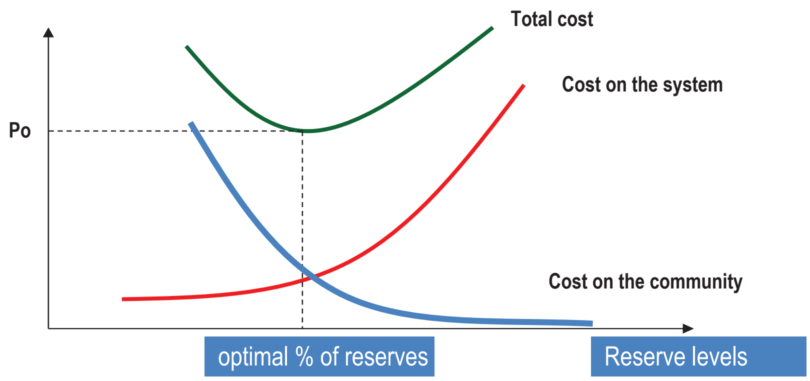
- The value of the reserve margin is not autonomous nor depends only on technical characteristics but rather is a function of a set of factors, some of them corresponding to the electric sector and others foreign to it.
- In general terms it can be stated that this reserve margin will define the quality of service, at least at the level of generation.
- If the margin is high, taking into account the costs of the equipment, the costs of the company that provides the service will also be high and therefore so will be its prices.
- However, if it is low, this will have an incidence on the community with a greater cost that is produced by services not provided or provided in a deficient manner.

Figure V.7 shows what has been expressed respecting the variations of these two costs. As can be observed there exists a value of the minimum total cost of providing the service, in which the costs are equal for the electric system and the cost to the community. However this so called balance is eminently a conceptual theoretical development. The quantitative evaluation of the cost for the community due a lack of electric service is very difficult to calculate, which makes the cost of opportunity of electricity something that has not been clearly defined. However it is understood that it is desirable to approximate this equilibrium to not over-equip the system or neither to face high degrees of rationing. An initial reasonable approximation consists in using as rationing cost the price established by the dispatch entity for that energy that has not been provided.

74 If the installed power is quite old or deteriorated, it will be necessary to consider for the estimate of the reserve, the effective power that is what effectively can be delivered by the system.

75 The equipment must be able to meet the demand and will not always be available due to: i) forced unavailability, ii) programmed unavailability, iii) eventual hydraulic problems, etc.

Figure V.7: Costs and Reserve Margin



Source: Authors.

Finally, to be able to cover the wide scope of possible uncertainties/unavailability, if possible, it is necessary to consider different types of reserves. For example, if the time periods required to cover unavailability are considered, the reserve could be classified in:

- √ Momentary or rotation Reserve
  - Up to 10 minutes. This can be covered with equipment that is presently working (rotating) with powers below the effective standard (thermal or hydroelectric)
- √ Short time or Hot Reserve (rapid response)
  - 1-5 min. average time of access to the short time reserve. Idem previous one, including TG, CC (cycle TG) and hydroelectric plants with dam.
- √ Long-term or Cold Reserve (slow response)
  - 0.5-8 h: average time of access to the long-term reserve. May be covered with turned-off equipment of the TV type
- √ Reliability Reserve (very slow response)
  - 30-60 h average time for repairs. May be covered with turned-off equipment of the TV type, Nuclear, Hydro with dam.

Additionally, some practical criteria that will permit the planner to quickly estimate the Reserve Margin of an electric system, could be the followings:

1. 20 % of maximum power demand;
2. 10% of effective (installed) thermal +20% of Hydraulic power;
3. The largest module of installed equipment; and
4. 40% of installed power (or guaranteed) hydroelectric

Reserve necessary to permit access to wind power generation

This reserve is also known as Backup wind power, and it refers to a purely operative matter, although it has an impact on the definition of future equipment (back-up).

The resource (in this case wind), although it may be abundant, is not constant. Therefore if the wind varies, the wind power generation also varies (remember that it varies with the cube of wind velocity and also with density). The remaining generating park must absorb these instantaneous power variations (to simplify it, taking into account that demand remains constant). These variations appear in brief periods of time, reason why the remaining generating park must provide such variations in almost real time (instantaneously). Therefore the generation of reserve for these variations must be rotating (and ready for supply). Then the greater the wind park, the greater the need of having available a rotating reserve (that must be taken into account in the planning). If this reserve is not available, it is not possible to dispatch wind energy, or if it is available but it is expensive (for example thermal burning Diesel), this will increase the operative cost, generating a paradox: the greater wind power dispatch, the greater operative cost.

It is important to highlight that wind variations are quantified (statistically) and are classified in frequent and rapid variations. Are defined as a “rapid variation of generation” the value of the maximum variation estimated of active power, within every 10 minutes, of the 10 values of average power registered every 1-minute. These are due to turbulences, wind gusts and/or rapid variations in wind speed. Are defined as “major variation of frequent generation” the value of the maximum variation of active power, within each hour, of the 6 values of average power registered every 10 minutes that is not exceeded during 95% of the time (of the hours in a year). These are higher variations that only appear a 5% of the total time.

In reality, these variations turn out to have an impact on the quality of service of the system (and are measured in variations in the levels of tension that regulations limit with various maximum admissible values). Under these considerations it would seem necessary that the planner of a wind park, establish back-up equipment, as well as for support of tension, the costs of which may, in certain cases, present obstacles to the original project.

Finally, there is no rule to determine how much Backup is necessary for wind generation. This will depend on the integration of each future electricity network system, of the stabilizing resources that it has, of the available rotating reserve, etc.

Dispatch of Loads – Performance of the plan

Electricity dispatch consists of diagramming the operation of existing plants to guaranty demand coverage, during all hours of the year, under all climatic/hydrological conditions and minimizing operation costs. This is the reason why dispatch faces uncertainties which are proper of the availability of infrastructure, as well as that relative to the availability of fluctuating resources.

When the *system is preeminently thermal*, the analysis of the functioning of supply which has to cover electricity demand, can be made in different manners. One of them is at the level of the daily load curve. The equipment required to cover energy demand and power of each one of the blocks of each curve will be different. There exist operative characteristics/restrictions. For example, gas turbines may operate for peak load, steam thermal power stations for base load, etc., with different efficiencies and costs.

In general, the base load is covered with thermal power stations of good performance, of larger sizes, which use fuels of less unit cost. On the other hand such power stations of the steam type, have a greater rigidity in operation: minimum high level requirements, difficulties for modulation[76], likewise, they are of the lowest operative costs, even though their investment costs are higher. They use fuels of a lesser relative value (coal, fuel oil, natural gas, etc.). Even though nuclear power plants are not used on a massive basis in developing countries, in principle it can be said that they possess similar characteristics to the previous types and therefore are competitive when the system has an appropriate scale.

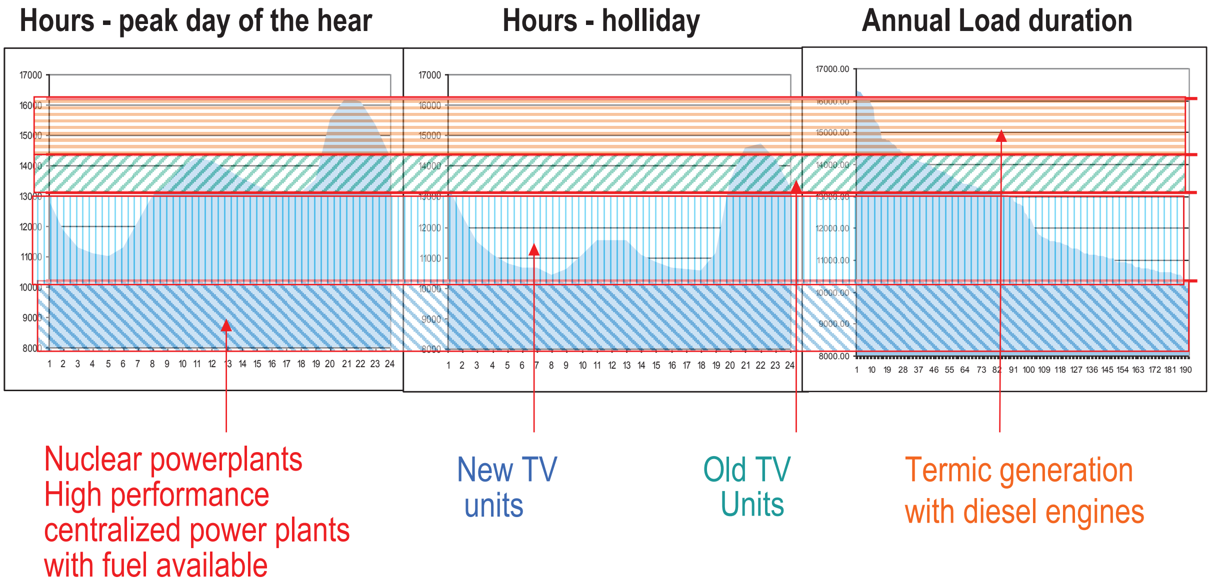
At the opposite extreme of possibilities, there exist power stations for peak load, of a much lesser relative performance, of smaller sizes, that use fuels of higher unit cost. Such power stations, of the diesel engines or gas turbine type, have lower minimum requirements, greater possibilities for load modulation, etc. In general terms, their investment costs are lower and their operative costs are higher.

The blocks of semi-base and semi-peak have intermediate ranges that would be gas turbines of a lower performance (these may be of the old type, or simplified turbines), diesel groups of a larger size, combined steam/gas cycles, etc.

Another form of studying or planning electricity supply, is working with an ordered load diagram (or annual monotonous curve), whose maximum represents the annual peak. This tool permits in an easy manner, by means of covering the diagram, placing in order of growing merit the power stations (growing order of marginal cost). Based on the load curve it is possible to estimate the factor of the annual use of each technology, according to the hours that it will be necessary for it to operate. This will rise from the quotient of hours during which each technology operates during the period under study and the total hours of it. Presented in the following graph are some of the cases previously mentioned.

76 Modulation corresponds to the characteristic of adapting to load changes in function of time.

Figure V.8: Processes for Dispatch and Planning



Source: Authors based on Fundación Bariloche, op. cit. 2006.

To cover the diagram with daily or annual loads, completing it in an ascending order, using first the machinery of lower variable or marginal cost, guarantees obtaining the minimum operative cost. This way, it is possible to estimate the average annual supply cost, on the basis of the hours resulting from the use of each technology, its specific consumption and the price of fuels used. This simplified method of calculation is called single bar.

Used Marginal costs

This is called a marginal dispatch because it brings order to the operation of the plants in function of the ascending marginal operation cost, that is the cost of producing an additional unit of energy and that is principally linked to the price of the used fuel and the efficiency of the generation technology, thus, first are generating the less expensive plants and later the more expensive ones. However, there is a caveat respecting hydroelectric power plants with a storage capacity (a matter that will be discussed later), with which is not followed the same criteria to find their position in the dispatch. As has been presented, they replace thermal generation of a greater variable cost and in this way the total operation cost is minimized. This means that conceptually they complete the peak of the dispatch diagram. Therefore it is frequent to speak about dispatch as a sort of synonym of marginal cost or a dispatch at a minimum cost. Therefore, it is important to not confuse marginal dispatch with the methodology of remuneration by marginal costs, a matter that is eminently regulatory, that obviously is linked to the property of generation assets. In very brief words, marginal remuneration consists in paying all generators a fixed annual charge for the power that they make available (indistinctly of the type of power station) equivalent to the annual value of the most economic machine with which a similar power could be obtained, in general a gas turbine. On the other hand, all generators that produce energy are paid, hour to hour a, the marginal production cost of the machinery of the greatest marginal cost that is operating in each band. With this remuneration system, each power station in the electric park that is perfectly adapted to the demand will gather the necessary income to operate. If the park would not be well adapted, the necessary signals for its adaptation would supposedly be generated, when excessive income is present for some and deficits for others.

An alternative remuneration to the marginal system is that of average costs. Under this agreement the investment costs relative to the particular power station would be recognized following a negotiation and audit with such a purpose, as well as the average variable production cost of energy.

Each methodology has its advantages and difficulties that are not relevant in what respects planning and are issues principally associated to regulation and the ownership of assets. Therefore it is important to highlight that when we speak of marginal dispatch or marginal analysis of investments, there is no allusion made to the marginal regulation of remuneration.

In many of the countries of the region, marginal remuneration was considered as to be sufficient to produce the necessary and optimum expansions of the generation systems. This is so much the case, that several countries of the region dismantled their planning teams, at the same time that they modified their regulatory frameworks to regulate such a mechanism for regulation. There is sufficient historic evidence that proves that it is not enough to have a marginal remuneration mechanism and set up the expansion to atomized investment decisions to guarantee a socially convenient expansion relative to the use of the resources for generation and integrating the electric link within the energy system. This is why among the methodologies for planning it is not considered as adequate the assumption that the expansion can be simply commanded by compliance with a system of marginal remuneration.

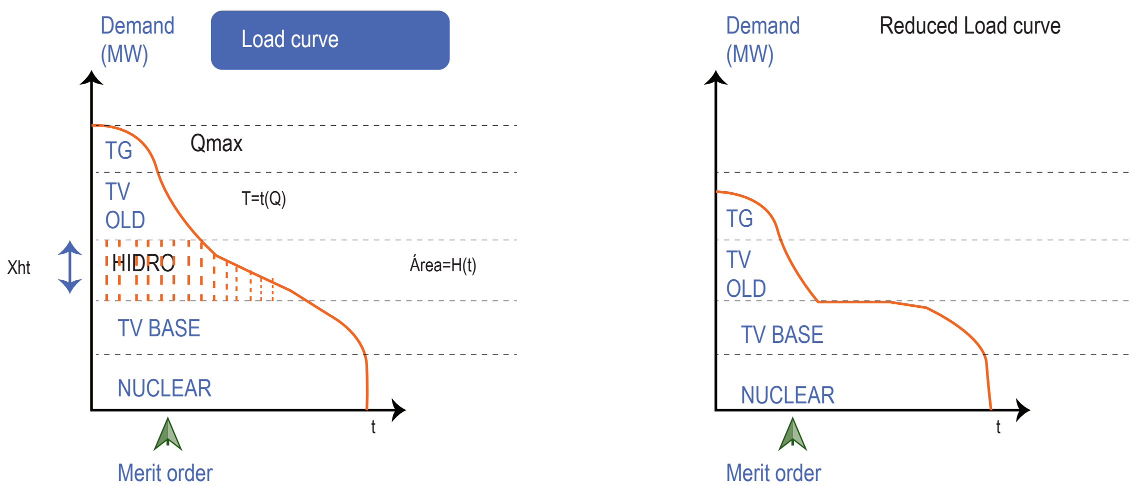
In case that in planning there is the intention of considering other complexities, such as geographic characteristics with the ensuing losses in transmission (which can be modeled by introducing an additional element, of a quadratic type, in the operative cost of each power station), there is the possibility of including for other power stations other terms in the function of operative cost. Additionally, in view of the importance of the cost of fuel transport, this must also be added; this is particularly important when the power stations are located in such a manner that transport costs are different for each one of them (either due to distance or method of transport).

In the case of *hydrothermal systems*, that is, when there are also hydroelectric power stations installed, or there is the possibility of installing them in the future, it is necessary to start with the basic hypothesis that their function will be that of being placed in the diagram to maximize fuel savings, in view of its lower operative cost in comparison to thermal power stations. This is why hydroelectric generation must represent all that can be technically produced (that is only limited by the installed capacity the hydraulic nature and unavailability of a programmed or forced origin). Since the energy that is producible hydroelectrically may be placed on the diagram with the same flexibility given by its excessive equipment (in general the equipped flow is superior to the river module), it is possible to search for that position in which the thermal units with a greater fuel cost are displaced, that is at peak [(77)]. "Further up" it is possible to place the hydroelectric power stations in the dispatch scheme, the greater will be the fuel savings they produce, insofar they use all of the available energy.

When the characteristics of hydroelectric power stations, in function of their hydraulic regime and reservoir capacity differ from one season to another, the load curve must also be seasonally decomposed to consider the variations of producible energy. Finally, it is convenient that hydraulic power plants are grouped by type (passing, peak, etc.) except if there is the desire to study any of them in an individual manner.

As an example, supposing that in any period "t" the hydraulic energy destined to generate electricity is "H" (see the following Figure)~~,~~ is known~~,~~ and that the installed capacity of the hydro is "X_{Ht}". If the objective of the hydraulic plant is precisely to maximize fuel savings, it must produce at full capacity that is the entire amount "H". in addition it must be operated during those moments when the fuel costs in the system are greater; this takes place at the moments of peak demand (that take place during period t), when are operating the oldest thermal plants that are less efficient or have more expensive fuels.

Figure V.9: Processes of Dispatch and Planning



Source: Authors.

The peak of the load diagram is characterized by low utilization factors where there is a great need of power providing little energy, while the opposite happens at the base of the diagram, where each MW of power is used during the 8760 hours of the year. In general, hydroelectric power stations with important dams are built with a power capacity that is superior to that which would be generated by the average flow of the river, implying a low factor of utilization for the power station, but permitting a strong peaking of available energy.

Once that the group of hydroelectric power stations are placed in their position of greatest operative savings for the entire system, it is possible to withdraw that portion of the demand supplied by them (as can be observed in the previous graph) and to establish the reduced load curve (or thermal monotone). After this, it is possible to dispatch this curve in the existing thermal power stations under the criteria that has been previously submitted.

77 Except for power stations that have a null or low guaranteed power or those that are referred to as in passing power stations, in which case the base generation will be displaced.

Methodologies for electric planning

It would be possible to begin defining the generation equipments, the determination of the production levels of each one of them, the requirements of the grid for transport and distribution in order to assure supplying the demand that was assumed at the beginning of the analysis.

However, there are interactions between the different stages that hinder the process of separation and in many cases obligate carrying out iterative analysis to assure the correct functioning of the system. Such is the case of the definition and operation of transmission networks and the operation of power stations, which are matters that evidently establish feedback. The complexity of each one of these links of the chain, often leads to the use of partial analysis for some of these elements, having led to the dissemination of different planning methodologies. However, the use and capacity of present day computers, has somehow changed the paradigm since it permits, without too much effort, to execute very complex programs of a sophisticated numerical resolution, modeling the system as a whole in a very detailed manner. Anyway, there is always present the difficulty of gathering the necessary detailed statistical information, historical chronicles, level of disaggregation required and at times the necessary statistical information (typically with respect to demand). This reality often limits the possibility of using programs that sometimes are inflexible regarding the degree of detail of information.

Two planning methodologies are next presented: the “global models”, in which the selection of investments and technologies is one of the aspects within a more ample type of modeling, that includes operation and other links in the energy chain; and the “Marginal Analysis for selection of investments” to evaluate the link in the chain that refers to the composition of the generating park by type of technology, that in general implies the biggest part of the system costs and concentrates a larger part of the possible alternatives. These two approaches are next presented in a much summarized manner.

Global Models

Global models have been developed to simultaneously evaluate a large number of alternative programs for equipment, which in general are optimization models whose excluding objective has been the minimization of the total cost of electric supply guaranteeing a determined quality of service. The objective is to indicate generally the development of a minimal system cost, which in turn can contribute with information to undertake a correct marginal analysis.

During a long time, there has been an interpretation that the solutions obtained from the application of optimization models, unquestionably constituted the program under which works should be carried out. However, these solutions are markedly influenced by the projection of an important series of factors, upon which uncertainty seems to be greater than what is explained. Evidently, this uncertainty increases in the long-term, and very often it cannot be solved with the consideration of probabilistic models. Fundación Bariloche (2006).

There is no “recipe” to determine what aspects are fundamental and which are secondary during the modeling of an electric system. This essentially depends on the system under study (degree of integration of the system, distances between consumption centers, degree of use of the hydroelectric potential, existence of a dry hydrological season, etc.).

In this sense, a difference is established between the resolution techniques and the models developed that use each one of them. This distinction is important since the technique in itself imposes a series of restrictions to the representation of a real system, but as a counterpart it offers a potential of analysis that can be, in function of the characteristics of the system for which it was developed.

Techniques for resolution and analysis of global models. Fundación Bariloche (2006)

Very often the global electric planning models use a set of techniques applied to the resolution of different types of problems within planning. As an example, is frequently applied a resolution through linear programing of the optimum dispatch of a determined expansion plan (that is being evaluated) which in turn is one of those tested within a dynamic programing to determine which better complies with the function of merit defined, among all possible ones. The following is a description of the principal techniques used in models.

Linear Programing

This technique has had a generalized use since the 50s. Among the reasons that favored its dissemination, we can mention the following:

It allows the study of very large size systems, without any limitations as to the number of variants. It considers all feasible solutions. Unless there does not exist a feasible solution, it always guarantees obtaining the best solution. It is possible to carry out a good sensibility analysis, by means of the dual problem solution, through which it is possible to obtain opportunity costs of the used resources.

Good computational algorithms of resolution have been developed, which can be applied in all cases. This technique facilitates the consideration of other planning objectives which have been already mentioned, incorporating them as restrictions to the problem of cost minimization. This fact, together with the analysis of the solution of the dual problem, facilitates the iterative process proposed to determine the optimum evolution of the system taking into account all different criteria.

However, the condition of linearity, both of the restrictions as well as the objective function, in general do not adjust to the reality to be presented and it obligates the implementation of real complex iterative processes that allow to verify the behaving of the system under real conditions. It does not permit the modeling of random variables, a matter that must be dealt by making multiple runs of the model with different values, what can increase the execution times to impracticable limits.

Theory of optimum control

This technique has a certain relation with dynamic programing, since it is possible to demonstrate for certain types of problems that the optimum conditions of the principle of optimality of Bellman, basis of dynamic programing, lead to identical results as those optimal conditions of the maximum principle of Pontryagin, on which the theory of optimum control is based. However, the optimum conditions of Pontryagin are expressed as a system of differential equations, for the resolution of which are used numerical methods based on the behavior of derivatives.

As in the case of dynamic programing, it permits an evaluation in great detail of each step of the iterative process that converges to the solution that optimizes the objective, function, taking into account the randomness of demand; of the hydroelectric contributions and the availability of equipment.

A frequent sequence of analysis with this type of model is the following:

1) Definition of the hydroelectric supply of the system in function of its hydrological characteristics.
2) Definition of policies for the maintenance of thermal and nuclear power stations.
3) Determination of the optimum expansion of the generation system and its operation.

Dynamic Programing

This technique presents several advantages over lineal programing among which the following are worth mentioning:

Both the objective function as well as restrictions may be of any type, on condition that could be applied the principle of optimality of Bellman, that is that any sub-trajectory of an optimal trajectory will in turn be optimal. This condition is the one that guarantees the recurrent resolution method will lead to the desired optimum.

Its characteristic of consideration of discreet increments in variables is especially appropriate for the analysis of expansion of power stations with different predetermined modules (which resolves a serious problem in lineal programing, since the size of the plants must be continuous variables, otherwise the complexity of resolution is very high). However, the dissemination of the use of this technique has been restricted, due to the fact that contrary to lineal programing it is not possible to define computational algorithms for the resolution of optimization problems through dynamic programing that can be applied to any problem. In consequence the use of dynamic programing additionally requires an effort to develop the computational algorithm, unless an already developed model is used.

The time for calculation increases considerably with the ramifications of the many alternatives for expansion. This normally forces a limitation of alternatives to be simultaneously considered, to maintain the model within the limits of operability. The analysis of regionalized electric systems considerably increases the alternatives for the expansion of the system, since the location of equipment appears as an explicit variant. Therefore it clashes with the restriction that dynamic programing establishes in that respect.

In contraposition with lineal programing, the calculation process presents difficulties for the sensibility analysis of the optimum solution.

Dynamic programing is especially appropriate for the consideration of the quality of service associated to each alternative of expansion. This consideration may be carried out in two manners. The first corresponds to the stage of configuration of the expansion network evaluating the quality of service in all the alternatives and eliminating those that do not fall within certain limits. The second manner is by incorporating to the objective function a measurement of the consequences of that quality of service, for example the cost to the community for not received energy.

The qualities of dynamic programing make it a much more adequate manner for the analysis of some specific characteristics of the electric system. However, the limitation with respect to the number of variants to consider, that practically discards the consideration of the transport and interconnection ~~or~~ of electric systems in the process of optimization, as well as the difficulty of setting forth a great number of variants of hydroelectric power stations, must be taken into account and evaluated in order to estimate the repercussions on the evolution of the system before defining the technique to be used in the selection of the electric equipment.

Finally, the *global models, whatever techniques or combination* of these are used to resolve the problem of an approximation to reality, will face "border" conditions, such as social, political and even environmental. Planning with the use of global models, permits the incorporation of decisions on expansion based on aspects that can go beyond a strictly economic evaluation (or minimization of a function of merit), including when there is the idea of including the value of positive or negative externalities of certain actions. Decisions such as determining priority in the use of own resources, the promotion of certain technologies due to recharging them with aspects of industrial or technologic development, among others, may be incorporated under this focus and will exert influence upon the total evolution of the expansion plan. Said in another way, with an integral modeling it is possible to set forth an expansion that goes from the one extreme of using models to decide the total nature of its evolution in an endogenous manner, based only on the economic evaluation, be it the traditional approach of the variables indisputably quantifiable and with reference values, up to the other when there certain more discussible valorizations are introduced (such as environmental impact or other social and economic aspects) up to the extreme of deciding in a more "digital" manner the expansion, responding to other considerations as those mentioned. In general, models are used in an intermediate stage, in which certain decisions are pre-fixed and the rest are decided on the basis of the result of the minimization of costs.

These models generally require as an input, the evolution of future demand, the load curve of the base year and its projection, the physical and economic description (with ~~a~~ different levels of detail according to the model) of the existing generation park, as well as the description of all the candidate machinery that may enter. In general the description of the transmission system is not included, if some power station has been quite penalized due to the considerable distance in comparison to others and the increment in costs and losses of electricity due to transport, these characteristics should be included in the physical description of the plant, altering its technical-economic parameters. On the other hand they require~~s~~ a scenario of fuel prices, a scenario of the unit cost of installation of the plant or of the technology, as well as values for emissions (if these are valued) and a cost of the not provided energy.

When the system that is being planned has an important hydroelectric component, within the description of the system, it is necessary to model the operative characteristics of reservoirs, if existing, as well as the fluctuation nature of hydroelectric resources for which reason historic chronicles of flows entering such plants are used. The behavior of the hydroelectric system is very different if it has or not the capacity for storing water and managing the resource, a matter that makes this a more complex case to analyze. This is due to the strategy that is adopted in generating or storing water that is compared year after year and to this are added the variability of contributions, which leads to the existence of practically infinite strategies for the operation of hydroelectric plants. Several of the programs that have been previously mentioned, possess internal routines to assist in the modeling of these strategies. For each expansion plan, after estimating the possible operating strategies, the mathematical hope of significant variables is calculated (costs, consumptions of the thermal park that operates as a whole, not provided energy) based on the probability of occurrence that each type of hydrological year has. This permits the evaluation of the performance of the expansion considered to be able to compare it with other possible plans. The dynamic programing technique provides tools that are very appropriate to model this phenomenology.

Without doubt, the complexity of the problem posed by an important hydroelectric participation with a significant capacity of regulation, makes it difficult to forego computational models to evaluate in depth the expansion of the electric system. In any way, working with average values of hydraulicity (and electricity production) coupled with chronicles of very low occurrence (or that which is denominated as hydraulicity of 95% of excess, that is flows that are being surpassed in 95% of cases) to estimate the reserve margins necessary for dry years and the average values for dispatch based on a medium type hydraulicity, it is possible to carry out a very good approximation of the performance of the expansion plan without the need of modeling with the detail and complexity demanded by simulating the probabilistic management of the reservoirs.

Marginal Analysis of investments[78]

The analysis starts from an initial program, arbitrary but reasonable, that is the reference solution, and later an attempt is made to improve it, (reducing costs), by means of marginal substitutions. The reference solution and the solution obtained after having carried out the marginal substitution, satisfy both the demand for power as well as energy.

A common application is the comparison of the conventional thermal and hydraulic alternatives to cover a given demand of electricity, thinking of this expansion with the following additional to the system. The hydroelectric plant requires a larger investment (I_H) than the thermal using fossil fuels ($I_H > I_T$), but total operative costs of the system in subsequent years are lesser.

78 Its first application dates from the decade of the 40s, in the Electricité de France Company. Source: Fundación Bariloche, op. cit. 2006.

Thus:

Ct_H = cost of operation (fuel included) of the entire system, in the alternative that includes the hydraulic, in year t.

Ct_T = cost of operation (fuel included) of the entire system, in the alternative that includes the thermal, in year t.

r = discount rate.

Present value, PV, of the economies obtained when substituting thermal for hydro, therefore is:

$$VP = (I_T - I_H) + \sum_{t=o}^{n} \frac{1}{(1+r)^t} (C_{tT} - C_{tH})$$

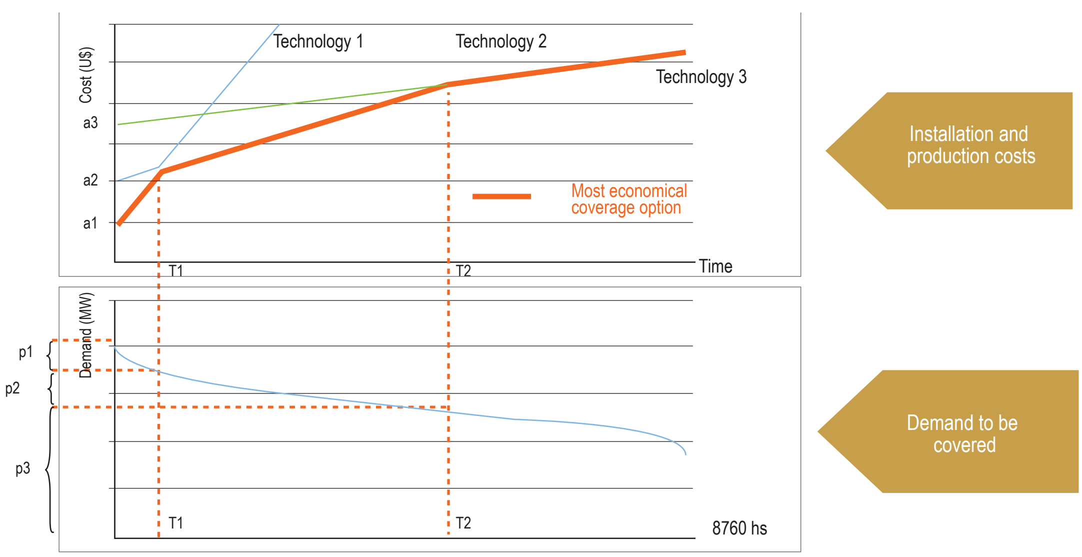
VP positive: The hydro **IS** is preferable to thermal

VP negative: The hydro **NOT** is preferable to thermal

And according if this is a positive or negative value, hydro is or is not preferable to thermal. This is a highly simplified analysis, that although it does provide an initial approximation, it generates numerous doubts.

By carrying out a comparison of the type presented in the following graph, this analysis permits the determination of the approximate order of proportions should be an electric system relative to peak (p1), semi base (p2) and base (p3) plants.

Figure V.10: Selection of investments



Source: Authors based on IAEA TRS 241 (1984). Expansion planning for Electrical Generation Systems, p. 234, IAEA Vienna 1984.

This calculation can be easily formulated also for comparisons between conventional thermal and nuclear plants on the basis of the load diagram, and steam thermal and gas turbines in the peak of the diagram, as shown in the preceding graph. In the above graph are included total annual operation costs according to the hours in the year that each plant is operating. Thus the ordinate to the origin of each technology represents its capital costs, in reference to the amount associated to the annuity of the investment, while the slope with which the cost increases as generation is made for more hours of the year, is linked to the price of the fuel used and the performance of the machine. The intersections of curves are the points of indifference between technologies, that is, values of the factor of annual use for which the two technologies will have an equal total production cost per unit of energy generated. The combination between these two indifference curves of the technologies and the load curve of the system determine the quantity of "ideal" power of each type of technology for this "photograph" of the system.

The sequential use of this methodology will permit the determination of an expansion plan.

This method permits adjusting the calculations to take into account many specific costs and benefits of a project. On the other hand it is necessary to consider that the two alternatives to evaluate, must be equated regarding performance, what means that, these must satisfy the proposed policies and provide a similar level of safety and quality of services.

So that the program of works finally proposed will be closer to the best option, it is necessary to assure that the constructed solution (for reference) will be "reasonably good" in order to not have to make an excessive number of marginal substitutions. This requirement is very difficult to comply when the system under analysis has not reached a high degree of development and there still remain many options for future equipment, especially hydroelectric. On the other hand, there may be some power stations in existence, fundamentally hydroelectric, the inclusion of which substantially alters the evolution of the system, which cannot be considered as marginal.

Finally, it must be stated that the marginal analysis of investments is highly static from the point of view of the investment and operation cost, in view of a determined configuration of the system and the manner of demanding energy. Additionally, it is very limited and does not offer the possibility of the incorporation of other necessary dimensions, such as those that have been previously justified.

Some considerations relative to planning tools

It is not an easy task to integrate the set of concepts mentioned along this Chapter, assuring that the evolution of the expansion plan to be evaluated (including the identification of "the" adequate expansion plan) due to the multiplicity of aspects to be considered, as well as the interrelation between variables. That is why there are many models or tools that assist in the planning process for expansion or of their different links. These tools may be categorized according to multiple criteria, among them, according to their scope, according to their algorithms of resolution, according to their conceptualization of the problem.

We can affirm that there is a recurrent matter in the identification of processes for electric planning with optimization models. To find the optimum solution is a very attractive proposal, but there are certain precautions that are necessary to highlight. Optimization requires defining a merit function, the result of which can be escalated, to thus be able to compare one solution with another and determine without any degree of doubt, which one is better. Generally, this merit function is associated to the total cost of a plan, in which there is an effort to include existing externalities that must be necessarily valued. This valorization is extremely difficult, and it would be adequate to observe what has happened in the carbon credit market. Additionally, the function of quantitative merit, the optimization models may include a series of restrictions to narrow the set of solutions and find among them the optimum one. Among such restrictions we can include environmental issues, availability of resources, of foreign currency, of maximum generation for specific units, among others. Restrictions represent a possible way of converting variables that are difficult to assign a value into "acceptable" solutions.

This way, electric optimization models will find the expansion plan that minimizes the total cost of investment, operation and maintenance, export/import (if it be the case) and non-supplied energy. Even from the conceptual point of view, when including the value of non-supplied energy such optimization models could solve the optimum margin of reserve of the system, precisely on the basis of the equilibrium presented in the section of reserve margin that shows that a low reserve margin implies a very high social cost (a great deal of energy that has not been provided and the economic and social consequences derived from this) while an excessive over-equipping burdens the cost of the system in a perhaps exaggerated manner. Thus, if it were possible to evaluate the value of the not provided energy, an optimization model could determine the optimal margin. Since now, although all of the organisms of electric dispatch possess some valuation to penalize the not provided energy, these values are generally quite ephemeral if there is the intention of using them in an optimization, resulting in an almost nil margin. This is a matter for debate devoid of a clear and accepted methodology.

Another problem associated to the optimization models is the value or price assigned to fuels. Neoclassic economic theory affirms that the prices of the Paretian global optimum will have to be used to feed a sub-sectorial energy model, considering the cost of opportunity of the resource. Evidently, the fuel prices have a major impact on the determination of the most adequate expansion system and these do not precisely rise from competition markets, therefore, they generally represent the prices of a global optimum, if such a thing could exist[79]. However, this is not necessarily true from the point of view of the economic development of a country considering that while the development of the energy sector may be observed as a key tool for economic development. Discussion becomes even more intense when the domestic cost structure for the production of fuels is strongly divergent from border prices. When this is so, it cannot be

79 Let us recall that from the theoretical point of view, a global optimum could only be reached for an economic system if all of its activities would answer to the functioning and the assumption of a perfect competition and that natural monopolies would be regulated. This is clearly far from being realistic, principally because a large number of industries whose products are inputs and/or goods that permit the consumption of energy. It is enough to mention the oligopolies of the automobile industries, of companies that produce electro-domestic appliances and companies that produce machinery for the generation of electricity, among many others.

affirmed that the optimum solution for the energy system as a whole or more ambitiously for the economic system, be that in which the electric subsector is optimized on the basis of international prices as an input. It is clear, that the solution of the optimum plan is strongly influenced by the value assigned to fuels. Therefore, the pretension is very doubtful of being able to reach the optimum solution, since the fuel price is not coming from any optimization for the entire energy or economic system of the country.

The optimization model is an important tool for the planner, as they permit the identification of a particular solution within the cumulus of almost infinite possible options. As a matter of fact, its results are useful to be placed in contrast with a determined energy plan or sub-sectorial policy, underlying in a plan that contemplates more ample objectives. Among the more frequently used optimization models we can highlight: SUPER OLADE, MESSAGE, WASP, OPTGEN, MARKAL. Some of which are models for the energy system as a whole, and which can be used if there is the need of evaluating electric expansion.

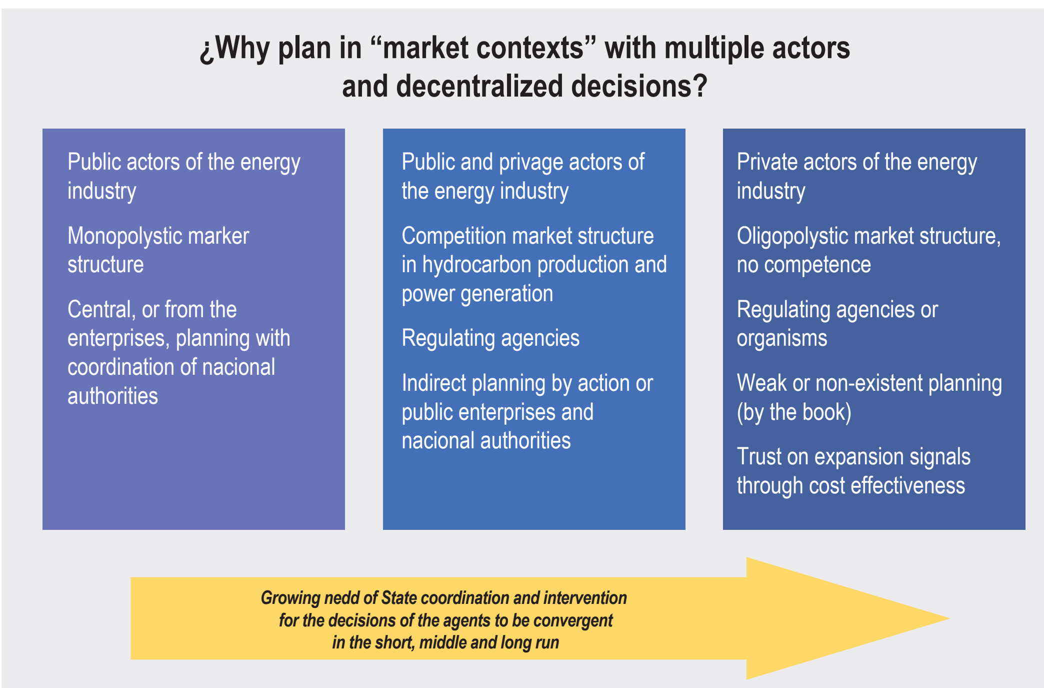
There are other models that pretend to simulate the behavior of an expansion plan or of a set~~,~~ of plans framed within a methodology of scenarios. Some of these scenarios could be fed with the outputs of an electric optimization model to be able to thus compare the implications of this plan or others proposed within the set of the energy system. The LEAP model is one that has these characteristics, even though in which although it does not possess the possibility of representing the electric sector with such operative details, a sufficient description is attained to evaluate an expansion plan with regard to other~~/~~s. In these last years, the LEAP model additionally incorporated a functionality of optimization to assist in the identification of a minimum electric cost scenario.

V.5.2. Planning of petroleum and gas supply

Actually it is increasingly clear that in a decentralized system with the presence of multiple stakeholders in the different energy chains, there may be a lack of coordination in the decisions for energy investments that lead the State to resort to at least Indicative, Strategic Plans and otherwise to measures of a direct Intervention or returning to a greater state control not only in the linkage to capture oil revenues, but also in that which is direct with problems of supply and investments.

The following Figure shows the evolution registered in many countries with respect to transformations from a State Planning Scheme through various entities such as Ministries, Secretariats and Public Enterprises to another one dominated by the approaches of “de-regulation”, “competition” and the decentralization of decisions[80].

Figure V.11: The need to plan



Source: Note “Supply Activities”. Master in Economy and Energy Policy and Environmental (MEPEA) of the Fundación Bariloche and the National University of Comahue.

This shows that, contrary to what was affirmed at the beginning of the decade of the 90s, in full boom of the reforms and privatizations, trust in market signals and a superficial or weak planning, led to the need for an ordering intervention on the part of the State, since it is the last guarantor for energy supply, whatever might be the existing institutional Scheme.

80 The material presented in the following point, is based on the note on “Supply Activities” of the Master’s Thesis Economy and Energy Policy and Environmental (MEPEA) of the Fundación Bariloche and the National University of Comahue, Bariloche, Argentina, June 2012.

It is therefore convenient to stop for a few instants and analyze the characteristics of this type of goods, so-called energy products, among them particularly petroleum and gas.

- Investments require a long period for maturity. For example, between the moment in which the tasks of exploration are started (and if these turn out to be successful and the commercial production of oil becomes a reality), and the development of an oil deposit, a period of five to ten years may ensue.
- Today, this product is indispensable for the functioning of the social and economic system both in sectors of final consumption, as well as of intermediate consumption. On the other hand, in some uses it still does not have substitutes at competitive prices. For example, diesel oil in transport, gasoline in Otto cycle engines (except in the latter case of countries with natural gas or with a production of Ethyl alcohol) and a proportion of biofuels, the impacts of which deserve a separate Chapter. These characteristics bring closer the activities destined to place these goods at the disposal of society with the so-called public services or at least highly strategic energy products. This means that the supply, or the reliability of such a supply in quality and quantity and in time, turns out to be a public necessity and therefore it must be subject to specific standards.
- In addition, the oil sector generates considerable revenues, and has a decisive influence on the commercial balance or in tax revenues and the level of internal prices.

In this context, the essential regulatory function of these activities cannot be delegated on the part of the State. The following are some of the reasons why the State should intervene in the oil sector of the countries:

- To protect consumers, that are numerous and varied, relative to the concentration of suppliers regarding: quality of products, safety of installations and monopoly or oligopoly practices reflected in unjustified alterations of prices
- To assure present and future supply of these goods, inasmuch as a lack of them could paralyze the functioning of the social-economic system of a country.
- Because it is a fuel that may be national or imported with different macroeconomic impacts.
- Because of the impacts it has upon the environment

It therefore seems necessary to: foresee the existence of minimum stocks of products; demand the undertaking of minimum exploration tasks that permit maintaining an adequate relation of Proven Reserves-Production; authorize exports and/or imports when certain determined quantitative guidelines are exceeded; provide a timely alert to public and private companies relative to future equipment destined to satisfy a possible expansion of demand, etc.

Then State, whether it acts as an entrepreneur or not, under no circumstances should cease to be regulator and planner, since the market exposed to its own forces doesn’t assure consumer’s protection and neither supply.

On the other hand, to be able to foresee his investment requirements and their financing, his participation in the market and which part of the benefits will not be distributed to stockholders, the Private Entrepreneur also needs to plan and if he is transnational or dominated by non-energy stockholders, his global strategies may defer the needs of a specific country.

The requirements of petroleum derivatives that are intimately linked to Planning are also deeply linked with the Energy System as a whole.

However, from the supply side (once the requirements of derivatives and of crude oil have been defined) it makes it possible for oil companies to operate with a greater autonomy. If these are state companies, theirs will be the responsibility of determining the type of equipment and the consequences of investment plans and of their evaluation on the basis of general policies established by the corresponding government organization.

In these cases, the ideal would be the formulation of contracts between state companies and the government, where will be determined the goals to be met for pluri-annual periods, granting to them an autonomy of management, stability in leadership and annual accountability of their operations as well as compliance with the agreed goals.
If in a country there do not exist state oil companies, it would be indispensable that the corresponding government organization should establish a regulatory entity to analyze, evaluate and report on the plans prepared by the private sector in order to assure a normal supply, protect consumers as well as the environment.

The oil and gas chain

The consumption of petroleum derivatives in a country or region is linked, by means of a complex chain of relations, with marketing, import, export, production, refining, variation of reserves, export and transport that constitute the activities of the petroleum industry. But when producing petroleum, natural gas is also produced, what makes it difficult and probably inconvenient an autonomous industrial and institutional management of each one of these energy resources.

In Figure Nº V.12 it is possible to appreciate how, based on a Model of Energy Requirements (MER, such as LEAP, MAED, MARKAL, etc., models described in Chapter VI of this Manual) we observe the elements of Final Consumption of Petroleum Derivatives (FCPD), coming from each of the Socio-Economic Sectors of a Country or Region under study. If we add to this (CFPD) the Self-Consumptions of Petroleum Derivatives (SCPD) of the Energy sector (Distilleries, Oil fields, etc.) we obtain a Net Total Consumption of Petroleum Derivatives.

$$(NTCPD)\ (BS_{10}DP) = (FCPD) + (SCPD).$$

Flows coming from other Transformation Centers, different from those of Oil Distilleries, (for example: fuel oil and diesel oil to generate electricity; gasoline for petrochemical industries) constitute the Intermediate Destination (BS_9DP), that together with Net Consumption ($BS_{10}DP$), originate the Supply of Petroleum Derivatives (BS_8DP).

$$(BS_8DP) = (BS_9DP) + (BS_{10}DP)$$

Adding the Supply (BS_8DP), Exports (BS_3DP), Non Used (BS_4DP), Losses (BS_5DP) and Variations of Inventories (BS_6DP) and deducting Imports (BS_2DP) we obtain the Production of Petroleum Derivatives (BS_1DP).

$$BS_1DP = BS_8DP + BS_3DP + BS_4DP + BS_5DP + BS_6DP - BS_2DP$$

Since a petroleum distillery is not the only producing center of PD, we must deduct the Production Derivatives from petroleum (BS_1DP) coming from other Transformation Centers, for example Petrochemicals ($PETR.BS_1DP$), and thus be able to determine the Distillery Requirement of Petroleum Derivatives that is ($DEPBS_1DP$).

$$(DEP\ BS_1DP) = (BS_1DP) - (PETR.BS_1DP)$$

A Model of Distillery, would provide information relative to the flow of Crude Petroleum to be Processed (DEP BP_9PE) that together with that processed in other transformation centers such as Petrochemical Distilleries ($PETR.BP_9PE$), constitutes the Intermediate Destination (BP_9PE). This value in turn is the Petroleum Supply (BP_8PE) since, in general, it is not convenient to directly consume crude petroleum. It is that the Net Consumption of Petroleum ($BP_{10}PE$) is nil.

$$(BP_9PE) = (DEP\ BP_9PE) + (PETR.BP_9PE)$$

$$(BP_8PE) = (BP_9PE) + (BP_{10}PE),\ \text{pero}\ BP_{10}PE = 0$$

By adding Petroleum Supply (BP_8PE), Exports (BP_3PE); Variation of Inventories (BP_6PE); Losses (BP_5PE) and Non Used (BP_4PE) and deducting Imports (BP_2PE), we obtain the quantity of Petroleum to be Produced (BP_1PE).

$$BP_1PE = BP_8PE + BP_3PE + BP_4PE + BP_6PE + BP_4PE - BP_2PE$$

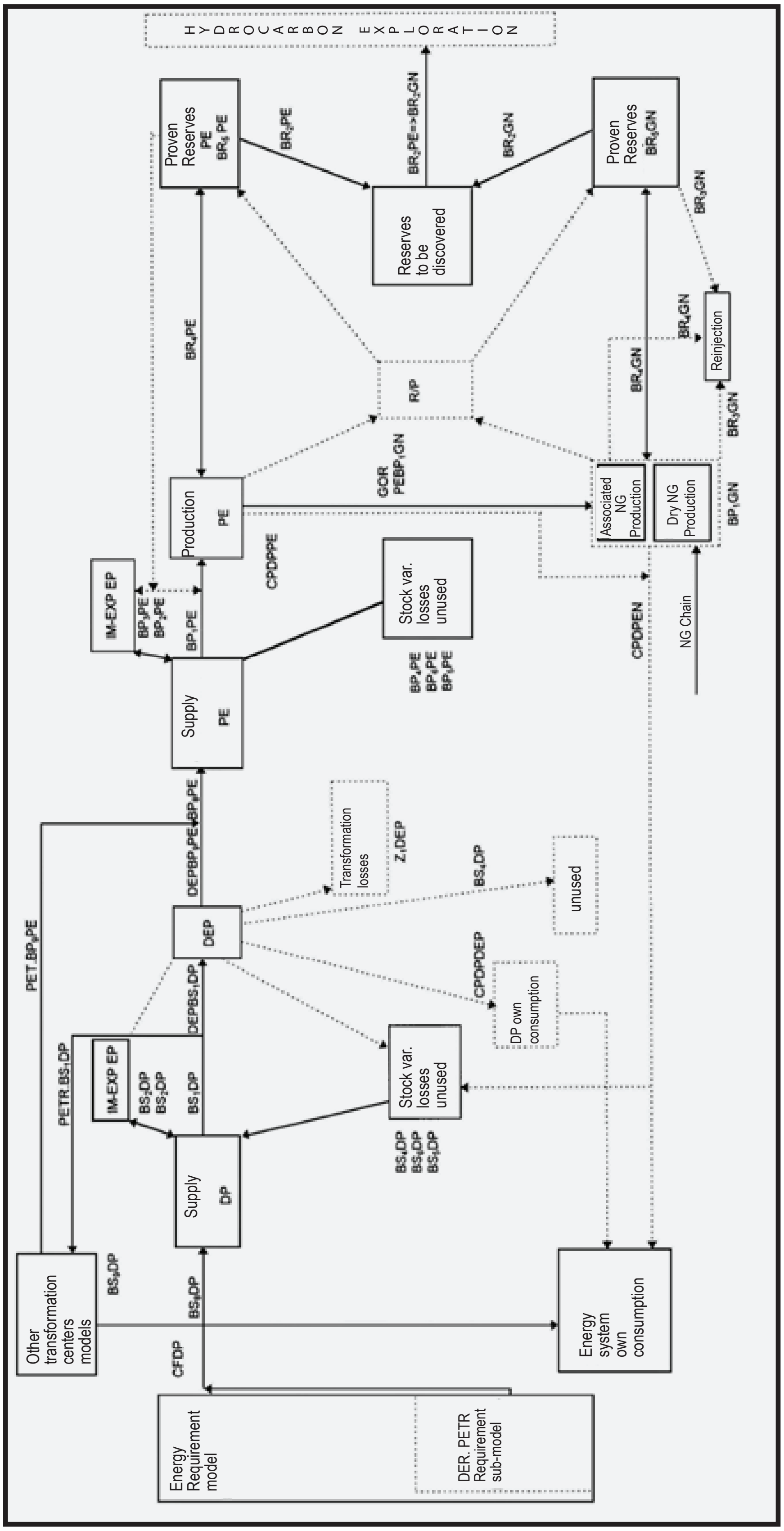
Once (BP_1PE) is known and the Gas – Oil Relation (GOR)[81] of the petroleum producing fields, it is possible to obtain the quantity of Associated Natural Gas[82] to be Produced ($PEBP_1GN$).

$$(PEBP_1GN) = (BP_1PE).\ (GOR)$$

81 Indicates the quantity of Natural Gas in volume that is extracted per unit of volume of the Petroleum in a Deposit. Thus, a GOR = 300, indicators that for every m^3 of Petroleum produced there are 300 m^3 of Natural Gas.

82 Natural Gas Associated to petroleum refers to the gas that is produced in the same well where the petroleum is extracted.

Figure V.12: Scheme of the Petroleum subsystem and its connection to Natural Gas



Energy Policies	Marketing and Transport Policies of Derivatives	Refining Policies	Marketing and Transport Policies of Crude	Policies for the Exploration - Production of Petroleum
- of Substitution - of Conservation - Petrochemical Policy - of Prices and Tariff Structures - Taxes - Policy for Technological development - Policy for Human Resources	- Role of the State - Import and Export of Derivatives - Analysis of International prices of Derivatives - Marketing and Transport Costs of Derivatives	- Role of the State - Import and Export of Crudes - Analysis of Costs and Refining Margins - Values of Derivatives in Distillery Tanks and criteria of appropriate them - Evaluation of Impacts - External Investments Sector - Relative to Local Industry - Development of Technologies - Labor Requirement - Environment - Relative to Public Investment	- Role of the State - Analysis of the Petroleum Market - Costs of Crudes at Well Head - Costs of Transport - Determination Differential Incomes - Price Policies for local crudes and appropriation of Oil Revenues	- Role of the State - Oil Legislation - Analysis of the Cost of Depletion - Analysis of the Costs of development of Exploration and Exploitation at the level of each Deposit - Policy of Mining Risk - Planning of Exploration and Development - Criteria relative to the Commercial Nature of Deposits - Evaluation of Impacts (similar to Refining)

Source: Note on “Supply Activities”. Masters in Economics and Energy and Environmental Policy (MEPEA, in Spanish) de la Fundación Bariloche and the National University of Comahue.

Codes to Figure V.12

DP	Derivatives of Petroleum	BP_2	Important
CFDP	Final Consumption (Consumo Final)	BP_3	Export
CP DP	Self Consumption (Consumo Propio)	BP_1	Production
BS_9DP	Intermediate Destination	BP_4	Not Utilized
BS_8DP	Supply	BP_5	Losses
BS_2	Import	BP_6	Variation of Inventories
BS_3	Export	F_A	Supply Factor
BS_4	Not Utilized	CPDPPE	: Self-Consumption of Oil Derivatives in Oil Production
BS_5	Losses	CPDPGN	Self-Consumption of Oil Derivatives in Natural Gas Production Gas
BS_6	Variation of Inventories	GOR	Gas- Oil Relation
CPDPDEP	Self Consumption of Oil Derivatives from Petroleum Distilleries	$PEBP_1GN$	Production of Natural Gas Associated to Petroleum
$PETR.BS_1DP$	Production of Petroleum Derivatives in the Petrochemical Industry	BP_1GN	Total Production of Natural Gas
BS_1	Production	R/P	Relation Reserves-Production
$DEPBS_1DP$	Production of Derivatives in two Petroleum Distilleries	BR_2PE	Petroleum Reserves to be discovered
DEP	Petroleum Distilleries	BR_2GN	Natural Gas Reserves to be discovered
PE	Crude Oil	BR_3GN	Reinjection of Natural Gas
$PETR.BP_9PE$	Intermediate Destination of Crude Oil to Petrochemical Industries	BR_4PE	Production of Petroleum
$DEPBP_9PE$	Intermediate Destination of Crude Oil to Petroleum Distilleries	BR_4GN	Production of Natural Gas
BP_8PE	Crude Petroleum Supply	BR_5	Final Proven Reserves
Z_1DEP	Losses in Transformation in Distilleries		

A similar reasoning is applied to get from the Requirement Model to Petroleum Production, what will also permit determining the Total Production of Natural Gas (BP_1GN).

If (BP_1GN) is deducted from the production of Associated Natural Gas ($PEBP_1GN$) we obtain the Production of free Natural Gas[83] (BP_1GNF).

$$(BP_1GNF) = (BP_1GN) - (PEBP_1GN)$$

On the basis of data of Proven Reserves in existence at the initial year of the study (BR_1PE); of Future Production of Petroleum (BR_4PE); and of the Future Proven Reserves (BR_5PE), we obtain the value of Reserves to be Discovered (BR_2PE) between the initial year and the future of the study.

$$BR_2PE = BR_5PE + BR_4PE - BR_1PE$$

For Natural Gas it is possible to apply a similar reasoning, taking into account the Petroleum Reserves to be Discovered (BR_2PE) and the GOR estimated for them that permits deducting the Discoveries of Associated Natural Gas ($PEBR_2GN$).

$$(PEBR_2GN) = (BR_2PE).\ (GOR)$$

To determine the Reserves to be Discovered of Free Natural Gas (BR_2GNF), we deduct from the Total Reserves of Natural Gas to be Discovered (BR_2GN), the Reserves to be Discovered Associated to Petroleum ($PEBR_2GN$).

$$(BR_2GNF) = (BR_2GN) - (PEBR_2GN)$$

Once that the Reserves to be Discovered are known, the plans for exploration, prospection, drilling of wells, etc. are estimated by means of probabilistic models and/or political economic policies with respect to mining risk that the study is willing to accept.

Preliminary visions of the type of hydrocarbons supply

For the purposes of planning hydrocarbon supply it is necessary to take into account the different stakeholders that are involved in this stage of the activity, since their objectives and/or interests do not always coincide and this generates conflicts.
It is then possible to identify five types of stakeholders:

- √ final users
- √ refining companies
- √ retailing companies
- √ the political energy organization and/or regulatory entity
- √ the public organization that collects taxes or grants subsidies

It will also be necessary to take into account in what type of market these transactions are carried out, thus the planning of the supply will be different, based on the characteristics of the country in question.

83 Free Natural Gas, refers to the gas that has been separate in the oil deposit, and only gas is produced from these Wells (eventually accompanied by some low proportion of condensates).

Types of Hydrocarbon Markets

At least in Latin America, it is possible to distinguish the following types of markets:

- State Monopoly: Both in the refining stage as well as in retailing. In these cases, prices are directly fixed by the financial organization of the country or by the energy organization. This is the case of Cuba and Mexico.
- State Monopoly in Refining and State-Private Oligopoly in Retailing: Prices are also fixed by the State. In Latin America this situation is present in Colombia (partially), Costa Rica, Ecuador, Paraguay and Uruguay.
- State-Private Oligopoly in Refining and Retailing: Prices are fixed by the State. This is the case of Brazil prior to its oil reform and at present of Colombia.
- Private Monopoly in Refining and Private Oligopoly in Retailing: Prices are fixed by the private sector under a previous agreement with the State, this is the case in Guatemala, El Salvador, Nicaragua, Honduras, Dominican Republic and Panama. Most of these countries are now passing to the following group.
- State-Private Oligopoly in Refining and Free Market in Retailing: In the case of Chile there is a stabilizing or compensating fund for the prices received by ENAP and there is freedom for the import and export of derivatives. It is that there is a Regulating Authority of the State. In Peru, the perspective is the free determination of prices. Starting in 2000 to the present date, Colombia has evolved towards this model, both due to the privatization of one of its refineries, as well as to the policy of "dismantling of subsidies" applied in a context for the equalization of subsidy and the distancing of opportunity costs. In this case, the FOB Price for exports are prices in New York markets. Thus, in all of these cases prices are in a direct relation with international prices.
- Private Oligopoly in Refining and Sales: Prices and foreign trade are free and are linked to international prices. The State only determines taxes. In practice the Refining Marketing Oligopoly determines prices. The State has no regulatory power. This was the case in Argentina up to 2002 and in Peru, it was also that of Bolivia up to 2006.

In addition, according to their principal **characteristics of the oil supply**, the countries of the Region can be classified within the following categories:

- Producers Exporters of petroleum and its derivatives (for example: Venezuela, Mexico)
- Producers Importers and Exporters of petroleum and its derivatives (for example: Ecuador, Argentina, Brazil, Colombia, Peru, Trinidad and Tobago)
- Producers Importers of petroleum and its derivatives (for example: Chile, Cuba, Guatemala, Bolivia)
- Non-producers of petroleum - Producers of derivatives (For example: Costa Rica, Dominican Republic, El Salvador, Nicaragua, Uruguay)
- Importers of derivatives, without local production of derivatives (for example: Paraguay, Honduras, Panama)

For example, in the case of countries that are strong oil producers and exporters, exports correspond to the difference between the projection of oil production (based on proven reserves, their declination and the incorporation of resources to reserves) and the internal demand for oil (crude oil that enters refineries to satisfy the internal market and possible exports of derivatives). It is that the supply of petroleum rises from the projection of production, from which is deducted the internal demand for crude oil, with the purpose of determining exportable balances. To determine the demand of national crude oil destined for refineries it is necessary to apply a simulation model of distilleries (example MESSAGE), that permits, on the basis of the requirements of derivatives that rise from the model of a Demand Prospective (plus some possible scenario for exports of derivatives) to determine the needs for the crude oil to be processed.

In the case of countries that are marginal producers (which at once could be marginal importers or exporters of crude oil), it is first necessary to calculate the internal demand for oil and then production will depend on the possibility of achieving self-supply (as for example Argentina and Brazil) or not. In this last case, production will depend on reasonable hypotheses of the evolution of reserves and of the difference with demand that must be covered with the imports of crude oil and petroleum derivatives.

For importing non-producing countries, we must establish a difference between those that have refineries or not, and in the latter case if they wish to have them. If they have refineries, it is necessary to calculate the crude oil to be processed with a simulation model of refineries under the condition or not of self-supply of derivatives (for example Uruguay), this will provide the demand for the crude oil required by refineries.

In the case of petroleum derivatives importing countries, that do not possess refineries, demand for derivatives will be the supply assimilated to imports (this is the case of many of the countries of the Caribbean and Central America). Requirements for derivatives rise from the model of the demand Prospective.

With respect to natural gas, countries can be categorized in the following manner:

- Producers Exporters of natural gas (for example Bolivia, Colombia, Peru and Trinidad Tobago)
- Producers importers of natural gas (for example Mexico, Argentina, Brazil, Chile)
- Non Producers Importers (for example Uruguay, Dominican Republic)

On a similar basis as that which has been mentioned in relation to petroleum, planning of the supply of gas will follow the previously mentioned guidelines, depending on the type of characterization that the country has in relation to the relative abundance or scarcity of the resource.

In the case of importing countries that have a re-gasification plant for natural gas (example Chile), the supply of this resource will be associated to the expansion plans of LPG plants, since in the immediate horizon there is no possibility of imports through gas pipeline from neighboring countries.

V.5.2. Planning for the supply of renewable energies

The evaluation of renewable energy resources presents specific challenges to the planner in view of the heterogeneous characteristics of renewable energy flows, and of an important series of restrictions that exist for their use and that essentially are in relation with geographic distribution, access and the use of these resources. A quantification of the gross potential is relatively simple, but offers little guidance in relation to the potential of real use of the resource in a given context, which is usually significantly inferior to the previous one. Therefore, the planner must identify the principal restrictions applicable to each renewable energy resource and its possible evolution through time in order to test a quantification of the resources that takes into account said restrictions. In this way it will be possible to reach values of the resource that are of practical use for the planning process.

Renewable energies provide a wide range of energy forms (electricity, thermal and mechanical energy, liquid, gaseous and solid fuels) that supply a diverse range of growing energy services. The integration of renewable energies to the energy Matrix presents special challenges to the planner as a consequence of some characteristics that tend to differentiate them from fossil fuels and nuclear energy. These determine that the introduction of renewable energies require changes of different magnitudes in the energy system. These changes will depend on the specific technology, its level of penetration, and of the characteristics of the energy system, among other factors.

Some of the aspects that tend to establish a difference in renewable energies and other forms of energy are:

1. **Renewable nature of the resource**. Renewable energies are based on the advantageous use of energy flows, in contrast with the stocks of energy products that characterize fossil fuels and nuclear energy. The magnitude of these energy flows is substantially greater that the present world energy demand but its distribution in countries is highly variable. In spite of being associated to energy flows, in some cases there is the possibility of depletion of renewable energy resources at the local scale, due to an inadequate management of the primary resources (example: biomass, geothermic).
2. **Variability in the production of energy at different time scales**, that may vary from seconds to years. Since they are associated to energy flows, renewable energies may be catalogued as: variables and in a certain degree unpredictable (solar, wind); variables that are predictable (tidal energy); constant (biomass, geothermal); and controllable (biomass, hydro). Some of these characteristics, coupled to the difficulties associated with the storage of energy, determine a requirement for the need of back-up systems or of an over-dimensioning of supply (solar, wind, tidal). In the case of biomass, the availability of the resource may have important seasonal variations (example: sugar cane). This stresses the need of complementing different energy products and/or planning for the storage of a stock of biomass or the corresponding energy product that results from the conversion of the raw material. The availability of some renewable energy resources may be affected by climate change (hydro, biomass).
3. **Low energy density in relation to fossil fuels**. This is an intrinsic characteristic of most of the primary renewable resources and is reflected in large areas of collection and infrastructure for the conversion of the resource into secondary energy (example: solar, wind). The conversion into energy products of a similar energy density as that of fossil fuels (example: synthetic diesel derived from biomass) is undertaken to the expense of a low efficiency of the process as a whole. This aspect has an incidence on the impacts and investment cost.
4. **Modularity and ample scale of application in terms of power**. Some of these technologies present the possibility of an application running from the scale of watts up to hundreds of MW.
5. **Geographic Distribution of resources**. Limitation or impossibility of its transport, importing and exporting without an intermediate energy conversion. This implies that primary resources must be used or converted on site. The geographic distribution of resources opens the possibility of their use by means of different schemes: centralized, distributed, or isolated. In the case of a centralized generation of electricity this requires an interconnection and transmission of electric energy to

demand centers, in some cases, covering great distances and with a significant cost. In the case of an isolated generation, renewable energies may play an important role to attain a greater security in supply and an accelerated access to such energy on the part of an important fraction of rural population, thus contributing to economic and social development.

6. **Cost and technologic maturity**. Some renewable technologies have reached an important degree of technologic maturity and of commercial dissemination, while others are still in the stages of pre-commercial development. Even more mature technologies such as high power wind energy or photovoltaic energy continue in their evolution and present different types of sub-technologies that share the market. The cost of renewable energy has been decreasing but in many countries it is still higher than energy costs, making necessary different economic and financial incentives to promote its penetration. In spite of this, there are certain situations and applications where renewable energy is already competitive.
7. **Environmental impact and sustainability**. Renewable energies present impacts, which are quantitatively and qualitatively different than those that correspond to conventional energies. The impacts that have been distributed along the entire chain and life cycle of the energy system, acquire special importance for the production and installation of systems. In general terms, impacts associated to the operation of systems are specific, and their emissions of greenhouse gasses are lower to those of fossil fuel energies, with the exception of certain chains of production of bio energies. Taking into account these characteristics, a consideration of environmental externalities of energy systems during the planning process, could represent an incentive to favor the insertion of renewable energies in the energy Matrix.

As previously mentioned, these characteristics are not universal. Technologies such as hydroelectricity, high enthalpy geothermal, or even thermoelectric stations that operate on the basis of biomass have many similarities with conventional thermoelectric power plants, which is the reason why their incorporation to the electric system in general do not present new challenges. On the other hand, the variability of solar and wind generation require that a massive interconnection of these power plants require a redesign of the electric system in order to maintain adequate standards of quality and reliability of supply. In general terms, the massive integration of renewable energies to the energy system is technically feasible but may represent greater costs. Therefore the scale of penetration is very important to determine the depth of the analysis that must be undertaken prior to the incorporation of renewable energies to the energy Matrix, to evaluate its possible impacts on the system as a whole. The threshold under which this analysis should be deepened is relative to each energy system and does not remain static in time, and depends on, among other factors of:

- **Structure of the energy system by type of energy**. For example, a greater proportion of hydro or thermal-electric power stations of a rapid response will allow a greater degree of incorporation of solar and wind power stations.
- **Geographic distribution of renewable generators connected to the same electric network**. A greater geographic dispersion of generators permits a reduction of variability in the generation of the set by a variation in wind and insolation regimes. The larger the geographic zone under consideration, the greater will be this effect.
- **Interconnection with other countries**. Interconnection with electric systems of other countries that can absorb a part of the variability of the resource (example: with a high proportion of hydro plants) permits an increase in the penetration of renewable variables.
- **Complementary nature between energy resources with energy demand**. The complementary nature between energy resources with energy demand may facilitate the insertion of renewable energy variables in the energy Matrix.
- **Specific characteristics of incorporated renewable energies**. Wind energy technologies are diverse and have been evolving to offer greater capacity of support to the grid, as well as security in case of outage of generators or when facing variations in the characteristics of the electric signal.
- **System for control and dispatch of generators**. Advanced system for forecasting renewable resources. (Example: reduction of the time between planning of dispatch and real dispatch (gate closure time), on-line monitoring of renewable generators, on-line gathering and interpretation of data from the national meteorological network to obtain more precise forecasts and with a greater anticipation).
- **Storage of generated energy**. Development of economic systems for storage of thermal or electric energy at different scales (example: heat storage in thermal-solar power plants).

The variability in energy production of certain renewable technologies implies that to cover the high percentages of energy demand on their basis, it may be necessary to turn to over-sizing systems for those moments when the resource is low. On the other hand, restrictions associated principally to the cost of investment and the need to comply with adequate levels of supply security, leads to an effort to avoid an over-sizing of systems. It is necessary to establish a distinction between isolated systems and those that have access to a reliable supply network (electric or of other energy products), and also between those uses that must have a high degree of supply reliability and those that could remain without supply in a temporary manner. In off-grid systems that require a high supply level (example: health stations, telecommunications), there is an over-sizing of storage in renewable systems or a conventional back-up system is installed. In on-grid systems with access to adequate networks in planning dominates the complementary nature of renewable and conventional energies. As an example, solar systems for water heating are conceived in general to complement conventional systems based on liquid fuels, electricity or firewood. However, in certain cases of small scale on-grid systems, such as distributed electric generation on a residential basis with photovoltaic energy, the magnitude of such generation may be significant in relation to the requirements of the home. In this case supply reliability is guaranteed by interconnection, and the cost of the investment is justified by means of incentives and the sale of energy to the grid.

Based on what has been previously stated, renewable energies present a great diversity of situations that must be adequately faced by the planner. This implies that the insertion of each renewable technology in a determined application must be evaluated in a specific manner and taking into consideration the contexts into which it is inserted. In general terms, it is not possible to establish extrapolations without adaptation of successful experiences developed in other countries or even in the same country but with different technologies.

V.6. Resources

V.6.1. Quantification of primary energy resources

Petroleum and natural gas

The hydrocarbon industry[84] has advanced significantly. However, is still to be developed a technique or technology that permits providing from the surface a certainty of the existence of underground hydrocarbons. The only manner of guaranteeing their existence is through the drilling of wells.

Therefore, the industry has an inherent risk that characterizes it, referred to as the mining risk. This is one of the principal features that define the hydrocarbons industry as an activity with risk, where as a reward there exist revenues associated to it.

This characteristic, in view of the future requirements of hydrocarbons that may rise from a strategic plan, turns out to be one of the principal problems to face on the part of the energy planner.

Among other questions that the planner must answer we can highlight the following:

- √ How much of the resource exists?
- √ What part of that resource can be converted into a reserve?
- √ What exploratory effort must be undertaken to satisfy requirements?
- √ How much can be technically and economically extracted?

The degree of uncertainty surrounding these questions may be approached, by means of preparing matrixes that will permit the classification of reserves and resources. The following section provides a description of each one of the components that comprise a part of this Matrix.

Criteria for the Classification of Resources and Reserves

Resources: Are understood as such all of those underground zones that due to geologic inference possess some type of hydrocarbon. Not all of the resource can be extracted, either due to its geologic uncertainty or due to economic reasons, therefore only a portion of it can be converted into Reserve. Besides, there exists a part of the resource that is not recoverable (no matter how improved are the geologic certainty or economic conditions). This is called a Non-resource. Example: petroleum that cannot be reduced by capillarity and that remains in the reservoir rock is a Non-resource. In a certain percentage this limits the volume of the potentially extractible resource.

Reserves: Is a part of the resources, which under present economic conditions and in view of geologic certainty, may be extracted in time. Later will be presented different sub-categories that comprise such reserves.

Matrix of Resources and Reserves

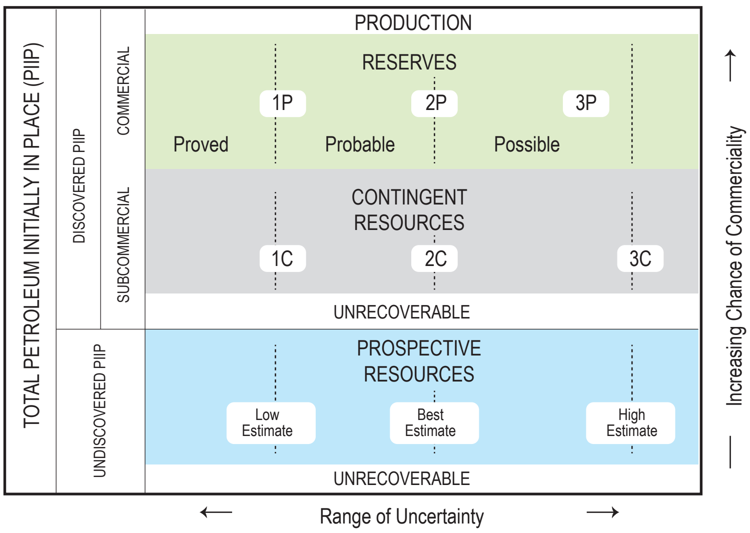
As has been seen, there are two important parameters that permit a characterization of resources and reserves, these are: the degree of geologic certainty and the degree of economic feasibility.

84 Refers to petroleum and natural gas.

Considering these two elements, in 1964 the geologist Vincent McKelvey, from the United States prepared a Matrix bearing his name that permits a classification of resources.

The Society of Petroleum Engineers (SPE) and the World Petroleum Congress (WPC), made an up-dating of these concepts that comprise this Matrix, among other questions due to the fact that the Securities and Exchange Commission (SEC) and the New York Stock Exchange, use the categories here defined to inform to stockholders regarding the reserves held by the companies that are listed in the stock exchange (SEC only considers as reserves those that are under the category of Proven). In the year 2007, the last revision was made of this Matrix, remaining thus conformed:

Figure V. 13: McKelvey Matrix, up-dated as of 2007



Source: adapted from McKelvey, V.E. 1972. "Mineral Resource Estimates and Public Policy."

Here we can observe that the initially quantities in situ of hydrocarbons, are divided in Reserves, Contingent Resources and Prospective Resources.

Under the concept of reserves we find three sub-categories: proven, probable and possible. Next, their definitions are presented:

√ **Proven Reserve**: Quantity of petroleum or natural gas that is economically recoverable of the volume in situ[85] of a deposit that has been proven with existing technology at the moment of its estimate. In the case of natural gas a distinction must be made between associated gas, fields with condensate gas and free gas. This concept of a proven reserve is that which is reported in the financial statements of companies. The information of proven reserves will be obtained from the oil company.

√ **Probable Reserve**: Quantity of petroleum or natural gas economically recoverable from the volume in situ of a field that is estimated will be discovered, with an appreciable degree of certainty, and with the existing technology at the moment of the estimate.

√ **Possible Reserve**: Quantity of petroleum or natural gas that is economically recoverable from the volume in situ of a field that is estimated will be discovered with a low degree of certainty, and with the technology existing at the moment of the estimate.

It is necessary to highlight that of the three sub-categories that make up the Reserves, the Proven refer to hydrocarbons that have been discovered and proven, while the Probable and Possible, refer to hydrocarbons that have been discovered but not verified (there are geological inferences relative to their existence). In addition, the three sub-categories of reserves are under the category of commercial, since prices and costs at the time of the estimate make feasible their extraction under economic conditions.

As 1P, are defined Proven Reserves; 2P, defines the addition of Proven plus Probable and 3P, is defined as the addition of Proven, Probable and Possible.

Relative to Contingent Resources, these are concentrations of hydrocarbons that have been discovered, but present market conditions or a lack of infrastructure for their extraction do not permit to include them as reserves (these are sub-commercial), and Prospective

85 Volume in situ: is the total quantity of Petroleum or Natural Gas contained in the reservoir rock of an oil deposit.

Resources, are those that have yet to be discovered, but that the geological conditions detected permit to infer their existence.

Finally, under the category of Non Recoverable, are included those hydrocarbons that previously had been denominated (in the first version of the Matrix), as a Non Resource.

Methodology to prepare a Matrix of Resources and Reserves

For the purposes of developing the planning of the hydrocarbon sector, a first step that must be taken is the preparation of the already mentioned Matrix. For this it is necessary to have available information on reserves and resources, which must be provided by the Ministries, Secretariats or Agencies in charge of the development and promotion of the hydrocarbons industry and/or those companies that are in charge of the exploration and/or exploitation of the areas.

The information referred to Contingent and Prospective Resources must be obtained either through field studies (Prospective, stratigraphic wells, drill cores, geological inference studies, etc.), requested by the organization that is in charge of the planning of the sector and/or carrying out consultations in international bibliography, referred to estimates of the hydrocarbons resources of the country. The latter type of information is provided by the USGS (United States Geological Survey), in its report Model for Undiscoverd for conventional oil, gas and NGL Resources. The last edition corresponds to the year 2000 (for the year 2013 a new updated edition has been announced), or by the Energy Information Administration of the United States, in its report called World Shale Gas and Shale Oil Resources Assessment.

Example. A case in Argentina

To carry out this example, there was an initial consultation of the databases of the Secretariat for Energy of the Republic of Argentina that provided details of reserves as of 31/12/11 in their different sub-categories. They have been complemented with a study denominated: Model for Undiscovered conventional oil, gas and NGL Resources-year 2000, together with publications of the USGS that permitted the identification of contingent and prospective resources, in terms of conventional hydrocarbons[86].

Table V.1: Matrix de Resources and Reserves of Argentina

	Conventional Oil	Conventional Natural Gas	Total	
Proven Reserves	394	333	727	31%
Probable Reserves	132	137	269	12%
Possible Reserves	101	156	257	11%
Contingent and prospective resources	151	921	1,072	46%
Total (million m^3 eq of oil)	778	1,547	2,324	
Total (%)	33%	67%		

Source: N. Di Sbroiavacca, prepared on the basis of EIA, USGS and the Secretariat of Energy of Argentina.

As can be observed in this Table, there would remain in Argentinian soil more natural gas than petroleum. We can also see that at the level of contingent and prospective resources, in the case of natural gas there still is a lot to be discovered and to be put to production. Also in view that during the last years, the country has faced an important deficit of that energy product, it would be recommendable (based on what can be observed in the Matrix), to implement prospection and exploration campaigns in the more promising areas to identify this resource and to consider the convenience of promoting the search and extraction of natural gas, by means of a price policy and/or better fiscal conditions.

86 Corresponds to a classification of hydrocarbons, where are included those accumulations present in the underground either or petroleum or natural gas, that are extracted with usual techniques, without requiring other special extraction processes that in general are more costly (example: hydrofracking: technique that consists in drilling horizontal wells close to multiple hydraulic fractures).

The planning process isn't static but dynamic, reason why it has to actualize periodically the information of that matrix. As an example regarding the dynamic nature that the issue presents, there is the recent publication by the Energy Information Administration of a report under the title: World Shale Gas and Shale Oil Resources Assessment (June 2013). In this document are presented estimates relative to non-conventional hydrocarbons resources[87] for 41 countries.

Considering the information therein presented, Argentina would be one of the countries with a greater potential for non-conventional hydrocarbons in the world. On the basis of this report, was prepared the following Matrix of resources and reserves of Argentina, considering both the conventional as well as non-conventional hydrocarbons.

Table V.2: Matrix of Resources and Reserves of Argentina, al 31/12/11 in millions de m^3 equivalent of petroleum

	Conventional Oil	Non Conventional Oil	Sub-Total	Conventional Natural Gas	Non Conventional Natural Gas	Sub-Total	Total
Reservas Probadas	394	4,285	394	333	21,659	333	727
Proven and possible Reserves and potential resources	384		4,669	1,214		22,873	27,542
Total (million m^3 eq of oil)	778	4,285	5,063	1,547	21,659	23,206	28,268
Total (%)	3%	15%	18%	5%	77%	82%	

Source: N. Di Sbroiavacca, prepared on the basis of EIA, USGS and the Secretariat for Energy of Argentina.

On the basis of the information in this Table, we can appreciate that conventional hydrocarbons represent an 8% (3% in petroleum and 5% in natural gas), of the total resources of the country, while the non-conventional are the remaining 82%. At present, this new scenario is modifying the decision making process within the petroleum scope of the country and the planner must take careful note of this, in order to generate the conditions that will foster the development of such resources and to consider how they will modify these decisions relative to the future availability of the resource.

Mineral Coal

The quantification of the coal resource of a country is based on geological, mining and economic criteria. The quantity of in situ coal in a country, and in certain cases of exploitable coal, is influenced by national criteria for the measurement of its resources. The bases to account for these resources vary from country to country and therefore, it is not possible to undertake direct comparisons relative to the presence of resources between countries.

<u>Resources</u>: this refers to the quantity of mineral coal that can be present in a coal deposit or field. This concept does not take into account the economic feasibility of its extraction. Using present day technology, not all resources are recoverable. Therefore reserves constitute those resources that are recoverable.

<u>Reserves</u>: these can be subdivided into <u>Proven</u> (or measured) and <u>Probable</u> (or indicated), based on this division are the results of exploration and the degree of confidence in such results. In general, proven reserves are estimated with a greater degree of confidence than the probable ones.

Mineral coal, under which are grouped a variety of solid organic fuels, for convenience it is divided into two subcategories, which in turn have two additional subcategories that comprise it, which according to the International Energy Agency are the following:

- √ Hard Coal
  - o Anthracite
  - o Bituminous Coal
    - § Coal for Coking
    - § Other bituminous coals
- √ Lignite (Brown Coal)
  - o Sub-bituminous coal
  - o Lignite

87 In mentioned report, there has only been made an estimate of non-conventional hydrocarbons resources, corresponding only to shale oil and shale gas (hydrocarbons extracted from compact mother rocks of clay or schists), without considering other hydrocarbons (non-conventional hydrocarbons contained in compact rocks like sandstones and carbonates).

In accordance with the International Coal Classification of the Economic Commission for Europe (UN/ECE), Hard Coal is that coal whose gross calorific value is not less than 5.700 kcal/kg, while Lignite possesses a superior caloric less than 5.700 kcal/kg.

Hard Coal is calculated as the sum of anthracite and bituminous coal.

On the other hand anthracite, is a Hard Coal of a high range, principally used for caloric uses in industry and the residential sector.

Bituminous coal is a medium range hard coal. This is divided into coal for coking, for the production of industrial coke (that will later go the blast furnaces to produce steel) and residential for caloric uses. Other bituminous coals, are principally used for thermal applications in the generation of steam (in general associated to the generation of electricity).

On its part, lignite is calculated as the sum of sub-bituminous coal and proper lignite.

Sub-bituminous coal possesses a gross calorific value between 4.165 and 5.700 kcal/kg, while lignite has one of less than 4.165 kcal/kg.

It is important to highlight that shale oil that is obtained from mining processes and later is burned directly, is reported as lignite, while shale oil is considered as hydrocarbon (within non- conventional).

In the case of mineral coal, the planner must follow similar criteria as those presented in the case of hydrocarbons to identify for the base year the provision of resources and reserves of the country, taking into account the categories and sub-categories previously presented.

Biomass

It is composed by the following types of biomass. Fundación Bariloche (2013b):

- √ Firewood (LE): raw wood from trunks and branches of trees destined to be burnt for cooking, heating environments, heating water, or for the production of steam or electric energy. Plantations could be natural forests or planted forests.

- √ Energy Crops (EC): are those destined to obtain energy products, for example sugar cane, soybean, rapeseed, palm and similar; planted with the objective of producing energy (ethanol, methanol, biodiesel, etc.). That means that, the same crop destined to the production of food or industrial inputs are not considered as an Energy Crop. Forest plantations are included within Firewood.

- √ Residues of Biomass (RB): are those generated by agricultural, agro industrial, forest and urban activities, together with cattle manure, only if it can be used for energy production purposes

  - Agricultural Residues: includes stubble of agricultural crops and the residues of pruning fruit crops.
  - Livestock Residues: are the manures generated by animal populations (horses, cattle, pigs, fowl, sheep, camelids, others)
  - Agro industrial Residues: organic materials that are generated in agroindustry, when agricultural raw materials are submitted to an industrialization process. Example: shells, pulps, sludges, bagasse, fruit pits, etc.
  - Forest Residues: are those generated in the extraction and processing of wood of natural or planted forests such as branches, shavings, board offcuts, sawdust and roots.
  - Urban Residues: are materials that are potentially fuels derived from biomass (papers, cartons, etc.) discarded as garbage in the activities of urban populations

Firewood

This source can be analyzed as a flow or a stock. In this case, the renewable "resource" is sustained by land, where it is possible to plant forest species and where these grow, including in natural forests. That means that an "annual potential of production of a forest energy mass" is verified, expressed in general in t/ha. But the "stock" of forest energy mass may be considered (in t) that exists in a given territory and for a specified year, as the equivalent of a "Reserve of forest mass". The following offers a detail of both approaches.

a) **As Reserves (stock)**

Total Gross Forest Resource (RFBT, in Spanish):

$$RFBT = \Sigma_j \text{ (total hectares)}_j \times (t/ha)_j = \ldots\ldots \text{ [t]}$$

This concept includes the forest mass of all species, being j ~~is~~ the species. It is said that RFBT is equal to the product of the total hectares of a forest (which might be natural or planted) multiplied by the yield in tons of wood per hectare of each specie j.

Gross Forest Energy Resource (RFEB, in Spanish):

$$RFEB = \Sigma_i \text{ (total hectares of energy species)}_i \times (t/ha)_i \times (kcal/t)_i = \ldots\ldots\text{[kcal]}$$

This concept exclusively refers to forest species for energy purposes (i). That is, those capable of providing Firewood, Charcoal, producer gas, etc. The value of the RFEB is obtained in kcal known as Lower Calorific Value of forest energy species.

Extractible Forest Energy Resource (RFEE, in Spanish):

$$RFEE = \Sigma_l \text{ (total hectares of energy species that can be extracted)}_l \times (t/ha)_l \times (kcal/ton)_l = \ldots\ldots\text{[kcal]}$$

Of the forest species j or i that are appropriate to be considered as energy resource, a part of them cannot or should not considered as useful due to technological, environmental and other restrictions:

- √ Inaccessibility: species are out of reach of the available means for extraction.
- √ National Parks and Reserves: species are in zones that have been prohibited for extraction.
- √ Protection of soil erosion and water basins: species are protecting ecosystems and provide stability to them.
- √ Other restrictions

Then only species l are those that overcome the preceding restrictions.

Economically Viable Forest Energy Resource (RFEEE, in Spanish):

RFEE in turn is economically viable for its extraction. That is, extraction, preparing and conditioning of the forest mass should not exceed the benefits derived from its use.

This concept is equivalent to that of a Reserve and it is the one that should be incorporated into the Balance. In this case, firewood is analyzed as a stock and not as a flow.

b) **As a Flow (Potential)**

Potential for Annual Extraction (PAE) [t/year] or Average Productivity:

The forest surface that corresponds to what is called RFEEE annually generates a volume of forest mass in Ton/ha-year. These [t/ha-year] multiplied by the hectares of this forest surface permit obtaining the (PAE) en [t/year]. This value can also be expressed as [kcal/year].

Annual Production (PA) [Ton/year]:

This is the quantity of forest energy mass, produced (or extracted) per year in a given space (province, region, country). It can also be expressed as [kcal/year].

Mining Exploitation of the Forest Resource:

When: PAE < PA, it is said that the forest is being exploited as a mine. That is, as if it were a Non Renewable resource, since under that rhythm of exploitation at the end of t years the forest mass would disappear.

Potential as a Reserve (P):

To calculate the "Reserve" of Firewood, based on the Potential per Annum of Extraction (PAE) we proceed in the following manner:

P = PAE [Ton/year] x Average age of species [years] =. . . . . [t

It can also be expressed as [kcal] with the LCV [kcal/t]. In a simplified manner, this can also be calculated as P with PA.

Energy Crops

Energy crops correspond to annual flows of raw materials that can be dealt with the methodology described for an annual flow of firewood where PA ≤ PAE.

Concepts:

Total Gross Potential (PBT, in Spanish):

Equivalent to the entire production of an energy crop generated in a year (example: soybeans or sugar cane)

Gross Energy Potential (PBE, in Spanish):

This refers to the part of PBT that may be used as energy. That means that from the PBT it is necessary to subtract that part of the crop that is used, or that it is convenient to be used, as raw materials, as food for animals, etc.

Economic Energy Potential (PEE, in Spanish):

It is that part of PBE that technically and economically can be used for energy purposes. That is, that part of harvesting, storage, conditioning, transport and transformation are technically and economically convenient.

The value of "Reserve" to show in the Balance is deducted from PEE, in the following manner:

Initial Reserve = R_i:

$$R_i = PEE_i \text{ [t/year] x Useful life (years)}$$

The criteria to determine Useful life depends on each type of energy crop:

- √ For pluri-annual Crops it is a function of the average Life of species. For example, 15 years for oil palm.
- √ For annual Crops it is a function of the number of years that it would take to deplete the soil where they are cultivated, if this crop would be uninterruptedly planted.

Biomass Residues

Concepts:

Total Gross Potential (PBT, in Spanish):

This is equivalent to the entire production of RB generate in one year.

Gross Energy Potential (PBE, in Spanish):

This refers to the part of PBT that may be used for energy purposes. That means that from PBT it is necessary to deduct the RB that are used, or is convenient that it should be used, as raw materials, as organic fertilizers for the soil and/or to sustain the ecosystem.

Economic Energy Potential (PEE, in Spanish):

It is the part of the PBE that technically and economically would be used for energy purposes. That means that those residues whose costs of harvesting, storage, conditioning, transport and combustion are technically and economically convenient. The value of the “Reserve” to be included in the Balance is deducted from PEE, in the following manner:

Initial Reserve = R_i:

$$R_i = PEE_i \text{ [t/year] x Useful life (years)}$$

The criteria to determine Useful life, depends on each type of RB and is defined in a relatively arbitrary manner:

- √ For Forest Residues it is a function of the average Life of forest species. For example 20 years.
- √ For Agriculture Residues it is a function of the number of years that would be needed to deplete the land where these are cultivated, if this crop would be uninterruptedly planted. For example 5 years.
- √ For Livestock it is a function of the useful Life of the animal species under consideration. Example: 10 years for horses; 5 years for pigs; and 8 years for oxes.
- √ For Agro industrial it is a function of the useful Life of the establishment. Example.: 30 years

Final Reserve = R_f: is estimated equal to R_i, but for the final period. The PEE_{final} are calculated as the $PEE_{initial}$. Discoveries are obtained by calculating: Desc = $R_f - R_i$

Hydraulic Energy

Definition:

Hydraulic Energy (HE): Is that forthcoming from a water flow to either generate electricity in a power plant or to activate pumps, mills, wheels, etc.

Concepts:

Theoretic Gross Potential (PTB, in Spanish):

This is the energy and power that are theoretically obtained from all water flows or waterfalls existing in a systems if these were processed through a turbine with an efficiency of 100% until reaching sea-level or until the borders with other countries.

Technically Equipable Potential (PTE, in Spanish):

This is the part of the PTB that can be channeled through ~~a~~ technically possible equipment.

Economically Equipable Potential (PEE, in Spanish):

Is that which is convenient to take advantage of, due to its costs and with the available technology. This is the concept that is used to complement the Balance of Reserves. This information is available in electric companies and is obtained in energy [GWh/year] and in guaranteed power [MW].

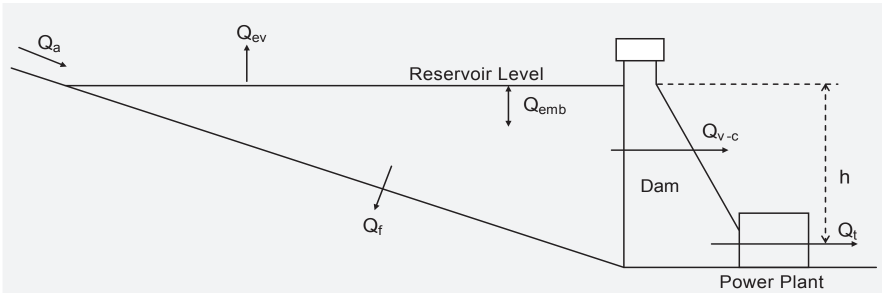
To obtain the “Reserve” it is necessary to multiply PEE by the useful Life of the plants, that is

$$R_i = \text{PEE (GWh/year] x useful Life [years]}$$

In general, 30 to 50 years are considered as Service Life. Values in kcal are obtained by using the theoretical coefficient of Electricity (860 kcal/kWh) or the coefficient of equivalence of thermal equipment, for example 2500 (kcal/kWh).

Balance of Primary Energy for Hydraulic Energy

The following Figure shows a simplified design of a Hydroelectric Central with a dam.



Where:

- Q_a: Mean annual flow of contribution of the river [m^3/s]
- Q_t: Mean annual flow through turbines [m^3/s]
- Q_{emb}: Equivalent mean annual flow equivalent that corresponds to the variation of the water volume in the reservoir
- Q_{ev}: Mean or annual equivalent of evaporation flow, corresponding to the volume of evaporated water in the reservoir
- Q_f: Filtration flow, this is the mean annual flow lost by filtration in the reservoir
- Q_{v-c}: Flow rate, is the mean annual flow computed on a calendar year, discharged in the spillway and the gate
- h: Level of the reservoir, this has the nature of annual mean level over the sea level between the level of the reservoir and the turbine shaft.

Flows Q_{emb}, Q_{ev}, Q_f, are not directly known and are determined on the basis of the corresponding annual volumes and the number of seconds contained in the year.

The material Balance between water masses is the following:

$$Q_a = Q_t + Q_{v-c} + Q_{ev} + Q_f + Q_{emb}$$

Potential gravitational energy is obtained by:

$$E = \rho x g \text{ x } t \text{ x } h \text{ x } Q$$

Where:

- ρ : water density [t/m^3]
- g : gravitational acceleration [m/s^2]
- t : time [s]
- h : height of fall [m]
- Q : any of the previously indicated flows [m^3/s]

The equation of the energy balance is:

$$E_a = \rho \text{ x } g \text{ x } t \text{ x } h \text{ x} Q_a = \rho \text{ x } g \text{ x } t \text{ x } h \text{ x} Q_t + \rho \text{ x } g \text{ x } t \text{ x } h \text{ x} Q_{v-c} + \rho \text{ x } g \text{ x } t \text{ x } h \text{ x } (Q_{ev} + Q_f) + \rho \text{x } g \text{ x } t \text{ x } h \text{ x} Q_{em}$$

that represents the total energy contributed by the river at the height h.

Solar Energy

This resource is analyzed as a flow.

Definition:

Solar Energy (SO): is the directly available energy in the form of radiation and which is captured and transformed by an intermediary equipment (collector, photovoltaic panel, concentrator). It is that which annually shines upon our planet and in consequence over the territory under study.

Concepts:

Gross Potential (PB, in Spanish):

Is the entire global radiation that hits on the territory under study. For example, this data can oscillate between 8 to 12 $kcal/cm^2$month during the winter months; and between 16 and 20 $kcal/cm^2$month during summer months. Incidence is measured on a horizontal plane that is estimated according to the latitude of the site, for each one of the months of the year.

Then:

$$PB = Sup. [km^2] \times \sum_{j=1}^{12} Rs_j [kcal/cm^2 month] \times 10^{10} [cm^2/km^2] = \ldots\ldots [kcal/year]$$

where:

Sup.: Surface of the territory
Rs_j: Global radiation for month j

Different levels of gross potential can be defined, since the estimate of the surface can be made with or without restrictions. In the latter case, we only consider the useable surface and excluded are surfaces dedicated to other land uses that are incompatible with solar use (example: forests, water surfaces, roads, airports, and other infrastructure facilities.). In certain cases, these restrictions may be introduced by means of a coefficient that reflects the fraction of the usable surface. Also considered may be other additional restrictions, such as those associated with the viability of interconnection with high power electric generation facilities. In this case, the surface must be accounted for on the basis of the distance to an adequate transmission line to be able to carry out the interconnection.

Net Economic Potential (PNE, in Spanish) [kcal/year]:

This is the global annual radiation captured through a device or equipment that exists in the system. That means that is only considered as solar energy potential, that radiation that is effectively used by a solar collector. For example: photovoltaic panel, flat collector and/or concentrator.

This concept is also equivalent to the Annual Production of solar energy.

$$PNE_c = PB_c \times \eta_c$$

where η_c is the performance of the collector.

Collectors are obtained from the surveys that are carried out to feed the Energy Information System. The Reserve, to be included in the Balance, either initial or final, is calculated by multiplying PNE times the useful Life of the collector.

$$R_i = PNE_i [kcal/year] \times \text{useful Life of collector} [years] = \ldots\ldots [kcal]$$

Approximate useful lives would be the following:

Flat Collectors: 20 years
Concentrators: 30 years
Photovoltaic: 25-30 years

These values can be directly taken to a toe (1 toe = 10^7 kcal) or use the equivalent of the alternative that produces a similar service:

- √ Flat and vacuum tube Collectors (with or without heat pipe): the equivalent of Natural Gas or Liquefied Petroleum Gas, what means that the solar kcal are transformed into toe of Natural Gas or liquefied Gas equivalents.
- √ Concentrators to generate heat: equivalent to Natural Gas or Fuel Oil.
- √ Concentrators to produce electricity and high power PV: equivalent to a thermal power station, Example. 2500 kcal/kWh.
- √ Low power photovoltaic: equivalent to the output of a gasoline generator set: 6500 kcal/kWh.

Wind Energy

This source is used as a flow.

Definition:

Wind Energy (EO, in Spanish): is the kinetic energy of wind captured by wind energy equipment (windmill) or an aero generator.

Concepts:

Gross Wind Potential (PEB, in Spanish):

This is estimated on the basis of the monthly wind maps of the territory, assuming that the velocity of such winds (V in km/h) has an incidence upon a flat surface of 1 m^2. The monthly flow of wind is the equivalent, conceptually speaking, to the flows of an hydroelectric facility. So, it is necessary to obtain the guaranteed average monthly velocity of the winds in the considered territory.

Then, according to the Law of Betz the Maximum Wind Power (PM) is determined:

$$PM\ [kW/m^2] = 8.1186 \times 10^6 \times (V\ [km/h])^3$$

where: 8.1186×10^{-6} is a coefficient to transform the units.

Then:

$$PEB\ [kWh/m^2\text{-year}] = t\ [hs/year] \times (V\ [km/h])^3 \times 8.1186 \times 10^6$$

where: t is the duration of the wind in hours per year.

That is that the PEB is expressed as an annual flow of energy per m^2 of incident surface.

Net Economic Potential (PNE, in Spanish):

As in the case of Solar Energy, the potential will depend on the wind energy collector (windmill or aero generator).

Net Power (PN, in Spanish):

$$PN\ [kW] = PM\ [kW/m^2] \times \eta_c \times a\ [m^2].$$

where:

η_c: performance of the collector (fraction of the energy collected with respect to the total that would have gone through that surface without collector)
a: surface of the collector

$$PNE\ [kWh/year] = PN\ [kW] \times t\ [h/year]$$

Example for a windmill:

diameter: 1,83 meters
η_c = 60%
V = 11 km/h
t = 365 h/year

$$PNE = 365\ [h/year] \times 11^3\ [km/h]^3 \times 0.6 \times 2.63\ [m^2] \times 8.1186 \times 10^6 = 6\ [kWh/year].$$

The Annual Production of wind energy is equivalent to PNE. Later, to obtain total Production it is necessary to know the number of windmills and aero generators. This information may be obtained from surveys or plans.

To carry out a total estimate of PNE, we must estimate the PNE by regions (for example, classified according to the average wind speed) and the number of aero generators than can be installed in each region. The latter can be estimated on the basis of the surface of land that can be used, the power per unit of aero generator of reference, and the density of power per unit of surface.

Like in the case of solar energy, the estimate of the usable surface can be made with and without restrictions. In the latter case only the usable surface is considered and surfaces dedicated to other uses of soil that are incompatible with wind use are excluded. It is also possible to consider additional restrictions, such as those associated with the viability of interconnection with high-power electric generation works. In this case, the surface must be checked against an adequate transmission line to be able to make the interconnection. Power density will depend on the type of use to be carried out. In the case of the installation of high power are generators, it is possible to use power densities that are typical for wind farms (example: 8MW/km2). Once that the PNE per region is known it is possible to estimate the total PNE by adding up for all regions:

$$\text{PNE total [GWh]} = \sum_i (\text{PNE}_i\,\text{[GWh]} \times \text{Aero generators})$$

Where i are the zones with a different capacity factor[88].

The initial as well as final Reserve, that will be included in the Balance, is calculated as follows:

$$R_i\,\text{[kWh]} = (\text{PNE}_i\,\text{[kWh/year]} \times \text{Useful Life of collector [years]}) / \eta_e$$

where: η_e is the performance equivalence for windmills

The useful life of collectors (indicative):

Windmill:	30 years
Aero generator:	20 years

To obtain the values in toe equivalence coefficients will be used. For example:

For windmills: gasoline powered water pump = 2030 kcal/kWh

Since Reserve is measured in the windmill as collector, it is necessary to take into account the performance of the water pump: $\eta_e = 0.3$
For small aero generators: gasoline powered generator: 6500 (kcal/kWh). For high power aero generators: 2500 (kcal/kWh)

Uranium

This source is analyzed as a stock.

There are three categories of resources: identified resources, not discovered resources, and non-conventional resources. The identified resources are subdivided into two subcategories: reasonably assured resources and additionally estimated resources. Non-discovered resources also have two subcategories: resources that have been forecast and speculative resources.

Reasonably Assured Resources (RRA): Is the quantity of Uranium (U) that can be extracted at a lower cost at a determined value (example: US$ 80 per kg of U or less than US$ 30 per pound of U_3O_8). This is equivalent to the concept of Reserve and this is what is included in the Balance.

Estimated Additional Resources (RAE): Are the quantities that may be extracted at a cost greater than the previous one (example: between 80 and 130 US$ per kg of U.).

Speculative Resources: Are equivalent to the concept of a Speculative Reserve as mentioned for Petroleum.

88 The capacity factor is defined as the quotient between wind Energy generated in a year and the product of the nominal wind power for 8.760 hours in a year.

Non-Conventional Resources: Resources with a very low concentration or sub-products that are lesser than other minerals that will require other technologies and/or prices to be commercially extracted.

Energy Equivalence: If an adequate estimate is not available to express values in toe, the following equivalence can be used: 1 t U = 9800 toe.

Production: This is the quantity of Uranium extracted in a year (initial or final) form the deposits in the territory under analysis.

Geothermal Energy

Definition:

Geothermal Energy (GE): Is the steam and hot water obtained from geothermal deposits coming out of them.
Concepts:

Gross Geothermal Resources (RGB, in Spanish):

The types of geothermal deposits are classified according to the state of the water in the reservoir as:

- √ hot water or humid steam of over 150 ºC
- √ hot water: between 20 and 150 ºC
- √ dry steam
- √ dry rock: when temperature increases over 5 ºC every 100 meters of depth

RGBs would be all of those underground structures where temperature would increase in more than 5 ºC for every 100 meters of depth.

Net Geothermal Resources (RGN, in Spanish): Is the amount of heat (RGB) that may be recovered by using present technology.

Geothermal Reserves (RG, in Spanish): Is all of the heat that exists in a reservoir that can be economically exploited with presently available technology. It is conceptually equivalent to the Volume "in situ" of Petroleum.

Recoverable Geothermal Reserves (RGR): Is the heat that can be economically extracted from RGs with presently available technology. This concept is the one that will be included in the Balance of Reserves.

V.6.2. Problems

How to add renewable and non-renewable resources

The first consideration is the problem that appears when an effort is made to add renewable and non-renewable sources.

For the first ones, it is possible to define an annual potential that can be used, which corresponds to that part of the total annual flow that is possible to capture for energy purposes, under technical and economic conditions at the moment in which the estimate is carried out. This value is an *annual flow*. But to the contrary, for the second type, a proven Reserve is normally defined that corresponds to the fraction of the total identified volume that is feasible of being extracted under existing technical and economic conditions in which the estimate has been made. The respective value corresponds to an *existence*.

There are other cases in which the distinction is not so clear and the problem may be interpreted both from the point of view of a flow, as well as that of an existence. For example, it is not very clear if in all these cases there is the existence of a geothermal reservoir and that it is a renewable or non-renewable resource. This will depend on the fact that such a reservoir has a natural recharging capacity or not and of its manner of exploitation. Another example is that of a forest, natural or planted, that may be considered as the total existence of the forest mass or exclusively in function of its annual productivity.

In order to resolve the general problem of assimilating flows and existences it is possible to use the well-known relation Reserves/ Production of common use in the petroleum industry. This relation indicates the number of "years" during which it will be possible to maintain in a constant manner, the production of a given year with the Proven Reserves of that same year. In the case of renewable resources it is possible to invert the reasoning and assign to each one of them a certain number of “years” to be able to calculate a value of the “Reserve” of the considered resource. This opens several possibilities to select the number of “years” and any one of them would have a certain degree of arbitrariness as happens in all conventions used in statistics to add non-homogeneous products. A possibility is that of determining the number of “years” that are common for all renewable sources and this would rise from the relation R/P of the most important non-renewable source (Example: Petroleum or mineral coal). This would assure some degree of “homogeneity” to the values obtained and would thus avoid favoring one or another source in particular in the process of conversion. Another criteria to be applied would be to determine the number of specific “years” for each source, in function of its particular characteristics. For example, in the case of hydro-electricity, it would be possible to take the useful life of the power station or of the dam. In the case of firewood, the average period of growth of the species considered in each specific forest. In the case of solar or wind energy, the useful life of the artifacts used to collect them. The fundamental aspect in this area is to select criteria to apply it in a systematic manner through time and to explicitly mention it as a footnote of the corresponding estimate. It is also advisable to simultaneously provide the values of the units that correspond to each source and in toe[89].

The second problem of a general nature is that of the criteria to be used to convert to toe the quantities of those resources that do not have defined a Lower Calorific Value (PCI, in Spanish). In the case of Hydraulic, Solar and Wind Energy, this problem can be solved under two criteria: a) measuring the quantities of secondary energy obtained (Example. Electricity) and divide it by the performance of the equipment, in order to obtain the input quantity of primary energy; and, b) use the calorific equivalent of the alternate fuel and technology that provides the same service.

Once both problems have been defined it will be possible to calculate the “Reserve” of that renewable resource. As an example, it has been set forth that in a system, a hydroelectric potential of 3.500 GWh has been identified that is technically and economically exploitable. In that system, the equivalent thermal power stations consume an average of 0,3 toe/MWh and it is estimated that the useful Life of a hydroelectric power station is of 30 years.

The hydroelectric “Reserve” of that country would be equal to:

$$3.500.000 \text{ MWh/year} \times 0{,}3 \text{ toe/MWh} \times 30 \text{ years} = 31{,}5 \times 10^6 \text{ toe}$$

In a similar manner, the “Reserves” of other renewable resources would be calculated. The same criteria defined to measure the absolute values of initial or final “Reserves”, may be used to value the annual variations produced by new “discoveries” or revisions of the previous estimates.

Information on energy resources

The preceding point has been specifically referred to proven reserves in the sense of the technical and economic volumes that can be exploited at the time when the analysis or measurement are undertaken. Although at the theoretical level, this concept is clear, in practice it turns out to be much more difficult to determine if the values of reserves published on the different sources really correspond to the theoretical definition. This problem appears especially related to those resources in which the estimates of reserves or potentials are not performed on a periodic and systematic basis. For example, changes produced in the international prices of different energy resources should bring coupled to it, a re-estimate of said potential.

This is why it is necessary to consider that the first priority of countries would be to try to obtain the most up-to-date estimates possible for the different resources, attempting to have a coincidence of the dates of the different estimates and that the values really correspond to the theoretical definition of proven or potential reserve, which are technically and economically feasible.

Independent of this objective, there is another of relative importance in particular when there is the need of undertaking medium and long-term planning. In this case, data relative to reserves, no matter how well they have been estimated, are not sufficient to define a long-term energy policy. For this, it is essential to have the most adequate as possible estimates of resources of Non-Renewable sources and the maximum Potential of the Renewable ones. This type of information is even more scarce and heterogeneous that that which refers to Reserves. However, at a second stage, it is considered necessary and convenient to try to obtain the maximum of available information regarding: Probable and Possible Reserves; Resources, for Non-Renewable resources and the maximum Potential of Renewable resources.

<u>How to incorporate reserves into the EIB (Comprehensive Energy Balance)</u> The Integral Energy Balance (EIB) adds, in relation to the

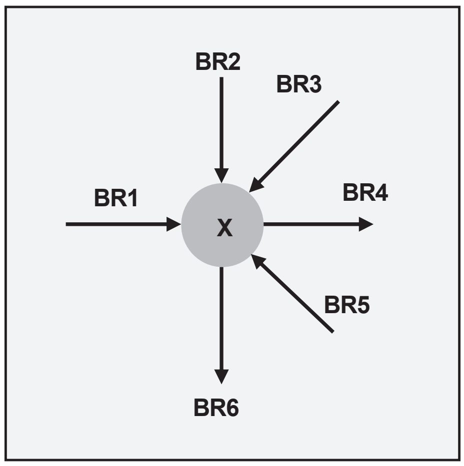
89 t: tons equivalent of petroleum. 1 toe = 41,868 GJ.

Base Energy Balance, the Balance of Reserves (considering proven reserves) and Primary Energy Potentials and, at the other end of the chain, Net Consumption (Final) for Uses and the Consumption of Useful Energy by Sources and Uses.

It takes into account certain important aspects for developing countries, which are not considered in other schemes, such as: a) losses in the production or treatment of certain sources; B) identification of energy sources produced and not used; C) identification of reinjection (natural gas, geothermal); D) identification of losses by sectors, sources and uses; E) greater opening to the processing centers (Alcohol distilleries, Carboneras, Biogas plants, etc.) and f) greater sectoral opening of consumption (Urban and Rural Residential, Rural Productive Sector, Services Sector).

In the case of Reserves of non-renewable energy resources (Petroleum, Natural Gas and Mineral Coal), the balance flow is presented below.

Figure V.14: Reserves Balance Flows



Source: Authors.

BR1: Initial Reserve	BR2: Discoveries and readjustments
BR3: Reinjection (only for natural gas)	BR4: Production
BR5: Production Replacement (only for renewables)	BR6: Final Reserve

In the case of non-renewable sources (eg for source i), the equation for estimating the final reserves from one year to the next is as follows:

$$BR6i = BR1i + BR2i + BR3i - BR4i$$

Es recurrente en los nuestros países que la información de los descubrimientos anuales no sean reportados, pero sí el dato de reservas iniciales y finales en cada período. En ese caso, la ecuación para estimar los descubrimientos (o ajustes anuales, los que implican valores negativos, en función de revisiones de estimaciones previas del volumen de reservas, debido a que se cuenta con mayor información), se obtiene con la siguiente expresión:

$$BR2 = BR6 + BR4 \ \ BR1 \ \ BR3$$

It should be noted that in the case of having information of final and initial reserves at the level of the production basin or reservoir, allows to identify in greater detail the annual discoveries.

V.7. Modifiers

As modifiers are meant those factors that quantitatively and qualitatively could alter the scenarios that serve as a basis for the adoption of Prospective solutions in the energy area. Therefore, modifiers constitute a key and privileged element to develop and characterize contrasted scenarios. Particularly, if these have been constructed in an analytical manner, modifiers can be expressed qualitatively using an abundant and sufficient description, narrative or text. In addition, it is possible to use certain criteria from experts or comparable records and experiences, to test some quantitative estimates. *Road maps* are one of the possible tools to present these developments.

Technological modifiers include efficient technologies, and technologies associated to substitution between energy sources, both renewable as well as non-renewable. Models that describe innovation and technological development may reflect linear type processes; including continuous processes based on sudden and substantive advances. In the first case, evolution generally takes several decades and its stages can be influenced by aspects that are particular for each country of a technological, social, economic, geographic, climatic, strategic and institutional nature, among other conditions of the environment.

The development of technologies requires vision and structural policies that fit the high degree of uncertainty implicit in the process of innovation, demanding public funds during relatively prolonged periods of time (decades). An early insertion of a technology and the association between technologies may create very stable sets in time, difficult to be displaced (example: light water nuclear reactor, vehicles that run on the internal combustion engine and liquid fuels), although some innovations may offer certain comparative advantages. If we couple this to an extended useful life and a close link with the technologies associated, generates slow transitions, in comparison with non-energy innovations. The analysis of the history of technological development shows that the penetration of final use technologies has predominated over energy supply technologies. Initially, the user values performance more than the cost of new technologies. However, energy scenarios award emphasis to the modern supply technologies, relegating the role of final use technologies –probably due to the limited information to model a great number of new final use technologies and their applications.

Environmental modifiers are linked to environmental restrictions, distinguishing two border or context conditions – where the energy system analyzed is inserted – of the parameters on the basis of which are built the future states of such a system. Environmental motivations - for example reaching a percentage of mixture of biofuels or renewables in the generation of electricity, in addition also constitutes a specific objective of policy. However, it is also mentioned that their implementation has not always considered the complete set of impacts involved. On the other hand, the definition of environmental indicators and their later monitoring may reflect the efficacy of environmental policies that in the final analysis will construct the modifier to be introduced into the Energy Scenarios.

The existence of provisions and policies that penalize or sensibly place fines on the environmental impacts derived from specific energy activities, accelerates the incorporation of strategies with a lower impact. Technology must be interpreted in an ample sense, without limiting it to machines or objects, but also including processes, organizational formats, management of information etc.

V.7.1. Technological Modifiers

Those models that describe the processes of innovation and technological development may reflect processes that are relatively linear and continuous or processes based on great and sudden advances. In the first case, the temporal evolution throughout the process usually takes several decades and the stages through which it transpires may be influenced by an endless number of conditions of the environment, such as technological, social, economic, geographic, climatic, strategic and institutional aspects. These conditions of the environment must be defined in the context of each country where the technology will be developed and applied. As an example of the rhythm of penetration, it is possible to indicate that the decline of the steam engine based on coal, in favor of technologies based on the use of petroleum and electricity, took almost one century, with an especially slow initial substitution. At this point it is necessary to establish a distinction between 1) processes that improve the efficiency of modifications based on existing technologies that already have a commercial foundation, and 2) processes of technological innovation and development that do not have that base as they imply more abrupt changes from the conceptual point of view. The first, normally involve slower changes, that are incremental, and take place in a shorter period of time than the latter. It is also important to mention that the development of a technology or of a technological system may have important ramifications and spill-out effects, opening the way to other technologies and fields of knowledge.

Stages in technological development generically may be grouped into those indicated in the following Table. As a matter of example, listed in an approximate manner, there are some of the technologies and their relative degree of development at the present time.

Table V.3: Stages in the process of innovation and technological development

Stage	Technologies and energy chains - Examples (2013)
√ Basic Investigation √ Applied Investigation	Advanced photovoltaic cells Liquid metal batteries Storage of H_2 Exploitation of methane hydrates
√ Development of processes and engineering	Fuels based on CO_2 Saline Gradient OTEC H_2 on the basis of renewables Fusion Reactor Maglev Transport Compressed air (storage EE) Hydrokinetic Turbine Intelligent electric networks Clean generation technologies based on Mineral Coal (CCT)
√ Demonstration and large scale tests √ Pre-commercial stage	Advanced fission reactors Advanced Biofuels (example: FT) Photovoltaic with concentrator Fuel Cells Electric vehicle Tidal Energy (tides and waves) Lignocellulose Ethanol (bagasse) Parabolic Disc Solar Concentrator with Stirling motor Solar Concentrator with central tower Linear Solar Concentrator with Fresnel
√ Commercial dissemination with incentives and/or limited market niches	Superconductors or inertia flywheels (storage EE) Hybrid vehicle Gasification of Biomass Energy from residues Linear parabolic solar Concentrator Offshore Wind energy Lithium Ion Battery, Ni/Cd Geothermal heat pump Biogas Biofuels of first generation Solar Photovoltaic based on Silicon Solar thermal Onshore Wind energy Geothermal Non-conventional Hydrocarbons (hydrofracking) LED Lamp Efficient electric engines
√ Commercial dissemination	Secondary recovery of hydrocarbons More efficient final use domestic artifacts Thermal insulation Flex fuel vehicles Compact fluorescent lamp High pressure boiler Fission reactors based on uranium Conventional fossil Thermoelectric stations CHP Combustion of biomass Lead Acid battery Hydro energy Conventional hydrocarbons
√ Substitution by other technologies	Some designs of nuclear reactors of first generation Steam engines Windmill for grinding and water pumping

Source: Authors.

It is necessary to remember that this representation in stages of technological development is a simplification and that:

- √ The transition between stages is not necessarily linear or smooth
- √ The different stages in the development of an energy technology from its conception to its dissemination in the market can have a mutual feedback
- √ Each stage may give rise to a set of new technologies
- √ Stages may have diffused limits
- √ Some stages may be absent
- √ The components of an energy system may have different degrees of technological development
- √ The relative location of a technology within the scale of stages may be specific for a determined country application

There exist different methodologies to evaluate in which stage of development is a determined technology. As an example, presented in Table V.4 is an evaluation of the degree of maturity of different technologies for the generation of electricity, based on the scale developed by the DOE[90].

Table V.4: Scale for the evaluation of the level of technological development of technologies for the generation of electricity

	TRL[91]	Definition	Description
Basic Technological Investigation	1	Basic principles observed and reported	Basic investigation begins to be translated into applied investigation
	2	Formulation of the technological concept and/or application	The process of innovation starts. Once basic principles are observed it is possible to invent practical applications. Applications are speculative
Investigation to test feasibility	3	Critical analytical and experimental function and/or test of the characteristic of the concept	R&D is started in an active manner. Includes analytical studies at the laboratory scale to physically validate analytical predictions of the different components of the technology
Technologic Development	4	Validation of component and/or system in a laboratory environment	A prototype has been developed and validated at the scale of the test bench in a laboratory environment (<5% final scale)
	5	Validation of a simile of the system at a laboratory scale in a relevant environment	Basic technologic components are integrated so that the configuration is similar to the final application in almost all of its aspects.
Demonstration of the technology	6	Demonstration of the prototype system at the scale of engineering/pilot in a relevant environment	Prototype models at an engineering scale are tested in the relevant environment
Commissioning of the system	7	Demonstration of the prototype of the system in a plant environment	Demonstration of a prototype of a real system real in a relevant environment. The final is practically completed (5%-25% final scale)
	8	Real system completed and classified through tests and demonstration in a plant environment	It has been proven that the technology works under its final form and under the expected conditions. In general, here concludes the process of technological development.
Operation of the system	9	Real system operated in the full specter of expectable conditions	Technology is in its final form and it is used in all of its range under operating conditions.

Source: (DOE, 2012a).

It is necessary to highlight that this scale refers to purely technological aspects.

In Figure V.4 are mentioned some aspects that accelerate or retard the process of the development of energy technologies and examples of technologies.

90 Department of Energy of the United States of America.

91 Technology Readiness Level.

One of the aspects mentioned refers to policies for technological innovation, the objective of which is to accelerate the development process by means of the influence they exert upon the rest of aspects contained in Figure V.4 and upon each of the stages of technological development and its inputs (knowledge, human resources, economic resources, institutional framework, etc.). Said policy intervention is justified when an energy technology that is evaluated has the potential of offering certain comparative advantages with respect to the dominant technology, from the point of view of very diverse factors such as its environmental impact, its performance, the possibility of using local resources, energy security, etc. Not always an evaluation is correct, and at times are obtained veritable technological "wagers" that finally do not provide the expected advantages or do so at a very high price for society (example: first veneration biofuels produced in replacement of natural forests and the intensive use of agrochemicals).

The characteristics of energy systems lead to the fact that the influence of some of the aspects mentioned in Figure V.4 may result in periods of development that may be much longer than those observed in the case of non-energy technologies. Therefore, the development of these technologies usually requires a vision and structural policies that are in relation to the high degree of uncertainty implied in this process of innovation. This usually demands the assignment of public funds to the development of technological innovation during periods of time that are relatively prolonged (decades).

The early insertion of a technology and the association between technologies may create very stable sets in time and which are difficult to be displaced by other technologies, even though the latter supply certain comparative advantages (example: light water nuclear reactor, vehicles based on internal combustion engine and liquid fuels). This phenomenon may block the entry of new technologies for several decades since it is not common that an energy technology be prematurely displaced. This coupled to its extensive useful life and the links that are developed with a set of associated technologies generates relatively slow transitions in comparison with those that characterize non-energy technologies. This phenomenon must be taken into account at the time of analyzing the potential processes of substitution between technologies. However, great accidents and catastrophes can bring about early withdrawals, as what has happened with some of the designs of nuclear reactors.

The development of a determined energy technology must be understood within the context of an energy system and an energy chain into which are inserted a set of technologies that makes the interrelated commercial development to be speeded or delayed due to this interaction. From the point of view of the definition of energy scenarios, this implies that it is more adequate to consider the impact of the insertion of sets of technologies more so than individual technologies.

Figure V. 15 Aspects that accelerate or delay the development of energy technologies

Low ← Rate of technological change	→ High
High investment and costs (Nuclear Fusion Reactor)	Existence of market niches and potential demand (solar hot water collector)
Long service life (Power plants)	Ease of mass production (photovoltaic cell)
High degree of exposure to financial risk (Solar-thermic generation)	Existence of standardization (Solar Panels)
Large size (Advanced Nuclear Reactors)	Reduced size (End-use Energy Technologies)
Introduction of abrupt changes in the system (electric vehicle, photovoltaic cell)	Introduction of smooth changes in the system (efficiency improvements, flexfuel vehicle)
Extensive learning and experimentation time (tidal power)	Environmental, strategic, other advantages (high-power wind turbines)
Extensive interaction time with other technologies (fuel cell)	High performance in satisfying energy requirements (Geothermal heat pump)
Important scale requirement (advanced batteries)	Multi-purpose technology (fuel cell, advanced batteries)
Specific Infrastructure Requirement (H2 Vehicle Loading Stations)	High reliability (geothermal energy)
Existence of stable dominant technology (Electric vs conventional vehicle)	Adequate availability of key components: raw materials, capacities
	capacitiesFavorable institutional, legal and regulatory framework (solar photovoltaic / Japan, Wind / Brazil)
	Innovation policies and long-term technological development (wind turbines / Denmark, Solar / Germany)

Source: Authors.

In view of the complexity of the time extension of the problem that has been set forth, it is not possible to anticipate the probable time evolution of a given technology and if it will or will not reach the stage of massive dissemination and in what time period. However, the analysis of some historic processes of penetration may provide elements to consider a relation to the modifiers of energy scenarios. In the following Table are presented some of the periods involved in the commercial penetration and improvement in the efficiency of some energy technologies for supply and final use.

Table V.5: Examples of the times involved in the commercial penetration and efficiency increase and cost reduction of some energy technologies

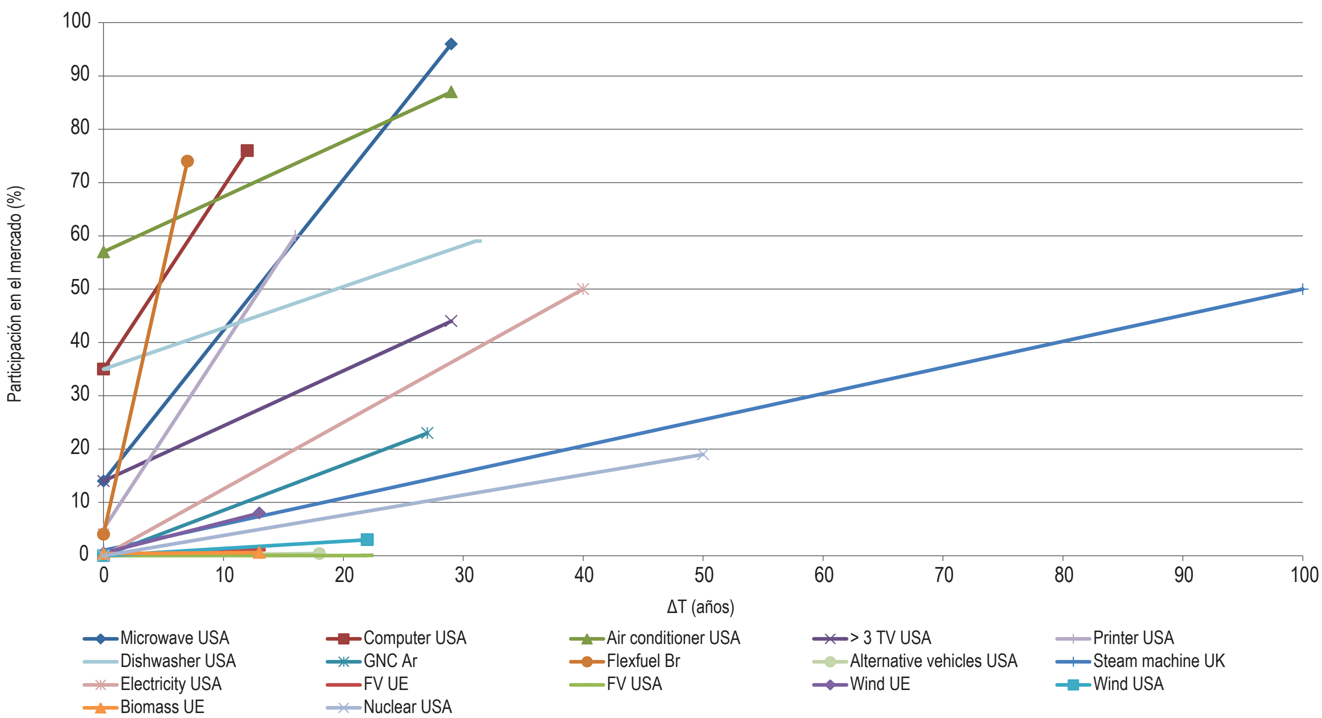
Technology	Time (years)
Steam engine	
Increase of efficiency from 1% to 20%	100
Increase of efficiency from 20% a 40%	100
Reduction of cost from 12,000 USD(2003)/kW to <3,000 USD(2003)/kW	150
Participation of a 50% in the installed power in the UK (displacing hydro and wind)	100
Displacement of the steam engine moved by mineral coal by more modern technologies	80
Photovoltaic	
Increase of efficiency of the monocrystaline Silicon cell from 14% to 25%	22
Increase of efficiency of the monocrystaline Silicon cell from 15% to 20%	20
Reduction in the price of the module from 65 USD/W to 1.4 USD/W (95%)	34
Increase in the participation in total installed power in the EU from 0% to 1.1%	13
Increase in the participation of net generation in the USA from 0.01% to 0.04%	22
Aero generators of great power	
Reduction of the investment cost from 4000 USD(2005)/kW to 1600 USD(2005)/Kw	20
Increase in the participation of total installed power in the EU from 0.5% to 8%	13
Increase in the participation in the net generation in USA from 0% to 3%	22
Modern Biomass for the generation of electricity	
Increase in the participation in total installed power in the EU from 0.4% to 0.6%	13
Nuclear Energy	
Increase in the participation of the net production of electricity in the USA from 0% to 19%	50
Substitution between sources	
Displacement of the traditional sources of mineral coal	120
Participation in electricity from 0% to 50% of the total of the total driving force in the USA	40
Technologies of final use of energy	
Increase from % of USA homes with a microwave oven from 14% to 96%	29
Increase from % of USA homes with a computer from 35% to 76%	12
Increase from % of USA homes with an air conditioning from 57% to 87%	29
Increase from % of USA homes with a dishwasher from 35% to 59%	31
Increase from % of USA homes with a three or more television sets from14% to 44%	29
Increase from % of USA homes with a printer from 5% to 60%	16
Increase of efficiency in engine driven vehicles in the USA from 18 l/100km to 13.5 l/100km	60
Increase in the % of vehicles with alternative fuels in the USA (includes GNC) from 0% to 0.4%	18
Increase in light vehicles with GNC of Argentina over the total of 0% to 23%	27
Increase in the % of light vehicles using Flex fuel in Brazil from 4% to 74%	7

Source: Authors based on (NREL, 2013); (IIASA, 2012); (IPCC, 2011); (EWEA, 2009); (EIA, 2012); (ANFAVEA, 2011).

In Figure V.19 has been depicted the time evolution of the participation of technologies listed in Table V.5. We can observe that the great dynamism of some of the final use of energy technologies with respect to supply technologies. Within renewable technologies for electric supply there exist great differences in the rates of penetration, partially explained by the cost associated with each technology (example: solar PV versus wind). In the case of photovoltaic energy we observe that in spite of the significant reduction of the per unit cost of power and the increase in efficiency, after more than a decade of commercial development with incentives, it is not possible to observe a significant penetration in the EU or in the USA within the electric Matrix. In a similar period, the participation of high power wind energy in the EU increased by 7 times more than PV energy.

Within the transport sector we can observe the accelerated penetration of vehicles using Flex fuel in Brazil (the most important among all of the technologies analyzed) with respect to the penetration of vehicles with CNG in Argentina or of alternative vehicles in the USA. Flex fuel vehicles meet several of the characteristics associated with rapid processes of technologic change: easy changes for the user and for the energy system in general (these vehicles were launched to the market in 2003, many years after the marketing of ethanol), flexibility in the election of the energy products to be used (variable mixture at the pump in function of the relative price of energy products throughout the year), absence of great investments in infrastructure (example: specialized service stations as in the case of CNG), Links with a highly dynamic and attractive sector for the user as is the case of the marketing of vehicles, a relatively short period of change, moderate to low investment, technology that is economically accessible and easy to implement within the existing industrial scheme (local automobile industry).

Figure V 16: Time Evolution of the participation in the corresponding markets of the different energy technologies



Source: Authors based on (NREL, 2013); (IIASA, 2012); (IPCC, 2011); (EWEA, 2009); (EIA, 2012); (ANFAVEA, 2011).

One of the conclusions that can be obtained from the analysis of the history of technological development is that the demand for existing and new energy services and of the respective technologies of final ~~used~~ have been a critical factor in the technological transition process at the level of energy supply. Historic evidence also indicates that the penetration of final use technologies has been predominant over those technologies of energy supply and that the final user tends to initially value better the performance than the cost of technological innovations. However, energy scenarios award a greater emphasis to modern supply technologies, while the technologies for the final use of energy are usually badly represented. This is due to the absence of information to reach an adequate modeling of a large number of new final use energy technologies and of their applications. It is also necessary to point out that in the scope of the modeling of final uses and in contrast with that which has taken place as a result of the introduction of new energy products such as steam or electricity, energy scenarios do not usually incorporate qualitative type modifications in energy requirements and essentially focus on substitutions between technologies. The planner must make an effort to mitigate these deficiencies in the representation of certain modifiers, especially on those that set forth ruptures in energy scenarios and which may help to model processes that have had a relevant weight in the history of technologic development in the field of energy.

V.7.2. Environmental modifiers

Introduction and context

Environmental restrictions may be interpreted as a sub-set of elements that permit development and help to characterize scenarios subject to comparison. For example a base scenario that reflects the emissions of contaminating gasses on the basis of a trend, may be contrasted with another characterized by a high level of emissions, linked to the intensive use of fossil resources, or also with a scenario of cleaner production of energy, based on the substitution of fossil sources, but renewable ones, and equipped with measures of Energy Efficiency or rational use of energy. In this manner, the environmental dimension normally constitutes a central part in the definition of the scenario desired, establishing for example a limit in the increase of GHG emissions of a 25% versus a scenario of a 50% increase.

The incorporation of the environmental aspect to the development of energy scenarios has two scopes that must be clearly distinguished: on the one hand, the environment constitutes a part of the border or environmental conditions that define and limit the space where later energy scenarios will be proposed (and previously their social-economic peers that constitute a framework of reference). On the other, there is a certain margin of maneuver or degrees of freedom available, in function of the uncertainty linked to environmental restrictions that the energy system will face. It is within this second sub-set where it is possible to propose parameters or drivers that will establish the limits of different energy scenarios.

Therefore it is relevant to distinguish between those modifiers that respond to sovereign decisions at the national, regional or local levels, from those that reflect changes in the international context. An example of the first type is given by the goals established by Costa Rica or Uruguay of achieving, in a nearby future, very high proportions of the generation of electricity from new and renewable sources; while an example of international conditions would be the case of the countries that signed the Kyoto Protocol, whether they agree or not - towards 2015 – in the obligatory nature of reducing emissions for the entire group of the Parties. In the first case, energy policy measures will provide a form to the scenario proposed, within an exercise of complete scenarios based on abundant information that sets forth quantitative measures, the actions of policy will permit to determine with precision and to quantify the transit from the initial to the desired situation.

It is also necessary to highlight that environmental motivations are one of the objectives of a specific policy. However, the specification of such objectives (for example achieving a percentage of the mixture of biofuels or a renewable percentage in the generation of electricity) must contemplate – as in the case of technological modifiers – the set of impacts that the measure produces.

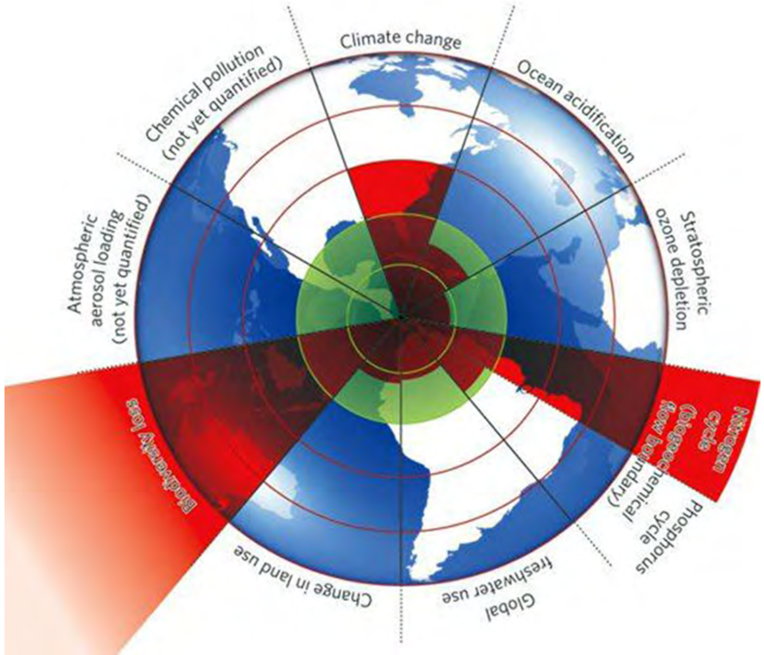
This approach is aligned with the description made for Technologic Modifiers. The incorporation of new technologies for the energy sector, in a context of planned decisions, with a structural vision sustained through time, will generate environmental impacts both positive as well as negative. As in the first section, where mention was made to the policies for technologic innovation that accelerate the development process through the incorporation of determined technologies, now in the context of environmental modifiers, emphasis is made on the environmental impact of the options promoted.

When preparing energy scenarios, decisions involve multiple aspects or objectives, in this instance an effort is made to reflect on environmental considerations. These may constitute a limit, example: the level of emissions or an objective of installed power of renewable energies. Specific policies implemented to avoid transgression of certain level of emissions, or to reach a determined quantity of MW or a percentage of participation of renewable sources, are the object of another discussion.

Framework for the development el energy systems: limits or frontiers

To be able to properly frame environmental modifiers, there is available a very interesting material of reference (Rockström, J. et. al. 2009) that is summarized in the scheme below. Presented are 9 specific frontiers that constitute the tentative limits of an extreme relevance for the trajectory of the planet through time. The acceptable or safe limit of one or several frontiers is established by means of the strong assumption that other frontiers are not being transgressed. However, what apparently is a clear physical limit may be modified for example if a parameter of gradual variation such as the loss of biodiversity – exceeds its threshold limit. At the aggregate level, desertification, induced by transgression of the frontier of climatic change – of special interest for energy systems – may cause for example a loss of arable land that is important, that it displaces its border downward. At the regional level, the deforestation of the Amazon, within a regime of climate change could have an impact on the availability of water resource in Asia – highlighting the extreme sensibility of the hydric frontier with respect to other frontiers that mark changes in the use of soil and climate change.

Figure V. 17: Biophysical Sub-systems or processes, representing nine planetary frontiers



Source: Rockström, J. et. Al.(2009).

Note: This scheme proposes an estimate of the quantitative evolution from pre-industrial levels to the present, in function of the respective **variables of state** defined for seven planetary frontiers: Climate Change; Loss of Biodiversity; Phosphurus Cycle (frontier of bio-geochemical flow); Stratospheric Ozone (reduction of the layer of the stratosphere); Acidification of oceans; Use of fresh water and Change in the use of land– the reader is suggested to examine the free access original paper for the methodological detail). The internal nonagon shaded in green represents the safe operative space, for which are proposed threshold limits in its external borders. The extension of the triangles shaded in red for each frontier, reflect the estimate of the present position of the variable of control.

Regarding the loss of bio diversity, the present limit exceeds the space available in the Figure. That sub-system, together with that which corresponds to the global cycle of Nitrogen (frontier of bio-geochemical flow); are defined by rates of change of the respective **variable of control**: annual extinctions per million species per year at a rate of N2 removed from the atmosphere due to the action of man, respectively– since it has not been possible to define for them a variable of state. More so it has not even been possible to establish quantified limits for Chemical Contamination and for the Aerosol Effect (loaded to the atmosphere).

In the analysis of reference, an attempt has been made to quantify the temporal trajectory of seven of the planetary frontiers proposed, starting in pre-industrial levels to the present – upper Figure. The acceleration of human activity since the decade of 1950 – in particular the application of fertilizers in modern agriculture– resulted in the transgression of the frontier in terms of the **global cycle of nitrogen**. Although aggregate data is not available for an extended period of time, for the **frontier of biodiversity**, the definition proposed for its threshold – 100 annual extinctions per million species per year – has been widely exceeded (even beyond the shaded scale in the Figure). Its authors indicate that the world cannot sustain the present rate of loss of species without suffering functional collapses. Towards the decade of 1980, humanity would have reached the border of the climate change frontier, but the trend towards high concentrations of CO2 has not shown any signs of abatement.

To the contrary, as a result of the signing of the Montreal Protocol, humanity did have success in reverting the trend of **stratospheric ozone** in the decade of 1990. By means of the Figure presented, its authors estimate that humanity is getting closer at a growing rate, to the limits or borders of the use of fresh water and changes in the use of soil. The frontier of the **acidification of the ocean** is at risk – however they recognize the absence of sufficient time series for this variable, as well as of information of the response of marine organism and ecosystems to the perturbance projected for CO_2.

The reflections discussed by the authors can be linked to five important Global Conventions, each of one which will determine different degrees of freedom or margin of maneuver for the possibilities of taking action within national energy systems in the world. For our analysis, we are interested in those that are linked to the energy sector although it is not possible to dismiss those dimensions that will be impacted, for example by the development of works of infrastructure. In the case of the construction of works for electric transport in high tension or hydroelectric undertakings for the generation of electricity– generally of a multipurpose since they also provide services or solutions for stakeholders interested in the control of floods in the rivers involved, water for irrigation, among others - the possible impact on biodiversity can be extremely relevant. As indicated in the case of stratospheric ozone, the signing of the **Montreal Protocol** has been able to invert the negative trend, while in that which refers to climate change, the **Kyoto Protocol**, within the Framework Convention of the United Nations for Climate Change, has yet been unable to reach the necessary minimum consensus to achieve a reduction in the contaminating emissions or at least to reach a stabilization of them. Other international conventions of relevance are:

International Waters; **Biodiversity** and **Desertification**.

Case for Analysis: Green House Gasses and other gasses of atmospheric contamination

The emission of greenhouse gasses (GHG) is only one of the impacts of greater relative importance, in function of the responsibility of the energy sector. There is also available a little more of information although strictly speaking, we can say that it refers to a slightly lower level of uncertainty.

Among the multiple causes, in addition to that which refers to the relative importance of the energy sector on total emissions and the availability of information that contributes to this, places an enormous repercussion in the media and in the society of the entire world.

Once the inventory of GHG has been made, it is possible to obtain the emissions of GHG by source and use. With these values that in general are expressed in tons of contaminant it is possible to establish a series of indicators that easily permit an international comparison and to obtain conclusions.

Among the most widely used indicators are the emissions of CO_2/Inhabitant; the emissions of CO_2/Energy Consumed and the emissions of CO_2/1000 U$S of GDP.

A high value for this first coefficient indicates a high consumption of energy per capita and an important degree of access, on the part of the inhabitants of a country, to energy sources. It also depends on the mix of energy sources used in each case.

Finally, the indicator t CO_2/1000 U$S, represents the relation that exists between the environmental and economic sectors. A high value for this coefficient indicates high emissions for a low GDP, a typical case for economies that have industrial energy-intensive sectors such as steel mills based on coal, with low energy performances and that produce products that have a low sales price. This could also be the case of plants that manufacture paper or cellulose, plants for the production of aluminum, among other intensive input industrial processes.

Reduced values in this coefficient would indicate, among other things that these are highly outsourced economies, with high GDP values in relation to the emissions produced.

In summary, the available evidence shows that in the majority of countries there exists a positive association between consumption of energy per capita, income per capita and emissions per capita. These association indicate the high dependence that exists between economic growth, the use of energy and the emissions of GHG so that the imposition of specific absolute limits to the consumption of energy would be translated, in cyclical terms, in an economic contraction of the region (Kozulj, 2010).

Other environmental restrictions

An eventual hardening of environmental regulation, including standards, trade, taxes, fines, prohibitions, goals, etc. may come from diverse stakeholders, among the following:

- √ Decrease in the present levels of uncertainty–principally based on scientific-diplomatic progress at the global level;
- √ Lobbying from pressure groups that have an ecological bias;
- √ New evidence of environmental damage together with specific events of contamination and catastrophes.

New information may appear on the results obtained by means of investigation and development, including pilot cases, or for unforeseen, random or accumulative situations. It is therefore relevant to identify the role of the generation and distribution of public environmental information, with a general social awareness, training of specialized human resources that are internationally connected, among other elements. Again these stakeholders can have an impact in their countries or generate new perceptions at the global level.

Another type of environmental problems, in addition to the emissions of GHG, linked to the energy sector will require a growing and systematic implementation of programs depicting “best environmental practices”, in particular for the sector of extraction and transport of liquid and gaseous hydrocarbons, a problem that can continue to grow in the measure that greater quantities of non-conventional resources are exploited, which implies special care to avoid the contamination of aquifers.

On a similar basis, the availability of hydraulic resources that have not been advantageously used, makes it desirable to emphasize procedures and scope of environmental impact evaluations (including by definition the social dimension), so that these do not turn out to be a veritable environmental threat, or a brake to energy development, which is also necessary for the development of the region.

- √ In this aspect, there is still a long road to travel to achieve an effective implementation of participatory processes that will bring together the different interests of the various links of society, but in an informed manner and in function of consensus and minimum common objectives.

V.8. Investments

V.8.1. Institutional frameworks, regulation and investments

A critical aspect in investment prospective has to do with the link of the investment process in the different links of the energy chain according to institutional and regulatory modes. In this respect, it is of prime importance to consider that the investments in the energy sector require a maturity period that foresees its initiation with a great deal of advanced time that in many cases can exceed five or ten years. In turn, such investments not only require available financing sources, but also training in technical capacities, lead time to obtain equipment and critical inputs.

A matter of particular relevance constitutes the fact that the multiplicity of stakeholders and diversity of regulatory frameworks may lead to very diverse criteria regarding investment decisions in different assets in the links of each energy chain, which configures an energy supply system that may differ from that desired to be able to satisfy future projected demands. That is to say that decentralized investment decisions resulting from criteria based on microeconomic considerations, do not necessarily converge in an optimum assignment of resources when the focus is placed on an articulated performance of the energy and on the real and advantageous use of the potential resources that are more abundant.

In a great number of cases, problems of the expansion of supply in different chains or their links have been detected with impacts either on the configuration of the sector, its performance, on the regulation and intervention of the State and upon the economy. The capacity for the injection of gas may become stuck or decline even in contexts with proven reserves, or also together with their decrease due to a lack of investments. In this case, not only the transport infrastructure may remain idle, but also the manner of the generation de electricity may also be affected. In other cases, the expansion of the infrastructure for the transport of gas may be delayed, limiting potential supplies or investments to bring into production reservoirs with proven reserves. The lack of planning and investments in electric transport lines may delay the development of hydroelectric works or the installation of wind parks when these potentials are in zones that are distant from consumption centers and there is no infrastructure in High Tension lines.

The absence of a global framework for planning and investments may present difficulties or delays in decisions in some of the links mentioned, if stakeholders do not perceive signals of coordination that provide some foresight to their decisions in terms not only of profitability but also of a schedule for the start and conclusion of key works. There are times when the conducts of agents enter into circular logics because contracts that would assure the viability of certain investments in their sector do not have contracts or the will to make investments in others that are linked to them, for example an increase in the supply of gas in a reservoir may require expansions in the capacity of transport of gas which in turn would require a volume of contracts that have not been made if the supplys of both energy products are undertaken separately or with criteria that lack coordination. This in turn will hinder the installation of new capacities of thermoelectric generation or of the development of gas networks to satisfy the demands of industries or distributors.

The absence of appropriate institutional frameworks and instances of coordination for investment processes, may delay works such as the construction of refineries that would lead either to an increase in imports, or to the announcement of projects in different countries that if they become a reality, would generate surplus capacities that would alter the expected return on investments. The risk implied with redundant capacities or their visualization may in turn stop decisions at the regional level. The narrowness of a supply of gas may imply the substitution by forms of supply of LPG that may be more expensive than those of the supply by means of a re-gasifying plant. The installation of such a plant may require five years to become operative and in the interim there may be reserves that are discovered or put into production, the development of which had been postponed, which has very strong implications for the establishment of prices in gas and electricity chains even for decisions that refer to the expansion in the capacity of the transport of gas or High Tension lines. The irreversible nature of works, leads to the configuration of defective systems due to unnecessary redundancies, or their vulnerability or inadequacy to satisfy the demands for different energy products.

One of the facts that has been proven on the basis of the analysis carried out in the frameworks of the regulation of energy in the sectors of electricity and hydrocarbons, together with studies on the supply and demand of energy by countries, is that the orientation of investments may be directed towards short-term visions that configure situations of scarcity of supply or redefine directions that are contrary to the strengthening of key axes such as the security of supply, access and accessibility, the minimization of environmental impacts and of total costs of supply.

Not few countries have shown that a narrowing of the space between supply and demand of energy, has led to state interventions to guarantee a supply devoid of a long-term vision in the sense of using the most abundant and less expensive resources. On the other hand, cases in which trust has been placed on price signals as the directors of investments and as self-sufficiency mechanism to expand the supply, have resulted in conflicting entrepreneurial strategies that run counter to the objectives of an energy policy.

A lack of coordination in the expansion of the supply of natural gas, in the capacity of transport, in maintaining an adequate policy for exploration to sustain the relations between reserves and production that in reasonable periods guarantee supply to different markets such as homes, commercial, vehicular, industrial and of the generation of electricity, have led to a sub-utilization of the capacity of the installations for transport, of consumption or of generation creating bottlenecks that can only be resolved by means of short-term substitutions, that have dislocated costs and the rational nature of the configuration of electric generation parks, reducing confidence in both chains of electricity and gas, placing at risk the useful life of assets as those of the combined cycles when these must operate with liquid fuels, increasing economic costs for industries and the environment for local and global societies. The absence of frameworks for programmed and coordinated investment have created paradoxes of scarcity or delays in expansions, or have introduced difficulties in long-term contracting that are necessary to provide stability, predictability and reliability to supply systems.

Those energy systems that have been subjected to this narrowness of investments, likewise have had to face very strong difficulties to be able to resolve the diversification of the energy Matrix in the direction of having to make use of the most abundant resources and of lesser cost, while the putting into operation supposes an access to long-term financing which in turn competes with the necessity of satisfying growing demands in the short-term, that duplicates the needs of investment and creates dissimilar rules for the recovery of costs for the different stakeholders.

In view of the fact of the existence of disintegrated schemes and with lax regulatory frameworks with respect to rules for investment- the predictability of the future system is quite low, it is necessary to generate comprehensive planning frameworks the modalities of which are not going to be identical in accordance with what the institutional framework of the sector will be. Likewise, it must be mentioned that the presence of state and private stakeholders in the same chain –or with horizontal and vertical intersections- may create paradoxes with respect to making investment decisions. Such is the case of public companies that could well expand their supply, but in doing so in an environment that has the participation of private stakeholders, may constitute a disincentive to the latter due to the fact that certain asymmetric situations would develop with respect to real or perceived risks. This would be due to the fact that in the imagery of the energy environment has been installed the paradigm that competition is among equals and in such a case the state company would allegedly enjoy certain advantages. In turn, as has been stated, private stakeholders may be adverse to taking such risks because the orientation of their investments is not on a long-term basis, which in itself creates a framework of limited narrowness or strength to satisfy the demands of energy within a determined nation or even at the regional level.

While most of the countries adopted marginal cost approaches, or rules for expansion that do not link benefits to reinvestments, the exercise of the power of the market has appeared as an unavoidable question since the contexts of scarcity are the appropriate environment to introduce growing and scaled marginal costs as for example when generators with inefficient equipment that also use costly fuels are dispatched, or when the closest substitute for a product such as natural gas from a reservoir in the earth, must be replaced by the supply of LPG. In this sense it can be stated that natural incentives can be better aligned in a direction of narrowness of supply than in a redundancy, if explicit mechanisms to assign costs to the reliability of the system are not in existence.

A modality that has risen as an answer to the narrowness of certain energy supplies is the creation of mechanisms of auctions or of bidding processes for future works or quantities of energy. In this case, competition is no longer “in the market” but is rather transferred to a competition “for the market”. This mechanism appears as an effort to conciliate future supply –in such a way that it can be planned in an anticipated manner – and in turn it is not irreconcilable with institutional and regulatory frameworks that have a strong participation of private stakeholders, guided by rules of profitability and recovery of investments in line with such frameworks. Truly, this mechanism is compatible with planning, but it is also a return to the criteria of *“cost plus”* that had been considered as having been overcome.

When such an approach to the expansion of the offer is adopted, in turn raises the question of the competition between technologies and if this should exist or not. In many cases, it is felt that it is convenient that auction processes should not be on technology, but rather directed to lower costs of the energy product under auction, which in itself decides the future expansion of the configuration of supply in determined directions, due to the incommensurable nature of the cost of some technologies in the long-term or short-term, especially when it is a matter of electricity generation. Such paths for decision may not consider the impact upon the need of foreseen investments in other energy chains.

However, in other cases, the mix of the integrated energy supply is predefined by a series of criteria where the economic dimension is only one of the multiple array to consider when working under the idea of an holistic approach that will bring together previously mentioned elements (security of supply, environmental impact, social regional positioning, possibility of being able to create value chains, etc.). In such cases, the task is lightened due to the fact that the capacities to be created are identifiable and therefore, the investments required have their own schedule.

By contrast, referring to the previous case, it is much more difficult to quantify certain investments because these will depend on that established by the regulator, a matter that does not limit the fact that this Figure can be used as a framework for the planning of investments in the short, medium and long range.

V.8.2. A definition technique of the investments required and their quantification

Another of the critical aspects is the quantification of investments, the methods for their estimate and the mechanisms for their financing. The Prospective of demand and supply, according to the Prospective of energy balances –that assure coherence of the projections of the different energy variables-, is the starting point to estimate short, medium and long-term investments in the different links of the chain.

Under this approach and once policies have been defined by a specific country that wishes to adopt its own framework of energy policy, the supply set to be created is defined for each scenario or even to be able to compare different options of the plan whether these are regulatory, indicative or referential.

However, this methodology requires previous steps, such as those that refer to the construction of referential units of value for each activity and work of infrastructure necessary, so that projected demands may be satisfied in accordance with the criteria of the political decision maker.

In this respect, there are many question that may rise: a) Is it desired that the “Comprehensive Energy Supply Plan” will be of a “Minimum Cost”?; b) Is it possible to obtain this by applying some friendly methodology? Is this approach desirable or is it preferable to compare predefined robust alternatives on the basis of multivariable criteria?

If the selected “Energy Plan” or “under comparative study” is guided by criteria of minimum cost, there exist models such as MESSAGE that may be the most comprehensive. This model was originally developed by the International Institute for Applied Systems Analysis, inasmuch as that of the International Atomic Energy Agency (IAEA) that acquired the latest version of that model, and made modifications in the *interphase* with the user to facilitate its application. This model is used to formulate and evaluate energy alternatives under restrictions such as limits of new investments, cost of fuels, environmental regulations and the speed of penetration in the market of new technologies.

Since this model permits the representation of an entire energy chain -from resources to final uses -, using tools for optimization, it is applied the *criteria of minimizing the total cost of the system throughout its expansion*. Such minimized cost includes the cost of investment, the cost for operation and any other additional penalty cost defined by the limits, ranges or restrictions. The sum of these costs adjusted by the discount rate is used to find the optimal solution. Therefore, such optimal solution may be transformed into an investment plan considering that the investment costs have been predefined, something that is true in those cases where it is assumed that the cost of fuels reflects opportunity costs, or rather if in turn it requires an additional modeling of the fuel supply chain to obtain the investment plan implicit in that supply at cost that may or may not represent opportunity costs. The program offers a detailed description of the modeled energy system that must include: a) Forms of Energy at each level of the energy chain; b) Technologies used for these forms of energy; c) Energy Resources. In the definition of the Forms of Energy, it is necessary to include the levels of the energy chain, starting from demand and reaching resources. However, the model does not assume modifications in demand according to prices = costs of computer runs of the model.

Other models, such as ENPEP are designed to simulate the mechanism of balance of the energy market, with the purpose of simultaneously maximizing the benefits to producers and consumers. This model combines the results of MAED and of WASP to determine a balance between long-term supply and demand of energy by means of calculating quantities and balance prices in the market. Once said balance has been determined, it is a matter of determining the quantities of investment required and to test that the parameters and costs used to estimate prices, are the ones that correspond to those hypotheses when they are not of an endogenous nature, and in this case they are not since MAED does not discriminate the costs of fuels by value chain (the consumption of fossil fuels is not disaggregated in petroleum, natural gas, coal, etc.).

Financial analysis models of expansion plans of the electric sector (FINPLAN), are instruments to understand and incorporate questions relative to financial limitations that usually represent the greatest obstacle for the application of optimum energy strategies. But FINPLAN provides assistance in evaluating the viability of projects for the generation of electricity by means of a calculation that is based on important financial indicators and which takes into account financing sources, costs, revenues, taxes, etc. It is especially useful to establish the long-term financial viability of projects, the preparation of treasury flows, income and expense statements, general balance sheets and financial ratios. Others such as LEAP permit their use for the projection of demand and emissions of GHG, but must be complemented with several analytical instruments to establish, both demand as well supply scenarios, that are indispensable inputs to determine a coherent investment plan. In this sense, Chapter VI deals specifically with the informatics instrumental available to attempt providing solutions to these questions.

However, it is necessary to remark that it is only the interaction between results of the model -or models and the expertise and knowledge of the investigating group or of the technical planning team, that will determine defining a delimitation of the supply scenario or scenarios which in turn provide a quantitative framework of the necessary investments estimated to be able to achieve the Plan. This warning is necessary in view of the present excessive confidence placed on the results of models or an exaggerated emphasis in data used, since under this circumstance, in the majority of countries information is still deficient or even when it is not, by need it must be expressed in orders of magnitude that are relatively imprecise.

Once that the scenario or scenarios for the expansion of supply have been determined and that it will become a part of the Energy Plan of Reference, it is necessary to estimate the investments and schedules that correspond to works for each link. For this it is necessary to work at the level of chains and links, but within a general margin of supply that must have been provided by the above-described process.

Investments in the hydrocarbon chain

Upstream Investments

Upstream Investments of the petroleum and natural gas industries refer to exploration and exploitation plans that must be carried out in order to assure that the minimum relation of reserves/production are compatible with the provision in time of the production of liquid and gaseous hydrocarbons, necessary to supply the demands of the plan within its own time frame and for future generations. The fact of not linking the rates of expansion of the production of hydrocarbons with a sufficiency of reserves, may lead to the depletion of the possibilities of supply determined in the costs foreseen and may require new investments. This can also have an impact on the linkages of investments in time.

Since we are dealing with proven, probable and possible reserves and resources according to international definitions such as those established by the SPE, the plan must indicate the goals of the activities for 2D and 3D seismic prospection, the number of exploratory wells, appraisal wells and of development compatible with the goals of increasing proven reserves and the goals of production.

In this sense, there is a difficulty that rises with respect to the uncertain relation between investment efforts and results, in particular at the stage of exploration. Success rates depend on many elements, among them the degree of prior Prospective and knowledge of the different areas, fields and reservoirs. The rate of success, a priori, will be high in mature areas that are in stages nearing the start of the development of fields. Success rates will also increase with the quantity of exploratory drillings, but will differ in well-known areas versus new areas. The declination in production in very mature areas may indicate that the fields are in a stage of depletion. Different studies must accompany the analysis of viability to be able to achieve increases among the stakeholders of recovery.

All of the above indicates that even though it is possible to estimate the activities that may be carried out in the seismic and drilling of exploratory wells, to incorporate new reserves, the results to be obtained are always uncertain and involve a high degree of risk. An additional difficulty resides in those results that have qualified as “failures” (example, dry wells of unviable wells in economic terms at a determined level of prices) may alter the succeeding decisions for investments not only for a determined field but also, by contagion to nearby areas or even to the entire country. In this aspect, again resurface institutional and regulation issues of the activity that lead to the concept of an *“integrated Prospective”* (geologic, economic, legal, social-political).

A habitual solution is the so-called summons to bids for areas of exploration in different basins and fields of activity convened either by National Hydrocarbons Agencies (Example. ANH of Colombia; ANP Brazil; etc.) or other organizations, as may be the case of the institutional and regulatory framework of the activity in each country. For the purposes of energy planning it is important to determine in an indicative manner the minimum standards of the activity compatible with the incorporation of reserves in a given period and to assure that bidding rounds take place. Only in this way will countries be able to define their future profile that is if they will be able to achieve total or partial self-sufficiency, if they will be exporters in an increasing or decreasing manner or if they will define themselves as importers.

Certainly these definitions are not neutral with respect to other investment decisions in the energy sector since from one or the other situation there are referential frameworks that may radically alter other investment plans (example. In the electricity sector or even in policies directed to the automobile industry).

The determination of standards of activity such as km. of 2D and 3D seismic, number of wells, etc. can be easily translated into schedules and amounts of investment. To do so, the organizations in charge must have available units of value of reference for each activity, cost per exploratory well for each basin, in accordance with depth, topographic characteristics, difficulty of access, availability of infrastructure, etc. This also applies for seismic activities. In principle, the physical goals for investment must be compatible with the hope of finding hydrocarbons in a time frame that permits achieving the magnitudes of investment to convene or to undertake in a determined period of time. Parameters to establish the relations between exploratory effort and expected results will necessarily rise from the centralized gathering of geologic information. In the case that this is non-existent, the first step is to invest in obtaining it, a matter that may require expensive studies and that also involves long time periods.

Investments in the development of existing reserves are easier to estimate and monitor. The importance of maintaining institutional structures that carry out this process is crucial for energy planning. If the results of the activity show a profile of depletion of fields, without the existence of possibilities of incorporating new reserves, the result will be quickly transmitted to other scopes, forcing the need of redefining goals in other sectors. For example, the expansion of thermoelectric generation may be affected by the lack of a supply of natural gas or rather its costs and competitive nature may be affected if such supplies imply imports of LNG. Likewise, authorities may decide to install or not plants of LNG. For the case of liquid hydrocarbons, the profile of discoveries according to quantity and quality will anticipate the needs of other investments such as the refitting of refineries, *upgrading* plants, infrastructure for transport.

It can be stated that investment processes in the *upstream* sector and their results constitute one of the pillars that will affect the entire conception of the expansion of the production and consumption of energy and therefore, affect the process of planning and investments in other chains and sectors. As previously mentioned, while results are always uncertain in terms of the relation *"investment efforts- results obtained"*, the continuity and monitoring of both players together with the institutional mechanisms to carry this out are indispensable for producing countries. Obviously, this problem does not apply to importing countries, which must concentrate in planning the infrastructure for imports and their connections with LNG and Refineries.

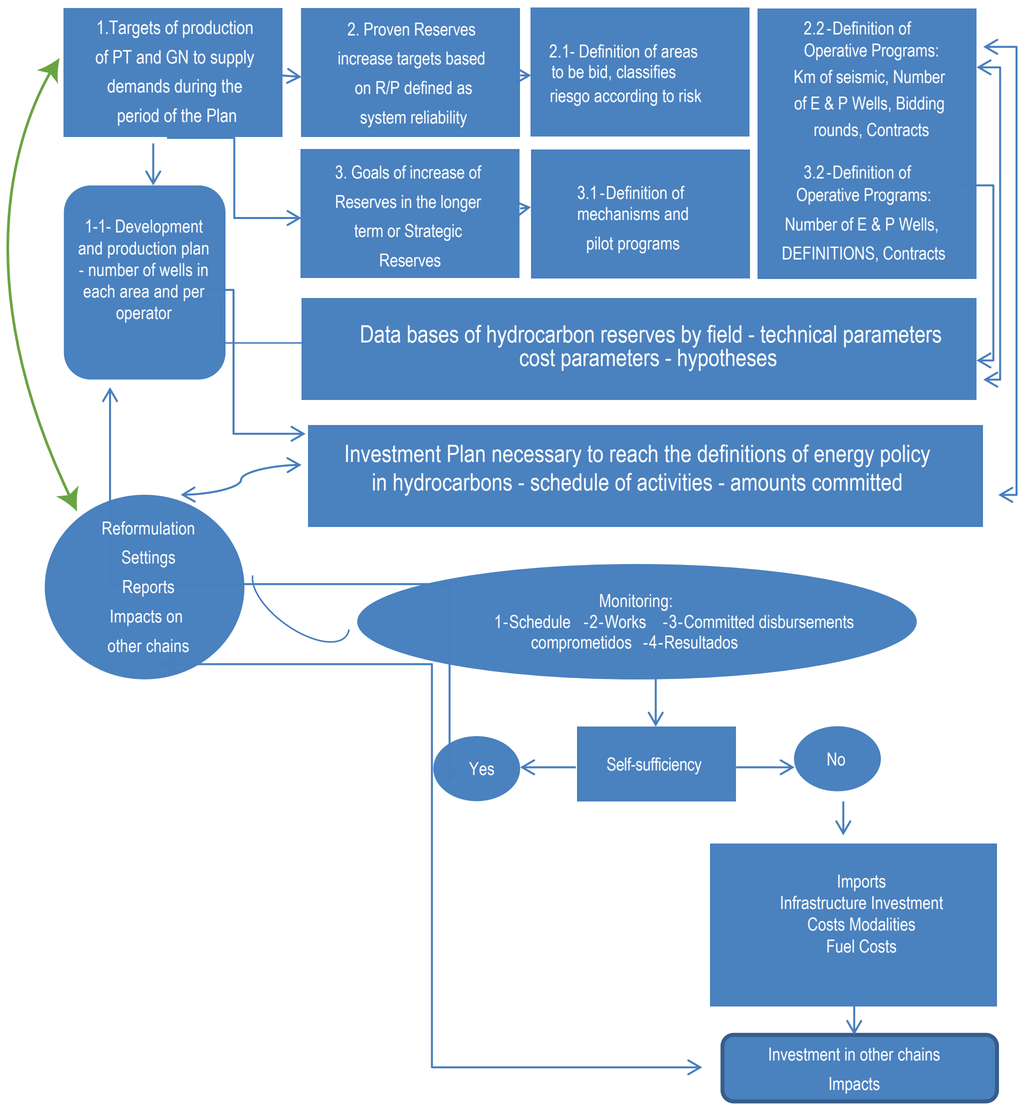
Since petroleum exploration and exploitation are activities with an inherent risk – and which present the longest periods of consolidation between initial efforts and the achievement of results - the question of the financing of the sector and the manners of private participation constitute key aspects.

In Figure V. 18 a possible scheme for the determination of the investments plan as well as some instruments are presented.

The central idea starts from a general modeling of petroleum and gas requirements that must be supplied, complying in turn with the need of having the relation reserves-production assure the continuity of the supply or that they provide signals to strengthen investments in exploration or in imports. On this basis, there are certain technical parameters that permit defining physical goals, which multiplied by values of reference provide by summation the amounts of investments of the plan by type of activity. In turn, on this basis it is feasible to subdivide the plan into Rounds or Bidding processes that extend an invitation to invest or constitute a guide for investments per area and activity within a timeframe that has been defined by some specific player. The plan must be monitored during its execution and in its results, since it is impossible to establish rigid goals. From the results appear Prospectives that provide a feedback to the Plan of Investments and appropriate guidelines for political direction.

Note should be taken that the scheme presented supposes the existence of a model of centralized decisions with the possibility of multiple players that compete for areas of exploration and exploitation, but it can only be applied to a model with a single player.

Figure V. 18: Scheme for the determination of the Plan for Investments in Hydrocarbons (Upstream).



Source; Authors.

Downstream Investments

i) Oil pipelines and refineries

Once having defined the nature of producing oilfields, total or partial self-sufficiency, the quality of crude oil and prior infrastructure, the physical investments in oil pipelines and the expansion or construction of refineries based on projected demands, the task seems to be easier. However, investment decisions and their execution may present problems and complexities. In the first place there is the fact that bottlenecks in refining can exist for a type of fuel and not for another one (example: Deficits of Diesel and self-sufficiency of gasoline). A private investor will not be in condition of installing a new refinery if demand does not satisfy a degree of use of the installation that will permit the recovery of capital within a reasonable period of time. Imports that are necessary to satisfy shortages between local supply and demand may signify currency expenditures and the construction of port facilities and of transport that would not be necessary - in the same magnitude- once demand reaches the volume that makes viable the installation of a new refinery. Although these refineries are built in modules, there are questions of complexity or economies of scale that must be considered. The evaluation of alternatives of investment and modalities to resolve how the path to be followed will look like must contemplate the particular characteristics of each case and consider state investment as a convenient possibility. In such case, this investment may be recovered in a longer term with lower costs than those implicit in the adding-up of imports during a prolonged period of time. This is an issue that may be important for countries with chronic problems in their balance of payments. In any event, an effort is made to optimize the set of available resources, within a framework of planning that does not consider that short term decisions will configure, as already stated, sustainable paths in the long-term.

ii) **Gas pipelines**

The trunk transport system may be new or a reconfiguration-expansion of an existing one. Its planning is necessary in respect to what has been mentioned regarding bottlenecks that may generate an insufficient supply capacity. For new or incipient systems with markets that are developing on a medium or long-term basis, private investment may not be a viable alternative, if there does not exist a mechanism of compensation for the idle capacity that will not be remunerated by consumers. In case that regulation attempts to have the investment recovered through tariffs, those that correspond to the first period may be very high and turn natural gas into a product that is not competitive. In certain cases, the investment undertaken by means of the BOMT system may require the creation of an administrating company that mediates between BOMT and the recovery through tariffs. This company could operate at a loss for a certain period of time (example ten years), but would later have a market value that would allow it to achieve the total or partial recovery of disbursements during the period of transition.

In mature systems, trust fund mechanisms have worked in a satisfactory manner to execute expansion works because the speed of demand growth has been high.

In the expansion plans of the gas industry, there are parameters to estimate the amount of investments, and there are multiple forms of being able to obtain such financing as well as the recovery of investments.

Investments in the electric chain

In some countries of the region, referential plans for electric expansion have been presented. In such cases, it is assumed that works have been predefined and will be attained in time to be able to satisfy the projected demands of power peaks and coverage of the demand of energy. If this exercise has not been undertaken, at least available will be the short and medium term demands with some long-term estimates.

It is important that the authorities should foresee well in advance, the definition of the mechanisms for expansion. Auctions or bidding processes for works that rise from such a scheme, permit obtaining the desired margins of reliability. However, bidding processes are usually governed by the lowest price offered for energy with the support of determined fuels and with a margin of variability fixed according to its price. Otherwise it may be necessary that adjustments in value are required that will reveal a wrong election during a period of “n” years after the investment was executed.

Auctions with quotas of participation of sources are ideal to diversify the Matrix of electric generation. In this scheme, the minimum cost of energy in the short term is not assured, but rather the minimum cost per source. Although this option may turn out to be more expensive for consumers within a determined period, it may provide assurance to each country, so that it may direct its investments towards those areas that provide a lower degree of vulnerability of supply, greater use of resources and less environmental impact in terms of the emissions of GHG. However, such an approach also assumes a strict order in planning the networks for transmission and to achieve their financing.

The scheme assumes the existence of a referential plan of long-term expansion, where each work will come into operation under the terms foreseen, a matter that requires a certain financial cushion and is not necessarily compatible with the minimization of costs for consumers.

Approaches that attempt to escape this restriction may become trapped in whatever happens in fuel markets and the scenario of international prices for crude oil and natural gas, even though in the case of gas there is no international reference price that is the only one or that guarantees investments with a bias to gas reserves. No doubt the latter takes place because thermoelectric expansion is the one that permits, with greater speed to be able to satisfy the growing demands for electric energy. Certain cases may reveal that the establishment of average costs based on this solution, is sub-optimal when an ex-post analysis is made of scenarios.

It is precisely the absence of a comprehensive framework of expansion of energy supply, as a pre-requisite that prevents the generation of an adequate scheme for planning investments and of the mechanisms to assure that the different investment projects be coordinated and made viable through the instruments included in those of regulation.

In regards to the quantification of investments, there exist multiple sources to assess the costs per MW of different types of technologies and also to establish costs of indicative value ranges per km of HT and MT lines.

V.8.3. Investments Plan in the energy sector

Once that sectorial goals for the development of reserves of conventional and non-conventional hydrocarbons have been established (Investments in exploration and production), in imports or infrastructures for them, in oil pipelines, refineries, gas pipelines, electric plants by type of technology and HT and MT lines, the plan - or diverse scenarios that the plan presents- can be quantified and ordered in time. Likewise, for each one of them, the organization will indicate the instruments by means of which their execution has been programmed (works of infrastructure undertaken by the State; areas of private or public-private participation; rules for the recovery of investments; budget availabilities assigned or recovery mechanisms by means of tariffs).

CHAPTER VI

Use of Energy Planning Models

KEY WORDS

Models – Energy planning – Top-down – Bottom-up – Study cases –Selection processes.

VI.1. Introduction

Energy consumption and supply projections are tasks that involve a series of areas of knowledge and include a great quantity of variables. In view of the scope demanded, in general it is necessary to resort to mathematical models that describe the energy chain, going from the extraction of energy sources up to their final use, throughout production, transformation, distribution and storage. Basically, the tools available for the analysis of the energy system may have two approaches: “bottom-up” and “top-down”. As will be described later on, these two approaches basically differ in the level of aggregation of the models.

In this context, the objective of this Chapter is to describe, discuss and explain the functioning of the different models that are applicable to energy planning in the countries of LAC. Definitely, the chapter is to present applications of the different models for the analysis of energy prospective in LAC countries. In order to reach this objective, in the first phase, the role and classification of the energy planning models are discussed, and later we will present descriptions, functioning and study cases as well as the process for the selection of the models analyzed. A questionnaire will be applied to several Member Countries of OLADE with respect to the matter of development, relative to the characteristics and application of energy planning models, so that the development of this chapter is based on their own information of the respective countries, on their experience in energy planning and on the guidelines of OLADE.

Initially, in the first section there will be a summary of the objectives of energy planning tools. Following that, a classification will be made of the principal models applicable to energy planning, according to their approach, scope, purpose and application. In the second section, it will be tried to describe the general characteristics of the different models for energy planning that are applicable to the LAC countries. Also there will be a description of the functioning of some of the energy planning models that are applicable to LAC countries. The third section seeks to describe prior experiences where these outlined energy planning models were applied in member countries of LAC. In the fourth section, based on the general characteristics, description of the functioning and prior experiences, a synoptic chart will be presented that will permit to the public policy designers to select energy planning models applicable to their country and/or region. Finally, the fifth section refers to some final comments.

VI.2. Role and classification of energy planning models

The sequence describes the supporting role of energy planning models provided to the decision making process during energy planning properly conceived. The specific objective of this section is to classify the different models according to their approach, scope purpose and application.

VI.2.1. Role of energy planning models

As explained by Connolly et al. (2010), there is no tool that will focus on all of the matters related to an integrated energy planning, and instead, the “best” tool will depend on the specific objectives that seek to address the analysis. The problem of consistency shows that it could be better to use a model that is ‘’approximately correct’’ to evaluate several problems at the same time, instead of bringing together several sophisticated models, with the risk of affecting the transparency and flexibility, in addition to creating a total inconsistency of the approach (Frei et al., 2003).

It should not be forgotten that energy planning tools must help those who make decisions, in the sense of supplying the growing demand for energy in an efficient manner. Therefore, it is necessary to build tools that represent the complexity of the energy system in an organized manner, to assist those who must make decisions in the formulation of sustainable energy policies (D´Sa, 2005).

Notwithstanding, the use of an energy-planning tool requires a process of strategic formulation that will map the objectives of its implementation. This is obligatory for the energy policy designers to be able to understand the capacities of the existing energy modeling, and in this manner be able to identify the goals of using each tool. It is a matter of understanding on an anticipated basis what is desirable from the energy planning tools, as well as what these may define. Fundamentally, the following questions could assist in the selection process of models (Codonni et al., 1985; Frei et al., 2003; Sohn, 2007; D´Sa, 2005; Connolly et al., 2010):

- √ What does it require? What does it need?
- √ Forecast of the energy supply and demand? Final energy or energy service? ¿Long, medium or short term? Simple or multiple horizons?
- √ It seeks only to improve knowledge of the energy sector?
- √ The model helps to test policies related to energy, industry or the environment?
- √ The model helps to analyze interactions between energy, economy, society and the environment?
- √ The model helps to build scenarios of the type "What if"?

One of the criteria that guide the process for the selection of energy-planning tools is in function of that which we want to estimate and its time horizon. As a matter of fact, estimates may turn out to merely be an exercise to increase knowledge regarding the variables under question, or directly centered on the definition of energy policies. In terms of interaction, on the one hand the chosen model may be used to make energy estimates in an isolated manner, devoid of any reciprocity with economic, population and environmental variables. And on the other hand, integrated models are capable of estimating energy aggregates based on the interaction with social-economic and environmental variables. Additionally, it must be mentioned that scenarios are stories that consider questions of the type "What if". These recognize that persons have beliefs and select that which will lead to a result, Scenarios consider a plausible range of futures and how these can emerge from the present reality, while the forecasts focus on probabilities.-

The majority of the models for energy and technological systems are used to describe medium and long-term horizons for energy infrastructure on a global or regional level. With certain models, the uncertainty associated with the future is usually taken into consideration when using scenarios that describe alternative "worlds" where we may find ourselves. The range of fluctuation of the results of the model calculated for these "worlds" shows the degree of uncertainty for different indicators. Although this approach is very useful to obtain results for optimization, it is not adequate to describe and simulate the framework in which decision makers operate.

In reality, decision makers do not have complete information related to future costs, prices, restrictions or uncertainty relative to the future of the energy system. A difference with the concept of risk, in which it is possible to associate to the future a possibility of a known occurrence, when speaking about uncertainty the lack of knowledge of any possibility of occurrence that could be associated with such a scenario is reflected. Frequently, this may lead to ponder in a greater measure those short-term decisions because there is more information available (lesser degree of uncertainty), thus postponing long-term decisions, until that time when new information is available to be applied. These types of aspects cannot be described in a model, where all of the information is exact and simultaneously available for the entire time horizon to be modeled (Keppo and Strubegger, 2010). In fact, there are few models that have specific modules to deal with the issue of uncertainty, among which we can highlight SUPER OLADE with its module MODPIN to deal with the uncertainty relative to future hydrologic regimes, growth of demand, fuel cost and construction time of projects.

In function of the degree of uncertainty that is considered by long-term energy planning, planners usually project resilient energy systems, capable of absorbing impacts/contingencies and or providing a rapid response to interruptions in the supply of energy services (Dyer H. and Trombetta M. J., 2013; Winzer, 2012). Contingencies may affect generation/production, or transmission and distribution, or may refer to other unexpected events, including natural accidents or attacks (UNISDR, 2012). Contingencies are classified as shocks (sudden appearance and short duration), and stresses (slow appearance and long duration) (Dyer H. and Trombetta M. J., 2013). With the intention of having resilient energy systems, it is frequent to plan introducing high safety factors, strategic reserves of energy products, and specifically for the case of electric systems, it is customary to keep reserve transformers, have available spinning power and apply criteria of reliability "n-1" for systems of transmission and distribution (lines and transformers) (Winzer, 2012; etc.). This type of exercise may be undertaken by using models for energy planning optimization, as well as those for simulation.

Additionally, there exist methodologies for energy planning that place emphasis on risk management and therefore are not searching for an expansion plan at a minimum cost, but rather an expansion that is more robust in the face of different risks and uncertainties, an example of this is the methodology "Trade-Off Risk" (Crousillat and Merrill, 1992) and the "Minimax" (minimization of the maximum regret value of Savage) used by SUPER-OLADE.

Faced with the advantages and disadvantages of each model, it is the task of the energy planner to opt for the solution that minimizes the risk associated with the intrinsic limitation of the different approaches. Therefore, there are some criteria that may be incorporated to the election of the model:

- The model must be of an easy execution, demanding thus a lesser time required for the preparation of the input information and the preparation of scenarios.
- The model must have a limited number of exogenous variables.
- The model must guarantee an internal compatibility that is in coherence with technical-economic hypotheses.
- The model must permit the analysis of energy and environmental policies that affect the prices of energy products.
- The model must evaluate the impacts upon the energy sector, relative to consumer behavior, specific policies, technical progress and technological substitution as well as production factors.

VI.2.2. Classification of the principal models applicable to energy planning

In energy planning, time is a key variable that for the planner includes the long-term perspective and for the decision maker is that of the short-term. The duration of this period of time or the term is based on the classic micro-economic theory that states that the factors of production structurally vary in the long-term, while cyclical variations are associated with the short-term and measures of control and follow-up are associated with the medium-term (Pindyck R. & Rubinfeld D., 2010). The quantities of inputs or of production factors vary in the long-term, during which time the technological evolution is evident (Pindyck R. & Rubinfeld D., 2010). It is also understood that in the short-term demand remains more stable. The selection of the time horizon for the analysis is very important and strategic, for instance models for optimization of the "perfect foresight" type will find optimal tracks that differ in function of the horizon. If we set a not too distant horizon (for example, 2050), the model will be subject to technological blockades (knock-in effect) due to the construction of high investment cost infrastructures and extended periods of useful life; on the other hand if we determine a more distant horizon (for instance, 2100), the model will enjoy a greater freedom to reach the optimum point through different paths, selecting those technologies, that perhaps in a longer time horizon show a greater economic viability (Vogt-Schilb et al., 2014). On the other hand, space is a key variable, and it corresponds to planning to guarantee the universality of energy services (Antonette, 2005). Thus, in consonance with the basic idea of long-term integrated energy planning, economic energy models may serve for that purpose (Frei et al., 2003; Antonette, 2005; Sohn, 2007):

1. Formulation of public policies.
2. Measurement of indicators of productive efficiency and quality of services (for the use of regulatory entities).
3. Consistent Analysis of the interactions between the chains of the energy sector and between this sector and others of the economy.
4. Long-term scenario analysis based on simulations of probable decision trees and tests of the type "What if". In this case there are less projection models and more planning and energy analysis tools.
5. Training of the planning action itself (didactic role of models).

Several authors have consistently created typologies for the models applied to long-term energy planning (Codoni et al., 1995; Bohringer, 1998; Costa, 2001; Bajay, 2004; Connolly et al., 2010; Jebaraj and Iniyan, 2006). These typologies continue to be similar but not identical. Usually, the most recent discussion adopts the comparison between the top-down type models (TD) and the bottom-up type models (BU) (van Vuuren et al. 2009).

The pure TD analysis are based on models of general equilibrium, and in theory are always consistent;. However, they do not permit *per se* detailed analysis, and deal with technical progress in an aggregate form. Potential gains in efficiency tend to be sub-estimated (Jacobsen, 1998; Koopmans and Velde, 2001; Klaassen and Riah, 2007; van Vuuren et al., 2009).

BU analyses are disaggregated on a sectorial (and even sub-sectorial) basis (Worrell et al., 2004). Notwithstanding this, the sectorial analysis of the bottom-up type, when associated, do not necessarily guarantee global consistency (Koopmans and Velde, 2001; Hourcade et al., 2006). These models deal with technical progress in a disaggregated manner. Potential gains in efficiency tend to be over-estimated, since the pure models do not take into account the so-called "hidden costs" of technological innovations (Gritsevskyi and Nakicenovi, 2001; Berglund and Söderholm, 2006). Table VI.1 offers a summary of these concepts.

Table VI.1: Basic differences between TD and purely BU approaches

Top-down **(TD)**	***Bottom-up*** **(BU)**
Uses aggregated data	Uses detailed data of technologies
It is possible to get a cost/benefit evaluation of planning through impacts on production, income and GDP.	It is possible to evaluate the cost/benefit of planning on the basis of the impacts of development and the application of technologies.
Assumes that markets are efficient	Does not begin under the hypothesis of market efficiency
Permits an evaluation of inter-sectorial effects	Does not permit an evaluation of inter-sectorial effects
Adequate for the evaluation of fiscal and monetary policies	Adequate for the evaluation of management policies on the demand side
Does not permit a detailed evaluation of environmental impacts.	Adequate for the evaluation of sectorial environmental policies.

Source: Based on Bajay (2004).

A substantial part of the present discussion on models for long-term energy planning is centered on distinguishing between TD and BU models (McFarland et al, 2004; Klaassen and Riah, 2007; van Vuuren et al. 2009). At present, efforts are being deployed, simulating different energy scenarios, to make compatible top-down with bottom-up models, and vice versa, striving to: i) verify the consistency of the bottom-up analysis, and, ii) add to the top-down analysis the possibility of the evaluation of sectorial energy policies, adding for instance details of the energy sector (Messner and Schrattenholzer, 2000; Hourcade et al., 2006; Klaassen and Riah, 2007, Rathmann, 2012; Wills, 2013).

In terms of computer tools, long-term models are usually based on techniques of optimization (frequently mixed integer programming), when evaluating optimum decisions for the assignment of energy resources complying with technical-economic and even institutional restrictions; or using simulation techniques, in which are carried out parametric, including econometric evaluations of energy and/or technological scenarios, devoid of the explicit objective of the optimum assignment of resources.

Optimization is used both in the bottom-up and top-down models, which guides to a combination of “preferred” technologies (or the assignment of production factors) in relation to the optimization goals chosen (for instance, lower cost or maximum private consumption) subject to certain restrictions (for example, maximum investment capacity that can be modeled with a restriction in installed capacity, tax levels, etc.). In the event that the model uses optimization also to define its baseline scenario, the introduction of a perturbation (for instance, prices relative to the emission of gasses) will automatically lead to a not optimal situation. It is important to highlight that these tools model competitive or perfect markets, and it is up to energy planners to incorporate market failures (subsidies, externalities, tributes and taxes, etc.) using restrictions, to be observed during the optimization.

For this reason, an alternative to save this hypothesis instead of the use of optimization techniques, is to describe the economic or energy system on the basis of a set of rules that will not necessarily lead to such a balance (these are the so called simulation models). Simulation models determine the behavior of consumers and of producers with relation to energy, based on the variation of prices, rent and technological progress. Normally, the determine the equilibrium of the market based on an iterative approach. This way, those models are not limited by the optimum behavior of agents. However, the relations between economic agents can be polemic and difficult to parameterize. Projections are also quite sensitive to conditions and to the initial parameters. In this case the disturbance to the model could even lead to results of lower costs (or higher levels of consumption). This is an important distinction to understand why certain approaches may result in negative costs (certain studies that are directed to specific technologies) or higher income levels.

Of course, a majority of models do not exclusively apply techniques for optimization or simulation; hybrid models assume both exogenous and endogenous macro-economic variables, and incorporate economic and energy alterations in a consistent structure[92].

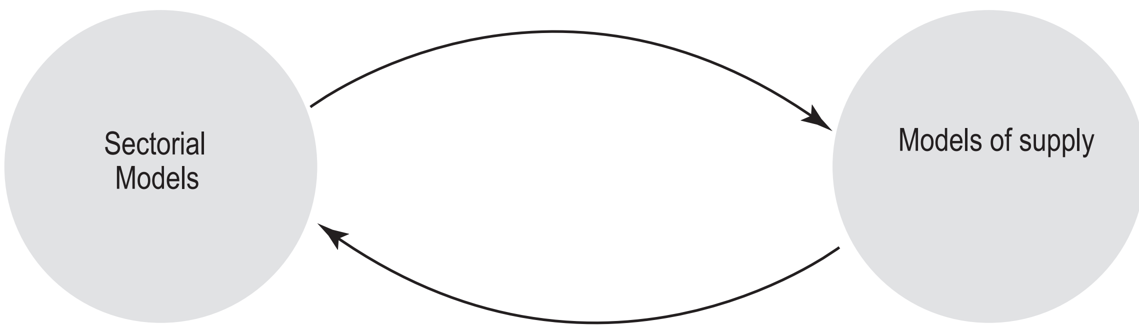
Finally, a relevant difference appears between models of a general equilibrium, in which the energy sector is simultaneously modeled with other economic sectors, and partial equilibrium models, barely associated to the energy sector, and even only to segments of this sector (sub sectorial models).

92 The hybrid models IMACLIM and MESSAGE-MACRO undertake a simultaneous projection of the input-product Matrix and of the energy balance (Rao and Riahi, 2006). There exist hypotheses relative to technical progress, especially in that which refers to energy inputs and the factor of production and work. Variations in quantities generated by technical progress, affect relative prices. Communication between the macro-economic and technical-economic models is done in an iterative form in function of the variations in prices and quantities.

These sectorial models are tools that permit an evaluation of the energy demand (in a medium and long-term) in a scenario that describes the hypothetical evolution of different economic, social and technological factors. In this modeling, energy demand is disaggregated in categories in accordance with its final use, and each one corresponding to a determined service or for the production of a given good. The nature and the level of demand for goods and services are later associated to different social factors (for example, regional demographic density, type and quantity of household appliances per residence); social-economic factors (for instance, priority for the development of certain industries or economic sectors, the country policy for public transport); purely economic factors (for example, the influence of the variation of fuel prices); or factors that are purely technological (such as the evolution of efficiencies of certain types of equipment, market penetration of new energy technologies or forms) considered in the above mentioned scenario.

In a simplified manner, sectorial models will have as a final result the demand for useful energy for different final uses-for the different analyzed scenarios [93]. For this reason, key variables for simulation of sectorial models refer to the performance of consumer equipment and the levels of economic or physical activity, according to the sector of consumption. Obviously, the performance of the end-use consumer equipment are not unrelated to final energy consumption. The integrated models are those that select the consumed energy sources to provide attention to the demand for useful energy, through a minimization of the total cost (considering relative prices of energy sources). Given models, in turn, depend on the results of the sectorial models that derive their assumptions on energy performance (depending on energy sources). This generates a cycle between models (for example, interaction between models of supply and demand - Figure VI.1) (Borba et al., 2012).

Figure VI.1: Circularity between models of supply and models of demand



Input:
Hypothesis on energy efficiencies (it depends on the energy sources used in final consumption of energy).

Output: Useful Energy.

Input:
Useful energy hypothesis on relative prices and technical and environmental constraints (it depends on the energy sources selected by the model).

Output: Final Energy by source.

Source: Borba et al., (2012).

In summary, seven types of tools were defined, which may be exclusively or collectively used to characterize an energy model. The energy tools or models typified according to their characteristics and performance appear in Table VI.2:

1. A tool of the top-down type is a macro-economic tool that generally uses macro-economic data to determine the growth of energy prices and of energy demand. Normally, tools of the top-down type are also tools of equilibrium.
2. A bottom-up tool identifies and analyzes specific technologies for the advantageous use of energy and this way, it identifies options for investment and analyzes specific technologies for the use of energy and in this manner, identifies investment options and technologic alternatives.
3. Optimization tools optimize the operation and/or investment in a given energy system. Tools for an optimization of the operation and expansion typically are also tools for simulation that optimize the operation and expansion of a specific system. Normally, a tool for optimization is also a tool for scenarios that optimizes investments in new infrastructures and new energy technologies.
4. A simulation tool simulates the operation of a determined energy system to supply a set of energy demands. Typically it simulates the operation of the plant for each hour during a typical year.
5. A sectorial tool for simulation is used to evaluate the evolution of energy demand (in the medium and long-term) of a scenario that describes the hypothetical evolution of the sector in economic, social and technological aspects.

93 except in the case of the electricity demand for captive uses of that energy source (for instance, in the case of illumination lumens are not specified but electric consumption is)

6. An integrated tool combines top-down and bottom-up techniques to overcome in a combined manner, the limitations that appear when techniques are applied on a separate basis.
7. An equilibrium tool strives to explain the behavior of supply, demand and prices in an entire economy or in a part of such an economy (general or partial) that has some or many markets. Frequently, it is assumed that agents are the ones that take prices and that equilibrium may be identified.

There are various tools that have been developed and applied to energy planning in different regions of the planet, including Latin American regions and countries. Usually, within the international context of long-term energy planning, there is a tendency to only work with models of the BU type based on optimization techniques, searching for the minimum sectorial cost (for a single energy chain or subsector, for example electricity, petroleum refining, etc.), or the minimum cost of the entire energy system (in this case, there is a simultaneous optimization of all energy chains). It is also usual to couple these BU tools to TD tools, with the objective of guaranteeing the macro-economic consistency and also obtaining the necessary macro-economic scenarios for the simulation of energy scenarios. With the intention of assisting the energy planner, in terms of accessibility to the different models, a mapping was made of their origin (organization that developed them) and availability (Table VI.3). Table VI.3 also indicates for each model, a link where it is possible to find information relative to access, training, on-line forums, events, support and contacts with other users of the models, etc.

Table VI.2: Types of models for energy planning

Modelos	Type								
	Top-down	Bottom-up	Simulation	Simulation	Sectorial/ Subsectorial[b]	Integrated/ Multi sectorial [c]	Equilibrium	Geographic Area	Term
AEOLIUS	-	YES	YES	-	-	-	-	National/state/regional	1 year[a]
BALMOREL	-	YES	YES	YES	YES	-	Partial	International	Max 50 years
BCHP	-	YES	YES	YES	YES	-	Partial	Only project	1 year[a]
COMPOSE	-	YES	-	YES	YES	-	Partial	Only project	Without limit
DECOMP		YES	-	YES	YES	-	Partial	National/state/regional	1 year[a]
DigSilent	-	YES	YES	YES	YES	-	Partial	National/state/regional	Without limit
E4cast	-	YES	-	YES	YES	-	General	National/state/regional	Max 50 years
EEPPS	-	YES	-	YES	YES	-	Partial	National	1 year[a]
EMCAS	-	YES	YES	-	YES	-	-	National/state/regional	Without limit
EMINENT	-	YES	-	-	YES	-	-	National/state/regional	1 year[a]
EMPS	YES	-	-	YES	-	YES	Partial	International	25 years
EnergyPLAN	-	YES	YES	YES	YES	-	Partial	National/state/regional	1 year[a]
EnergyPRO	-	-	YES	YES	YES	-	Partial	Only project	Max 40 years
ENPEP	YES	-	YES	-	-	YES	General	National/state/regional	75 years
ENVISAGE	YES	-	YES	-	-	YES	General	Global	Without limit
EPPA	YES	-	YES	-	-	YES	General	Global	Up to 2100
FINPLAN	-	YES	YES	-	YES	-	Partial	Only project	Without limit
GCAM	YES	-	YES	-	-	YES	General	Global	50+ years
GEMME	-	YES	-	YES	YES	-	Partial	National	Without limit
GTMax	-	-	YES	YES	-	-	Partial	National/state/regional	Without limit
H2RES	-	YES	YES	YES	YES	-	Partial	Island	Without limit
HOMER	-	YES	YES	YES	YES	-	Partial	Only project	1 year[a]
HYDROGEMS	-	-	-	-	-	-	-	Only project	1 year[a]

Modelos	Type								
	Top-down	Bottom-up	Simulation	Simulation	Sectorial/ Subsectorial[b]	Integrated/ Multi sectorial [c]	Equilibrium	Geographic Area	Term
IKARUS	-	YES	-	YES	YES	-	Partial	National/state/regional	Max 50 years
IMACLIM	YES	YES	YES	-	-	YES	General	National/state/regional	Without limit
INFORSE	-	-	-	-	-	-	-	National/state/regional	50+ years
Invert	-	YES	YES	YES	YES	-	Partial	National/state/regional	Max 50 years
LEAP	YES	YES	YES	YES	YES	YES	Partial	National/state/regional	Without limit
M-REF	-	YES	-	YES	YES	-	Partial	National	Without limit
MAED	-	YES	YES	-	YES	-	-	National/state/regional	25 years
MARKAL	-	YES	-	YES	YES	YES	Partial	National/state/regional	Max 50 years
MEDEE-2	-	YES	YES	-	YES	-	-	National/state/regional	Max 60 years
Mesap	-	YES	-	-	YES	-	-	National/state/regional	Without limit
MESSAGE	-	YES	-	YES	YES	YES	Partial	Global/National/regional	50+ years
MiniCAM	-	YES	YES	-	YES	-	Partial	Global and regional	50+ years
MoMo	-	YES	YES	-	YES	-	-	National	50+ years
MOPERD	-	YES	YES	-	YES	-	Partial	National/state/regional	Without limit
NCP	-	YES	-	YES	YES	-	Partial	National/state/regional	1 year
NEMS	-	-	-	-	YES	-	General	National/state/regional	Max 50 years
NEPLAN	-	YES	YES	YES	YES	-	Partial	National	Without limit
NEREUS	YES	YES	-	YES	-	-	General	National	Without limit
NETPLAN	-	YES	-	YES	YES	-	Partial	National/State/Region	Without limit
NEWAVE	-	YES	-	YES	YES	-	Partial	National/state/regional	1 year
OPTGEN	-	YES	-	YES	YES	-	Partial	National/State/Region	Without limit
ORCED	-	YES	YES	YES	YES	-	General	National/state/regional	1 year[a]
PERSEO	YES	YES	-	YES	YES	-	General	National/state/regional	Max 50 years
PLANEL	-	YES	-	YES	YES	YES	Partial	National	Without limit
PLEXOS	-	YES	YES	YES	YES	-	Partial	National/state/regional	10 years
PRIMES	-	-	-	-	YES	-	General	National/state/regional	Max 50 years
ProdRISK	-	-	YES	YES	-	-	Partial	National/state/regional	Multiple years
RAMSES	-	YES	YES	YES	-	-	Partial	International	30 years
RETScreen	-	YES	YES	-	YES	-	Partial	Solo project	Max 50 years
SAM	-	YES	-	YES	YES	-	Partial	Solo project	Without limit
SAME		YES	YES	-	YES		-	National/State/Region	1 year[a]
SDDP	-	YES	-	YES	YES	-	Partial	National/state/regional	Without limit
SimREN	-	YES	-	YES	YES	-	-	National/state/regional	1 year[a]
SIVAEL	YES	-	YES	-	-	YES	-	National/state/regional	1 year[a]
STREAM	-	-	YES	-	-	-	-	National/State/Region	Without limit
SUPER OLADE	YES	YES	YES	YES	YES	-	Partial	Local/community	Multiple years
TRNSYS16	-	YES	YES	YES	YES	-	Partial	National/state/regional	Max 50 years

Modelos	Type								
	Top-down	Bottom-up	Simulation	Simulation	Sectorial/ Subsectorial[b]	Integrated/ Multi sectorial [c]	Equilibrium	Geographic Area	Term
UniSyD3.0	-	YES	-	-	YES	-	General	National/state/regional	Without limit
WASP	-	-	YES	YES	YES	-	Partial	International	1 year[a]
WILMAR	-	-	YES	YES	-	-	Partial	Internacional	1 year[a]

[a] Models that can only simulate one (1) year at the time, but these may be combined to create a scenario of multiple years.
[b] Sub sectorial makes reference to each segment of the energy sector, petroleum, gas, electricity, etc. that are segments or subsectors.
[c] Multi sectorial Models are those that consider diverse sectors (Industry, Residential, Public, Services, etc.). There is no consensus to affirm that all multi sectorial models are integrated. In an integrated model any variation in one of its sectors must also affect/have an incidence upon the other sectors.

Source: Prepared on the basis of IIASA (2009); Connolly et al. (2010); IAEA (2013).

Table VI.3: Developers of models and number of users in terms of downloads / sales (position up to 2010)

Model	Organization that developed the model (link)	Availability	Downloads
High number of users			
RETScreen	RETScreen International (http://www.retscreen.net/)	Free download	> 200.000
HOMER	National Renewable Energy Laboratory and HOMER Energy LLC (www.homerenergy.com)	Free download	> 28,000
LEAP	Stockholm Environment Institute (http://www.energycommunity.org/)	Commercial	> 5,000
BCHP	Oak Ridge National Laboratory (http://www.ornl.gov/)	Free download	> 2,000
EnergyPRO	Energi-Og Mijødata (EMD) International A/S (http://www.emd.dk/)	Commercial	> 1,000
High number of users			
EnergyPLAN	Aalborg University (http://www.energyplan.eu/)	Free download	100-1000
EPPA	Massachusetts Institute of Technology (http://globalchange.mit.edu/research/IGSM/eppadl_form)	Free for educational purposes	100-1000
Invert	Energy Economics Group, Vienna University of Technology (http://www.invert.at/)	Free download	100-1000
GCAM	Joint Global Change Research Institute (http://www.globalchange.umd.edu/models/gcam/download/)	Free download	100-1000
MAED	International Atomic Energy Agency (http://www-pub.iaea.org/)	Free download	100-1000
MARKAL	Energy Technology Systems Analysis Program, International Energy Agency (http://www.etsap.org/)	Commercial	100-1000
MEDEE-2	International Atomic Energy Agency (http://www-pub.iaea.org/MTCD/publications/PDF/CMS-18_web.pdf)	Free download	100-1000
MESSAGE	International Institute for Applied Systems Analysis (http://www.iiasa.ac.at/)	Free/Simulators must buy	100-1000
ORCED	Oak Ridge National Laboratory (http://www.ornl.gov/)	Free download	100-1000
SAM	National Renewable Energy Laboratory (https://sam.nrel.gov/content/downloads)	Free download	100-1000

Model	Organization that developed the model (link)	Availability	Downloads
TRNSYS16	The University of Wisconsin Madison (http://sel.me.wisc.edu/trnsys/)	Commercial	100-1000
WASP	International Atomic Energy Agency (http://www.iaea.org/OurWork/ST/NE/Pess/PESSenergymodels.shtml)	Commercial/Free for members of the IAEA	100-1000
Medium number of users			
EMCAS	Argonne National Laboratory (http://www.dis.anl.gov/projects/emcas.html)	Commercial	20-50
EMPS	Stiftelsen for Industriell og Teknisk Forskning (SINTEF) (http://www.sintef.no/)	Commercial	20-50
ENPEP	Argonne National Laboratory (http://www.dis.anl.gov/projects/Enpepwin.html)	Free download	20-50
GTMax	Argonne National Laboratory (http://www.dis.anl.gov/projects/Gtmax.html)	Commercial	20-50
IMACLIM	CIRED (http://www.imaclim.centre-cired.fr/spip.php?article111&lang=en)	Commercial	20-50
MoMo	International Energy Agency (www.iea.org)	Commercial	20-50
NETPLAN	PSR (http://www.psr-inc.com/psr/download/folders/netplanfolderpor.pdf)	Commercial	20-50
OPTGEN	PSR (http://www.psr-inc.com.br/portal/psr/servicos/models_de_apoio_a_decisao/studio_plan/optgen/)	Commercial	20-50
SDDP	PSR (http://www.psr-inc.com.br/portal/psr/servicos/models_de_apoio_a_decisao/studio_opera/sddp/)	Commercial	20-50
Low number of users			
AEOLIUS	Institute for Industrial Production, Universität Karlsruhe (http://www-iip.wiwi.uni-karlsruhe.de/)	Commercial	1-20
COMPOSE	Aalborg University (http://www.socialtext.net/energyinteractivenet/index.cgi?compose)	Free download	1-20
DECOMP	CEPEL (http://www.cose.fee.unicamp.br/cose/it511/newave-decomp-dessem/Newave_comentado.pdf)	Only for internal use	1-20
ENVISAGE	World Bank (http://siteresources.worldbank.org/INTPROSPECTS/Resources)	Only for internal use	1-20
FINPLAN	International Atomic Energy Agency (http://www.iaea.org/OurWork/ST/NE/Pess/PESSenergymodels.shtml)	Commercial/Free for members of IAEA	1-20
IKARUS	Research Centre Jülich, Institute of Energy Research (http://www.fz-juelich.de/ief/ief-ste)	Commercial	1-20
INFORSE	The International Network for Sustainable Energy (http://www.inforse.org/europe/Vision2050.htm)	Free for NGOs	1-20
Mesap	Seven2one (http://www.seven2one.de/de/technologie/mesap.html)	Commercial	1-20
MOPERD	Synex Consulting (http://www.synex.cl/)	Commercial	1-20
NCP	PSR (http://www.psr-inc.com.br/portal/psr/servicos/models_de_apoio_a_decisao/studio_opera/ncp/)	Commercial	1-20
NEMS	Office of Integrated Analysis and Forecasting, Energy Information Administration (http://www.eia.doe.gov/)	Free/Simulators must buy it	1-20
NEWAVE	CEPEL (http://www.cose.fee.unicamp.br/cose/it511/newave-decomp-dessem/Newave_comentado.pdf)	Only for internal use	1-20
NEREUS	FIPE-USP (http://www.usp.br/nereus/)	Only for internal use	1-20

Model	Organization that developed the model (link)	Availability	Downloads
PERSEO	Institute for Industrial Production, Universität Karlsruhe (http://www-iip.wiwi.uni-karlsruhe.de/)	Commercial	1-20
ProdRisk	Stiftelsen for Industriell og Teknisk Forskning (SINTEF) (http://www.sintef.no/Home/)	Commercial	1-20
PLANEL	Empresa de Pesquisa Energética (www.epe.gov.br)	Only for internal use	1-20
PLEXOS	Energy Exemplar (http://energyexemplar.com/)	Commercial	20-50
RAMSES	Danish Energy Agency (http://www.ens.dk/)	Projects carried out in one quota	1-20
SIVAEL	Energinet.dk (http://www.energinet.dk/en/menu/Planning/Analysis+models/Sivael/SIVAEL.htm)	Free download	1-20
EMINENT	Instituto Superior Técnico, Technical University of Lisbon (http://carnot.ist.utl.pt/~eminent2/)	To be determined	1-20
PRIMES	National Technical University of Athens (http://www.e3mlab.ntua.gr/)	Projects carried out in one quota	1-20
The number of users is not specified, since this is not controlled			
BALMOREL	Project Driven with a user's network and forum around it (http://www.balmorel.com/)	Free download	Not specified
DigSilent	DIgSILENT (http://www.digsilent.de/index.php/products-powerfactory-application_examples.html#bottom)	Commercial	Not specified
E4cast	Australian Bureau of Agricultural and Resource Economics (http://www.abare.gov.au/)	Commercial	Not specified
EEPPS	Battelle Memorial Institute (http://www.battelle.org/)	Free download	Not specified
GEMME	Not specified	Not specified	Not specified
H2RES	Instituto Superior Técnico and the University of Zagreb (http://powerlab.fsb.hr/h2res/)	Only for internal use	Not specified
HYDROGEMS	Institutt for energiteknikk (http://www.hydrogems.no/)	Commercial/Free for users of TRNSYS	Not specified
M-REF	Not specified	Not specified	Not specified
MiniCAM	Pacific Northwest National Laboratory (http://www.globalchange.umd.edu/)	Free to download once contacted	Not specified
NEPLAN	BCP (http://www.neplan.ch/html/e/e_archive_default.htm)	Commercial	Not specified
SimREN	Institute of Sustainable Solutions and Innovations (http://www.isusi.de/theerjreport.html)	Projects carried out in one quota	Not specified
STREAM	Ea. Energy Analyses (http://www.ea-energianalyse.dk/)	Free download	Not specified
SUPER OLADE	Organización Latino Americana de Energía (http://www.olade.org/en/product/SUPER/more-information)	Commercial	Not specified
UniSYD3.0	Unitec New Zealand (http://www.unitec.ac.nz/)	Jonathan Leaver: jleaver@unitec.ac.nz	Not specified
WILMAR	Risø DTU National Laboratory for Sustainable Energy (http://www.wilmar.risoe.dk/)	Commercial	Not specified

Source: Prepared on the basis of IIASA (2009); Connolly et al. (2010); IAEA (2013).

VI.3. Description of the functioning of models selected for energy planning

VI.3.1. RETScreen

The model RETScreen may be classified as a simulation model focused on a partial equilibrium (bottom up), the purpose of which is to analyze a determined sector/technology and that provides results in a specific application (project to project).

RETScreen is a free use computer program available in 35 languages that was developed by the CANMET Energy Technology Centre – Varennes, in Canada. This model is used to analyze projects for electricity generation, heat generation, cogeneration and Energy Efficiency actions. In addition it permits managing investment, and O&M costs[94], calculates CO_2 emissions of the project, prepares a financial analysis and develops sensitivity and risk analysis. These analysis provide useful arguments during the decision making process.

With RETScreen it is possible to develop projects with different technologies: wind, small hydro power stations (SHPS), solar photovoltaics, concentrated solar power (CSP), geothermal, energy based on ocean waves, heating by biomass, solar water heating for sanitary applications, water and air heating for room heating, passive solar heating for architectural projects, thermoelectric power stations with different fossil fuels and biomass, and additionally it permits to simulate Energy Efficiency actions for the residential, commercial, industrial sectors and public buildings. These analyses can be done for distributed or centralized generation systems (with connection to the grid).

RETScreen has access to a meteorological database with information provided by NASA for more than 6.500 places in the world. The model also has a database for equipment such as engines, turbines, etc. (Government of Canada, 2012).

Structure and input variables

The environment of RETScreen presents a color code that helps the user to identify input data to be provided: those that make a part of calculations (yellow color), if they are input data selected from a database (blue color), if they are merely referential input data (grey color), and the results of the calculations made by the model (white color).

The model, designed on an Excel platform, presents friendly and intuitive working environment. It is important to be careful with the activation of its macros in order to assure its adequate operation. According to the type of analysis, different “tabs” or working sheets are activated that characterized the structure of RETScreen. Basic tabs are:

- Start: This permits loading the general information on the project and climatic conditions of the site of implementation. This also defines the general configurations of the energy system, technology, energy source and configuration of the distribution/transmission system.
- Load and network: This tab is only activated when a selection has been made of “grid with an internal load” in the Start tab. This option is useful when in addition to evaluating the electric generation of the plant/building an effort is made to analyze the internal consumption of energy and its monthly variation. The load curve contains monthly values (kW med) of electric consumption for the entire year. It is also possible to identify the additional energy consumption of the system at peak load. It is necessary to indicate that the electric tariff of the Distributor (including taxes and rates) permit the model to calculate the income obtained from the sale of the electric surplus (injected into the distribution network is the difference between gross production and internal consumption).
- Energy Model: Depending on the selected technology, it will be necessary to provide data on the power to be installed, specific fuel consumption (for engines and turbines), the price of the electricity exported to the distribution system, a factor for the use of the plant and other information data relative to the equipment modeled.
- Analysis of costs: This is where the information of costs is inserted (of capital, O&M and others, costs/periodic income). For this purpose there are two methods available that permit changing the complexity of the model according to the availability of information.
- Analysis of emissions: Optionally, keeping account of the emissions de CO2e that would be prevented due to the implementation of the project it would be important to evaluate the financial contribution to determine if the project qualifies as Clean Development Mechanism (CDM).
- Financial Analysis: In a first stage it is necessary to indicate the financial parameters to be considered by the analysis (readjustment of fuel costs, inflation, and discount rate, useful life of the project, financing mechanism, fraction of debt, rate of interest, time length of the debt, etc. In a second moment, tax details are specified (taxes, depreciation, fiscal exemptions). Finally, the model calculates the cash flow, the leveled cost of the energy produced, revenues from the sale of electricity, income from the sale of carbon bonds, other income and expenses. RETScreen presents a summary chart with the principal financial indicators (IRR, NPV, time for the recovery of capital, summarized cash flow).
- Analysis of sensibility and risks: The Analysis of sensibility and risks shows a percent variation of one of the results when the input data varies within a range to be defined by the user. Risk analysis permits knowing the impact (deviation pattern) on the IRR, NPV and the return of equity due to a variation in initial costs, fuel costs, price of the electricity exported and the period for the payment of the debt, subject to an acceptable risk level.

94 Operation and maintenance.

- Tools: Other components are available for multiple purposes, among them: tools to estimate the annual production of biogas for a determined group of animals, tools to estimate the generation of biogas sanitary landfill, etc.

Additional details can be found in the User’s Manual of RETScreen, available in its webpage, according to Table VI.3.

Scenarios, simulation and results of the model

Once the values for the input variables have been supplied, the RETScreen model automatically calculates cash flow, financial indicators, the total annual generated energy and its leveled cost, among the most important results.

The model permits the testing of different scenarios with a variation of input parameters. It is possible to experiment with alternative scenarios of energy efficiency, financial incentive scenarios, scenarios that include carbon markets, etc. A good way of analyzing the implications of the variation of certain parameters is by using the sensibility and risk analysis offered by RETScreen.

Among the most important results obtained is the leveled cost of energy (LCOE), annual generated energy, indicators of financial viability, such as the internal rate of return (IRR) and net present value (NPV).

Results obtained from the RETScreen model generally serve as input data for more complex comprehensive energy planning models. Usually, results such as the leveled cost of energy (LCOE) and performance factors of the plant feed the database of programs such as MESSAGE or LEAP.

Recommendations for the use of RETScreen in energy planning in LAC

The RETScreen model, since it is a model that is freely available in internet and that can be easily operated in an Excel environment, at the same time permits a rapid technical and financial evaluation of an energy project, turns out to be a valuable complementary tool for energy planning, especially in the initial stage of this process. This model permits preparing preliminary evaluations of financial viability and technical feasibility of a project, program or policy. These results will serve as an input to feed more complex and elaborate models that are more appropriate for long-term energy planning.

It is quite often that in the countries of LAC, there are not available specific climatology data or in the appropriate format, the link between RETScreen and the meteorological data base of NASA represents a great deal of help to fundamentally simulate solar and wind energy projects.

The complementary tools presented by the model, available in its last tab, are also valuable for energy planning in the countries of the region, contributing with the analysis of the environmental component. This is the case of a tool to calculate the volume of biogas on the basis of a set of residues.

In no case RETScreen will be able to be used in an isolated manner for long-term planning, but it will always be useful in the initial stages of the decision making process.

VI.3.2. SAM (System Advisor Model)

The System Advisor Model (SAM) may be classified as a model with a partial equilibrium focus (bottom up), that develops simulation and optimization, the purpose of which is to analyze a determined sector/technology, and that provides results of a specific application (project to project).

SAM is a free use program, managed by the National Renewable Energy Laboratory (NREL). Initially SAM was developed to satisfy the needs of the System Driven Approach (SDA) project that was part of the Solar Energy Technologies Program (SETP) of the Department of Energy of the United States (DOE). At present, several investigation institutions around the world are using this model due to its versatility.

Version 2013.1.15 permits the simulation of projects with photovoltaic solar energy (PV-c[95] and HCPV[96]), solar concentration (parabolic cylinder, solar tower, Fresnel and parabolic disc with Stirling motor), solar collector for heating sanitary water, wind, thermoelectric based on biomass and conventional geothermal and thermoelectric.

The most important functions of SAM are: a) sensibility or impact analysis due to a variation of performance factors of the plant; b) financial analysis of the project; c) parametric analysis; and, d) optimization analysis (Gilman et al., 2008). In particular, the component

95 PV-c: Photovoltaic panels with cystaline silicon cells.

96 HCPV: High Concentration Photovoltaic.

for optimization is very useful to determine ideal values for key parameters of design, operation and financing. Additionally, SAM permits access to and use of a-wide climatological database for specific sites at global level. This is particularly useful for the simulation of electricity generation hour by hour along a typical meteorological year of plants with intermittent renewable energies (sun, wind).

Structure and input variables

SAM presents a structure with the following windows that may vary slightly in their name according to the technology under analysis:

- Meteorological Site and Data: The geographic point of analysis constitutes the principal variable of input. There exists a broad database of meteorological information, taken from the principal airports and weather stations around the world. When selecting a city, it automatically provides information such as direct normal and global irradiation, wind speed, humidity and environmental temperature, etc.
- Technology: For technology type CSP, it is necessary to indicate in several windows the values of the input variables related to the solar field, collectors, receptors, power block and heat storage. For technology type PV, the windows available determine the information relative to the module, inverter, positioning of the panels in the system and their direction. In a wind plant it is necessary to enter key data relative to the turbines in the wind park. More simplified schemes are available for biomass and geothermal, where it is only necessary to specify the characteristics of the power cycle and the source of energy.
- Costs: For solar and wind technologies it is only necessary to indicate the costs related to the infrastructure, establishing a difference with biomass and other thermoelectric plants in which it is also necessary to specify fuel costs. In the first case, cost logic is simple since it is organized by capital costs (investment) direct and indirect, costs of operation and maintenance.
- Forms of dispatch: The technology for solar concentration with heat storage permits the simulation of the dispatch of electricity with configurations in accordance with the weather season, day of the week and peak and hourly schedule according to the load curve that is inserted. Several windows with similar options are presented for geothermal technology and for thermoelectric plants that use biomass as well as conventional ones.
- Financing: Financing conditions must be established such as rate of interest, fraction of the debt, period of payment, inflation and taxes.
- Incentives: Different incentives may be tested. However it is recommendable to carefully analyze their applicability, since these have been designed for the United States nodes. In the case of LAC, it is necessary to carefully evaluate their adaptation.
- Depreciation: Several depreciation options are presented.

Further details may be found in the User's Manual of SAM, available in its webpage, according to Table VI.3.

Scenarios, simulation and results of the model

It is possible to simulate energy systems with an empirical model (based on referential values of real plants that are fundamentally located in the United States) and with a physical model (based on equations and principles of thermodynamics, transfer of heat and fluid mechanics). Upon executing a model of SAM several series of the program "Transient System Simulation Program – TRNSYS", compiled in Fortran, must be run to immediately deliver reliable results.

Parametric and sensibility analysis quickly permit the simulation of several scenarios. These options allow the execution of several runs of the model for a value interval of the selected parameters.

Among the principal results obtained are the levelized cost of electricity (LCOE), the pay-back time of the investment, annual electric or thermal generation, capital cost and those of O&M, the land surface requirement, annual water consumption, etc.

Recommendations for the use of SAM in energy planning in LAC

Since SAM, is a model that is freely available in internet and which can be easily operated under a friendly environment, at the same time that it permits to technically and financially evaluate an energy project, it is a valuable complementary tool for energy planning, especially during the initial stages of this process.

In LAC countries, where very often there are no meteorological databases available in an adequate format to be used in energy projects simulations, the link to SAM permits access to temporal series with information on hour to hour and for a typical meteorological year (Component D-VIEW) that constitutes a great help. This database contains very detailed information on direct solar, diffused and global, wind speed, humidity among other data, for different cities in LAC. This information permits the simulation with a greater degree of technical detail of the operation and dispatch of a plant of electric generation throughout the year.

On the other hand, it is important to take note that since SAM is a model developed in the United States, it has information on the costs of technologies and tax rates and tax base that reflect its reality. In this sense it is useful to take into account that these costs must be up-dated to reflect the reality of each country (cost of fuel, labor, operation and maintenance, land values, etc.), as well as other types of taxes and tariff exemptions suggested. These elements, in no manner limit the value of the model that is permanently up-dated, has an on-line forum for discussion and offers a good reference of the capital costs of technologies.

VI.3.3. HOMER

The HOMER model can be classified as a partial equilibrium model, with a bottom-up focus that develops simulation and optimization, whose purpose is the planning and design of projects for hybrid energy systems that can satisfy a demand with a certain availability of resources.

HOMER is a model for optimization at a minimum cost developed by the National Renewable Energy Laboratory (NREL) of the United States. These systems may be comprised by conventional generators (reciprocal engines or micro turbines), systems for cogeneration, wind turbines, photovoltaic systems, batteries, fuel cells, hydroelectric power stations, biomass and others. In turn, the operation of these systems may be evaluated with two configurations: connected to the grid or isolated.

Structure and input variables

To be able to use the HOMER model it is necessary to provide the following input variables to the model:

- √ Construction of a Schematic Diagram: It indicates what general components will be included in the evaluated system (Example: photovoltaic panels, generators, load, batteries, etc.), and it specifies if it will be an isolated system or connected to a grid.
- √ Input of demand data: Entered are all data of hourly load (be it electric, thermal, or for the production of hydrogen) in terms of power. This information can also be imported for the 8.760 hours of the year.
- √ Input of costs and of component characteristics: Specified are costs, efficiencies, size of components, useful lifetime, etc. that will be used in the simulations for each part of the system. Information relative to the size and quantity of components that are variables for optimization. HOMER will simulate all possible combinations between the sizes and specified availability of components.
- √ Input of resources data: this data relative to resources describes the availability of solar radiation, wind and water on a monthly basis. This type of data may also be imported. In the case of fuels it is necessary to provide their cost and annual availability. When entering the characteristics of thermal machinery the type of fuel to be used is specified, as well as its specifications (heating power, density, carbon content, sulfur content, etc.).
- √ Input of parameters for economic evaluation: In order to calculate net present value, it must specify discount rates, the useful lifetime of the evaluated project, fixed capital and O&M costs (that are independent of the configuration of the system), and the penalty for not provided energy or the shortage cost (US$/kWh). It is also possible to determine a penalty on emissions (example: US$/t$CO_2$).
- √ Other restrictions: This permits the definition of the maximum non-delivered capacity, the minimum fraction of renewables, reserve margin. It also permits restrictions to limit the maximum of emissions.

Additional details may be found in the Manual of the User HOMER, available in its webpage, according to Table VI.3.

Scenarios, simulation and results of the model

Simulation and optimization

HOMER simulates the operation of the configurations of the system for all of the combinations of components specified for each of the 8.760 hours of the year. The model does exclude all unviable configurations of the system, this is to say, those that do not adequately address the load assigned with the available resources, nor don't serve the additional restrictions that have been specified. In the section relative to optimization appear all of the viable systems ordered by minimum cost (at present value).

Analysis of sensibility

This function permits the planner to analyze the effects on present value and on the optimal configuration due to a variation in input parameters (costs, discount rate, demand, etc.). The principal objective of using the sensibility analysis in HOMER is to provide an additional tool to the user when there is uncertainty about which value to use for a determined variable, or relative to the design of the energy system when facing changes in external factors. This analysis will permit the observation of its influence on the operation and costs of the system.

Recommendations for the use of HOMER in energy planning in LAC

This is a highly recommendable model for the economic design of isolated systems, to be able to evaluate the introduction of renewable technologies (solar, photovoltaic, wind and biomass) in parallel (hybrid systems), the operation of conventional generation systems (reciprocating engines, micro turbines, etc.). Among the advantages of the use of this model, is the simulation on an hourly base, considering efficiency curves of equipment in function of their load, resources and demand. It is not recommended for the use in evaluating the operation and expansion of large scale systems, due to the great quantity of input data that would be required to construct the base case, the considerable time required for simulation, and because it does not have a function that permits the expansion of future demand.

VI.3.4. WASP

The model *Wien Automatic System Planning* (WASP) may be classified as a model with a partial equilibrium, with a bottom-up focus, that permits designing or proposing a policy for the expansion of a electricity generation system, from an optimization analysis that seeks to determine the economic optimum subject to certain restrictions established by the user.

It uses methods such as probabilistic estimation of the system for production costs, the costs of not provided energy, and the principle of reliability, in addition to linear programing techniques that permit a determination of the optimum dispatch policy that will satisfy exogenous restrictions such as emissions, fuel availability, generation of minimum electricity, and restrictions in investment capacity which in turn can be understood as restrictions in the maximum capacity that can be installed. Finally, it also uses methods for dynamic optimization to compare the costs of alternative expansion policies.

Structure and input variables:

WASP-IV is comprised by a general information system with eight modules that operate in a sequential manner. The principal entry modules are the following:

- General Information of the System: The starting and final years of the study are entered, as well as the number of periods per year, hydrological data and the probability of their occurrence.
- LOADSYS: In this module are entered the maximum demands and the curves foreseen for the duration of each one of the periods of the years under study.
- FIXSYS: The information that describes the existing generation power station is entered. Thermal power stations are represented by: number of generation units, minimum and maximum operation capacity per unit, type and cost of fuel, minimum and average heat rate, fixed and variable costs, emissions, percentage of forced exits and days for maintenance reserved per year, etc. Hydroelectric power stations and storage pumps are represented with their installed capacity, storage capacity, affluent energy, minimum energy generation, and maximum power for each hydrology, as well as its costs of operation and maintenance by capacity.
- VARSYS: The different projects of generation plants are entered, to be simulated as candidates for expansion in the generation of the system. Parameters for each central are fed into the VARSYS that are similar to those entered into FIXSYS.
- CONGEN: In this module are determined the number of configurations that will be analyzed by the programs for simulation and optimization for each candidate project for each year of the horizon under study, as well as the range of the reserve margin for the expansion.

Additional details can be found in the User's Manual of WASP, available in its webpage, according to Table VI.3 and in **IAEA** (2001).

Scenarios, simulation and model results

The following modules are those of simulation and results, although in certain cases they also include the input of variables:

- MERSIM: This module simulates and determines the operation costs ~~of operation~~, reliability and ~~energy~~ not provided energy for each configuration defined in the CONGEN.

- DYNPRO: Into this module are entered the discount rate for national and external costs, as well as the number of years for an economic comparison of alternatives. Additionally, are also entered capital costs and the useful life span of each specified power station for generation. Later, this module will carry out the economic evaluation of the alternative plans for expansion considering the simulations but with the configurations of CONGEN and the costs for operation and maintenance of the simulations performed with MERSIM. By means of dynamic programming the model will determine the installation sequence of installation that minimizes the up-dated investment and operation costs of the system.

- REMERSIM: This auxiliary module simulates, as in the case of MERSIM, an optimum expansion with the objective of keeping the data of the simulation for a future printing.

- REPROBAT: Auxiliary module that permits printing the summary report with all of the information entered into the model with the optimal solution, complemented with data from the generation of energy, capacity factor and the corresponding cash flows.

The WASP model permits the execution of the sensibility analysis regarding the economic parameters contemplated in the optimal solution of reference, and it is sufficient to run again the DYNPRO module. This can be relatively simple if the set of new values of the parameters do not produce optimal solutions beyond the previous space of solutions determined in the CONGEN module. If the new space for solutions is kept within the previous limits established in CONGEN, the time for processing (iteration modules CONGEN-MERSIM-DYNPRO) will be minimal. Additional details may be found in the User's Guide of WASP in IAEA (2001).

There are no specific functions to carry out an analysis of uncertainty, for which reason, the user will have to do it on an exogenous basis.

Recommendations for the use of WASP-IV in energy planning in LAC

This is an appropriate model for the economic planning of electricity generation systems on a national level, or for larger isolated systems. It is highly recommendable for systems of predominantly thermal generation, due to the fact that the characterization and simulation of thermal power stations that are presented by this model is highly detailed (minimum and maximum capacity of generation per unit, forced and planned exit of equipment, efficiencies at minimum and maximum operation, etc.). On the other hand, the characteristics for the modeling of hydroelectric plants are reduced. Restrictions in investment capacity can be modeled by determining restriction for maximum capacity to be installed for each technology. A similar treatment can be considered to model limitations in the national productive chain (local content policies).

VI.3.5. EEPPS (Economic and environmental power planning software)

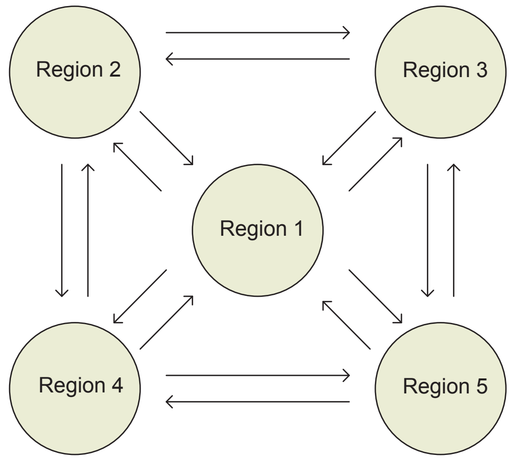
Economic and Environmental Power Planning Software (EEPPS) is a model for the optimization of minimum cost developed by the Battelle Memorial Institute (BMI) (Schaeffer and Szklo, 2001). The objective function is defined as the minimization of system costs, including cost of generation, of transport and of transmission of electric energy, in addition to the costs of pollution control and of the externalities derived from emissions caused by electricity generation. This is a model for inter-temporal optimization, of perfect information, that determines the quantity of electric energy by technology necessary to satisfy electricity demand, exogenously defined, at a minimum cost of the entire period of study defined by the user.

This model was developed in Excel spreadsheets of Microsoft. The software uses linear program to analyze production and consumption of energy by sectors and regions, that are defined by the users relative to the technologies of electric energy generation[97] present and proposed (considering restrictions in investment capacity, that may be modeled as restrictions of the maximum capacity to be installed), as well as fuels used and environmental restrictions. It is necessary to take into account that the model considers five periods, where the first one makes reference to the base year that is precisely the year for the calibration of the model. The remaining four periods are spaced every five years in the standard model, however it is possible to use these intervals attributing the time that the analyst considers necessary.

As has been pointed out, the model has the possibility of establishing different regions, such as presented in Figure VI., permitting as a maximum, the incorporation of five regions. These regions must be clearly differentiated by availability, quality and cost of the technologies of the energy supply. In this sense, the model is susceptible of being used in regional, national or multi-regional planning of systems for electric energy generation. The disaggregation level of the model will depend on the availability of information in each country and region. The energy planner must evaluate the dispute between disaggregation and the degree of detail versus simplicity and versatility. The model must respond to criteria of reasonability and be able to answer the specific questions that have been formulated.

97 It is necessary to define fixed and variable costs of each technology, efficiencies, load factors, useful life, among others.

Figure VI.2: Regional structure of the model

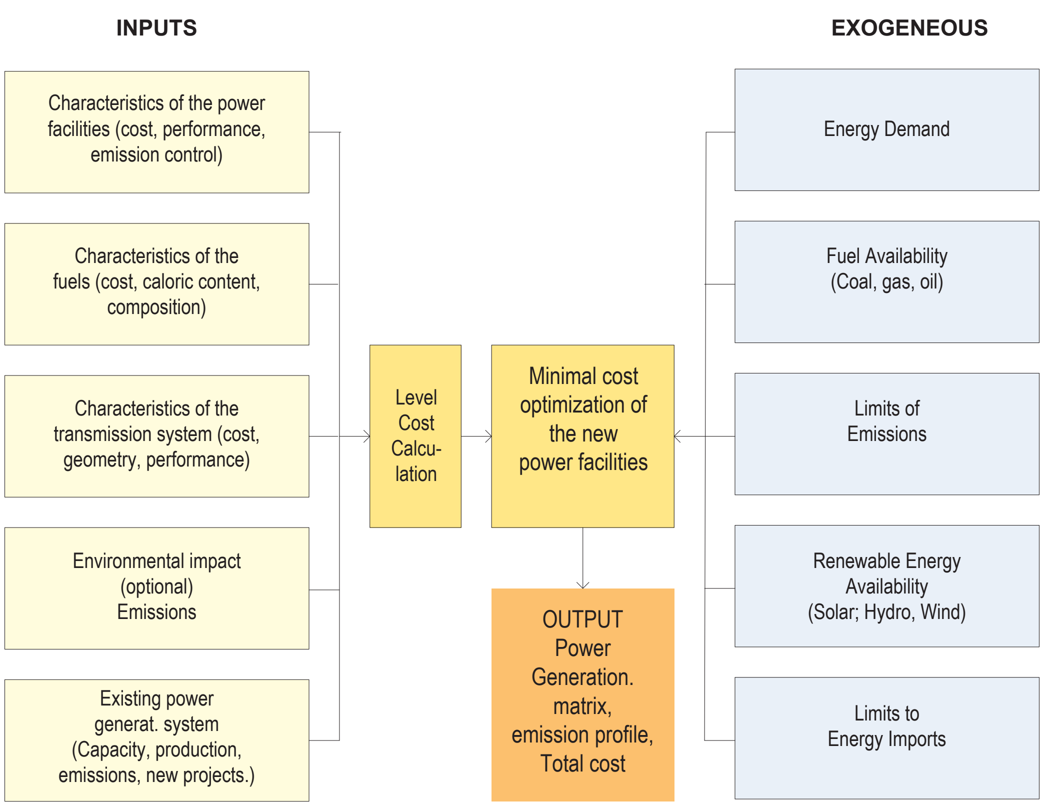


Source: Chandler, 1998.

Structure and input variables

Before offering this description, it is worthwhile to analyze the structure of the model of Figure VI.3. In this Figure it can be clearly observed that there exist data that must be provided as input for the model and others that are incorporated in an exogenous manner. This information feeds the model in order to obtain a levelized cost of energy (LCOE) and the optimization of the minimum cost of the new generation plants. The results obtained from the running of this model would be the Matrix for present and future electric energy generation, the profile of emissions (result of the use of the Matrix obtained) and the total cost (result of the minimization of the cost of the expansion).

Figure VI.3: Structure of the model



Source: Schaeffer and Szklo, (2001)and their consequent environmental burdens, over the period to the year 2020. It does so in the framework of two policy scenarios to test economic and environmental policy measures against a business as usual projection, which assumes energy policies existing in Brazil today remain in place and that no new major policies are adopted to reduce energy-related GHG emissions. It provides results from an analysis using a linear programming model that simulated scenarios through changes in emissions fees and caps, costs for technologies (including clean energy supplies.

As has been indicated, the model was developed in an Excel environment. The user must provide the model with the data necessary to simulate the system of electric energy generation. Within the data which are necessary to achieve this representation there are the evolution of electric energy demand, the profile for the present electric energy generation, the expansions foreseen, fuel reserves and the potentials for expansion of generation that are later described in detail.

- Base year: It is necessary to determine a base year with the objective of calibrating the model starting with that year. It is advisable to use the last year for which the greatest amount of information is available.
- Discount rate: It is necessary to define the discount rate in order to calculate the levelized cost of energy of each one of the technologies.
- Characteristics of the fuels used for the generation of electric energy: The characteristics of the fuels presently used for electric energy generation must be included, as well as those that will be forcibly included in the future Matrix. In this sense, it is necessary to have information related to the cost, calorific values and sulfur content (optional) and that of coal in order to obtain a final balance of emissions.
- Existing or planned capacity: In this page the characteristics of the present energy supply of the electric sector must be represented, in addition to any other action that may be implemented during the period of study. It is possible to include information by regions and for different periods. It is necessary to take into account the power and time of operation of each one of the technologies that have been considered.
- Technological profile: For each one of present technologies it is necessary to incorporate data relative to capital costs, period of construction, fixed and variable O&M costs, capacity factor, efficiency, life-cycle of the equipment and emissions (optional). With this information the total capital cost and the levelized cost of each technology are calculated.
- Environmental externalities: The incorporation of this information is optional. It is necessary to insert the value of environmental externalities for sulfur dioxide, carbon dioxide, nitrogen dioxide and particulate material. It is also possible to incorporate the value of the externalities caused by the installation of a hydroelectric plant.
- Transmission system: When the model is used as regional data it is necessary to include the value of distances among regions and transmission losses.
- Demand projections used in the model: These projections are included in an exogenous manner in the model. These may be obtained from Energy Planning entities in the countries or can be calculated using econometric tools. The values obtained must be incorporated in TWh.
- Potential of each technology for the supply expansion: This is one of the ways in which the model, being of minimum costs, restricts the maximum expansion potential for each technology. In this sense it is necessary to define the production of some renewable energies, such as hydro, solar and wind.

Scenarios, simulation and results of the model

Once all of the input values previously described have been entered, the model proceeds to automatically calculate the leveled cost of energy for each technology, the Matrix of the future energy supply of energy that refers to the criteria of minimum costs, the total cost of the system expansion and if the values of emissions have been provided, the model calculates total emissions of global and local contaminants.

To run different scenarios, the model permits the modification of the input values provided to test what would be the effect of a change in fixed or operation and maintenance costs of the supply expansion. It is also possible to model scenarios that establish a top limit to the emissions of CO_2 or some local contaminants.

The results of the model can be compared with energy policies to verify if these are addressing or providing incentives of minimum cost or if to the contrary, they are addressing other types of policies of an environmental approach.

The flexibility of this model, on an Excel platform permits an easy execution of the sensitivity analysis, it is enough to change the desired parameters and again run the model.

Recommendations relative to the use of EEPPS in Energy Planning in LAC

This model is recommended to test simple hypotheses, such as obligatory insertion of a new energy source or the decree that limits maximum emissions. However, it has disadvantages that correspond to the logic of linear programing to which it serves. This model will always elect the cheapest technology available until one of the restrictions limits it, in other words, in the absence of restrictions the source with the lowest levelized cost will be depleted, and in this sense, it does not tend for the diversification of the energy Matrix. It also presents deficiencies related to the impossibility of including the load curve. Another limitation is related to the assumptions of perfect competition and information reflected in it that does not take into account the preferences of certain agents such as investors. Investment restrictions can also be modeled as restrictions in the maximum capacity to be installed.

VI.3.6. LEAP (Long range energy alternatives planning system)

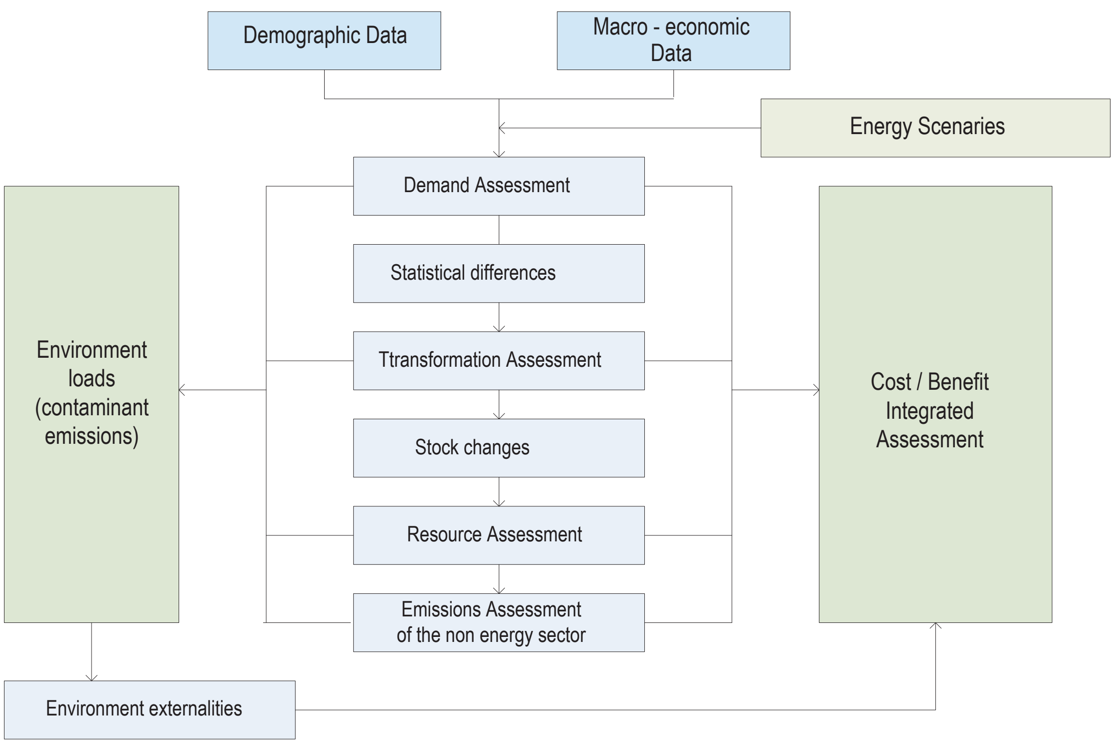
Long Range Energy Alternatives Planning System (LEAP) is a model deigned by the Stockholm Environment Institute (SEI-Boston) whose objective is to provide a comprehensive and reliable support for the development of energy planning studies, as well as of the mitigation of GHG. This model may be classified within the bottom-up type, based on the characterization of final users that refers to the type of energy and the technologies used by them, as well as the characterization of the energy supply. This is a demand-driven model, which means that when facing a final energy demand scenario, LEAP assigns energy flows among the different energy supply technologies that a country has available (Di Sbroiavacca, 2011).

The general logic of the LEAP model is clear since it has not included a feedback process among the supply and demand modules, which makes it easy to understand due to its transparency. In this sense, the model is quite flexible and it is directed to energy planning starting with the construction of scenarios set forth using the logic of "What if?"

Structure and input variables

The general structure of the LEAP model has six blocks: Analysis of energy demand~~,~~; analysis of energy supply~~,~~; analysis of statistical differences~~,~~; analysis of variations in stock~~,~~; analysis of resources and explanatory variables. The flow of calculations made by the model is represented in Figure VI.4.

Figure VI.4: Flow of calculations



Source: Di Sbroiavacca, 2011.

In the analysis of the demand block a scheme is presented of hierarchical levels that is sufficiently flexible to simulate a wide range of sectors of final energy consumption. The analyst has the possibility of disaggregating it as much as possible, and for the residential sector it could be disaggregated by: income levels, regions, use, source and technology. For other sectors such as the industrial, the type of economic activity could perform this primary disaggregation.

For the analysis of energy supply, the LEAP model has modules that permit the user to define different transformation centers. It must be highlighted that within these, those that represent the greatest disaggregation is that of the generation of electricity. This model also requires the inputs of the energy resources that exist in the country, as well as the proposal of a scenario that foresees their evolution and contemplates the possibility that these may be imported.

In relation to the environmental analysis that is susceptible of being carried out by LEAP, it must be stated that the result to be obtained is related to the impacts that would be generated by each one of the scenarios established in the emissions of greenhouse gasses (GHG). In this sense, LEAP has available a technologic and environmental database by default. Notwithstanding this, the analyst can modify it in accordance with the information available for each country.

The information required to feed this model may be divided in two, one of a historic type and the other of a prospective type. In very general terms, desirable historic information to be inserted into the model is:

- Energy balance of the base year: net and/or useful energy.
- Technical parameters: efficiency, specific energy consumption, heat rate.
- Energy intensities for final use processes and of energy transformation.
- Information on the uses of biomass.
- Costs per technology: This information is optional in view of the fact that the model is not governed by a principle of minimization of costs. It is desirable to have this information in order to calculate the final cost of the supply of energy.
- National Environmental Coefficients: If possible, LEAP should be fed with the environmental coefficients for the specific country. However, if this information is not available, LEAP has a database by default that may be used for the calculation of emissions.

On the other hand, in the prospective type information it would be desirable to have the following:

- Social-economic and energy scenarios.
- Information related to structural changes, such as the insertion of new technologies and substitution between energy sources.

Additional details may be obtained in the User’s Manual of LEAP, available on its webpage, according to Table VI.3.

Scenarios, simulation and results of the model

LEAP has a module for the management of scenarios that as its principal characteristic offers the possibility of identifying advantages and disadvantages of each one of the different measures of the proposed policies. In this sense, this model permits the impact evaluation of the application of policies such as the penetration of new sources of energy, structural changes in the different sectors, application of a new price policy, introduction of new sources of energy, renewables, among others. In addition it is necessary to take into account that according to the scenarios set forth, it is possible to determine if the resources are sufficient to satisfy the needs of the country.

The principal results obtained with this model are: prospective of the energy demand, prospective of the energy supply, impact on resources, impact on the environment~~al~~, projection of energy balances and evaluation of measures for the mitigation of GHG in the energy sector.

The LEAP model permits the execution of sensitive analysis with relative ease. The possibility of creating diverse scenarios, based on the structure of a base scenario, permits the modification of values in the technical and/or economic parameters upon which it is necessary to understand the implications of their variations. It is even possible to observe the effects in a graphic manner.

Recommendations for the use of LEAP in energy planning in LAC

This model is appropriate for the formulation and simulation of scenarios and the identification of the cost of each one of them. An advantage of the use of LEAP is that it is flexible and relatively simple to use, that permits the possibility of analyzing different policies proposed without the need of making the analysis more complex. In addition, this model presents another advantage related to the estimate in a direct manner of GHG emissions and reduction produced by the energy efficiency policies established.

LEAP permits the incorporation of restrictions of investment capacity or restrictions in the industrial chain that will provide certain specified equipment by establishing restrictions relative to the maximum capacity to be installed.

LEAP is a model that generates processes for the optimization of the electric sector, hardly from the last version. This possibility is still not available for the sectors of transport and refining. It must also be stated that this is a physically consistent, but not economic model, for which reason it is not possible to evaluate the impacts on economic variables such as GDP or unemployment, among others.

VI.3.7. MESSAGE

The *Model for Energy Supply Strategy Alternatives and their General Environmental Impact* (MESSAGE) was developed by the International Institute of Applied Systems Analysis (IIASA) in Austria since the decade of 1980 (IIASA, 2009; Borba et al., 2012). Depending on the approach and the matter of investigation, different versions of MESSAGE have been created with hundreds of users. This is a free access model for academic purposes, and an agreement between IIASA and IAEA (International Atomic Energy Agency) permits its use in IAEA and its member countries. This agreement has facilitated a number of training courses for energy experts in the member countries of the IAEA: usually taking approximately two weeks of training that permit the completion of basic applications.

MESSAGE is an engineering optimization tool used in medium and long-term planning of energy systems, analysis of policies for climate change, and the development of scenarios for national or global regions. This tool uses time frames of 5 to 10 years to simulate a maximum of 120 years (Connolly et al., 2010).

MESSAGE selects the means of energy production to satisfy the demand for useful energy (exogenous to the methodology, calculated by sectorial models) that minimizes operative and maintenance costs of the entire energy system for the studied time horizon (Messner and Strubergger, 1995; Rao and Riahi, 2010; Borba et al., 2012). In order to do this, the model analyzes the possibilities of substitution between the sources of energy in different transformation centers through the level of consumption and transmission of final energy, under restrictions on the available potential (reserves and capacity for generation and transmission of electricity) and the levels of environmental impact (limits of atmospheric emissions). Investment restrictions can be modeled, as well as restrictions on maximum capacity to be installed by technology, as a result of the complementary analysis of the national productive chain or access to sources of financing.

This time horizon is divided into sub-periods of similar size, and the optimization is performed on these sub-periods, simultaneously, corresponding to the variables of the model. The model considers a number of primary sources (petroleum, coal, natural gas, uranium, water resources, solar, geothermal and others) as well as different sources to be able to produce the required energy service (electricity, liquid and gaseous fuels and heat) (Borba et al., 2012).

The energy demand may be originally divided and in the case of electricity, it is represented in terms of a curve of the load profile. Each source of primary energy may be divided into a number of optional classes, taking into consideration the price of extraction, the quality of the source of energy and the location of deposits. This stratification permits the representation of non-linear relations between the extraction costs and the quantity of available resources. Later, these primary resources are transformed, direct or indirectly, to secondary resources that satisfy the demand (Messner and Strubergger, 1995; Rao and Riahi, 2010; Borba et al., 2012).

Structure, input variables and results of the model

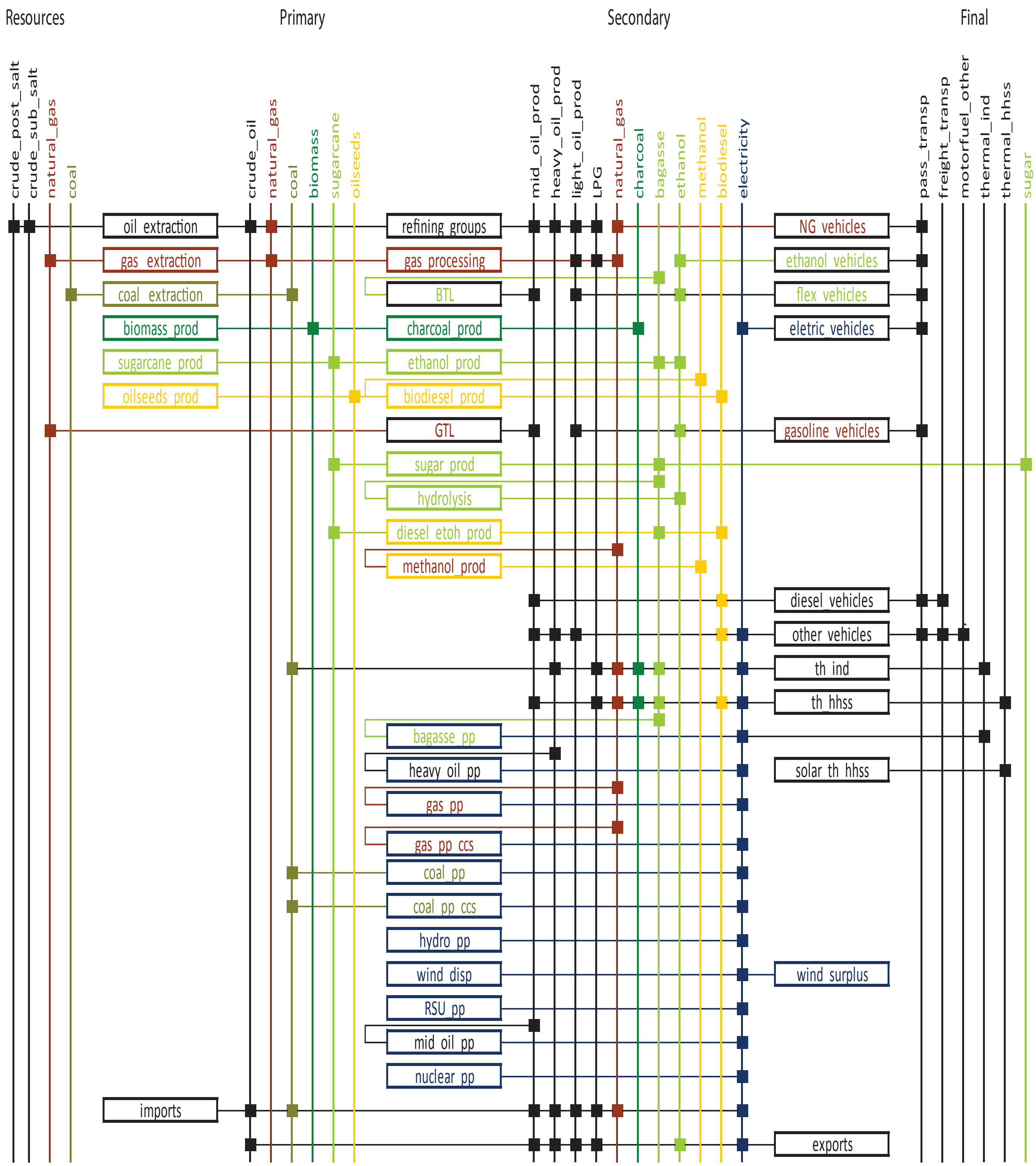
MESSAGE is designed to formulate and evaluate strategies for energy supply in accordance with the restrictions defined by the user for new investments, rates of penetration in the market for new technologies, availability of fuel and marketing, and environmental emissions. The underlying principle of the model is the optimization of an objective ~~a~~ function (example: minimum cost, minimum environmental impact, maximum self-sufficiency) under a series of restrictions (maximum capacity to be installed by technology, and where it is possible to consider other restrictions such as the capacity of financing or the size of the local productive chain) (Szklo, 2013).

The essence of MESSAGE is the technical-economic description of the energy system that has been modeled. This includes the definition of the categories of forms of energy considered (example: primary energy, final energy, useful energy), fuels (commodities) and the technologies used (example: electricity, gasoline, ethanol, coal, heat and urban heating), as well as energy services (example: the useful heat provided by type of energy/technology) (IAEA, 2013).

Technologies are defined by their inflows and outflows (principal and co-products), their efficiency and variability. Economic characteristics include the investment costs, fixed and variable operation and maintenance costs, costs of imported and domestic fuels and the estimate of leveled costs and shadow prices.

Fuels and technologies are combined to build energy chains, where the energy flows from supply to demand. The model takes into account existing facilities, their age and withdrawal at the end of their useful life. In Figure VI.5 we can observe a simplified example of energy chains that are depicted in the tenth version of MESSAGE Brazil (Schaeffer et al., 2013).

Figure VI.5: Simplified Flow Diagram of energy chains in MESSAGE Brazil



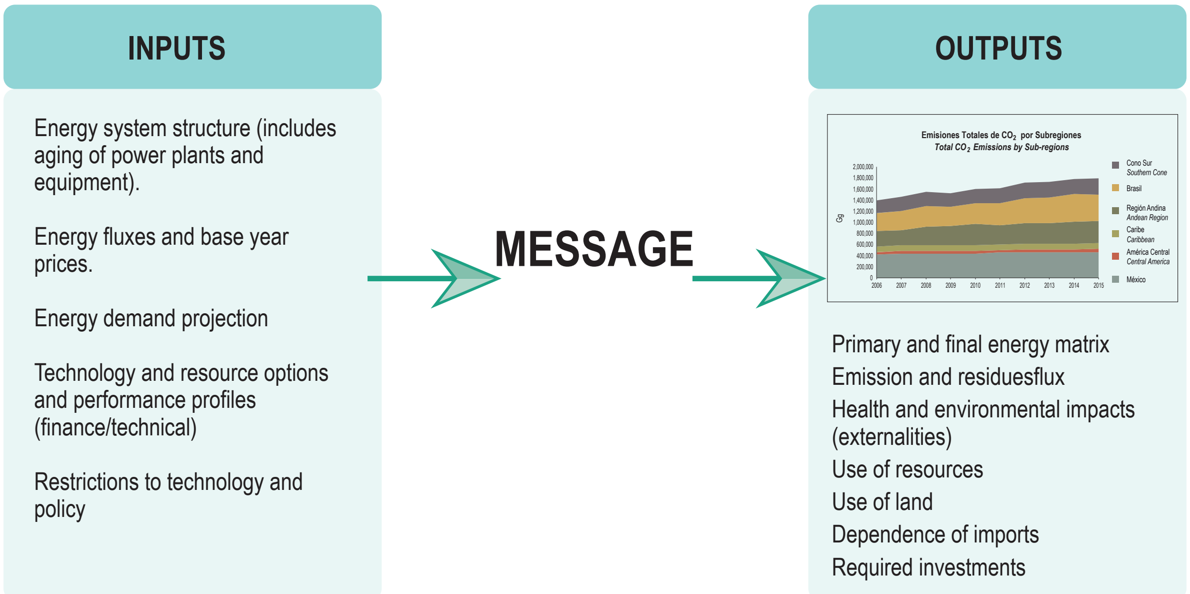
Notes: NG – Natural gas; Prod – Production; BTL – Biomass to Liquids; GTL – Gas to Liquids; UTE – Thermoelectric power plant; UHE – Hydroelectric power plant; RSU – Urban solid waste; Derv – Derivatives.

Source: Nogueira et al., 2013

Investment requirements may be distributed over the construction time of a plant and can be divided into different categories to reflect with greater precision the requirements of the industrial and commercial sectors. The requirements of base materials and non-energy inputs during the time of construction and operation of a plant can also be accounted for by tracing their flows in the originating industries, either in monetary terms of physical units.

To assure certain availability for some fuels within a determined period of time implies considerable costs and management efforts. The plant must provide electricity at the exact time in which it is demanded and these types of situations are simulated by MESSAGE. In relation to environmental aspects, this model additionally permits a follow-up, to limit the contaminants emitted by the different technologies in each section of the energy chain. This contributes to evaluate the impact of environmental regulations on the energy development of systems. Entries and exits of MESSAGE are represented in Figure VI.6.

Figure VI.6: Principal inputs and outputs of MESSAGE



Source: Designed on the basis of IAEA (2013).

MESSAGE uses the projections of useful or final energy demand of a sectorial model to generate supply to the system. The most powerful characteristic of MESSAGE is that it provides the opportunity of defining restrictions for all types of technology. Among other option, the user may limit a technology in relation to other technologies (example: a limit of participation of wind energy that may be managed in an electric network), establish exogenous limits over technologies (example: a limit on accumulated emissions of SO_2 or greenhouse gasses), or to define additional restrictions between production, investment capacity and installed capacity (example: assure take-or-pay clauses in international gas contracts, forcing consumers to pay for a minimal participation of the level contracted during summer months). The model is extremely flexible and may also be used to analyze electricity and energy markets, as well as matters related to climate change.

The MESSAGE tool permits executing a sensibility analysis under different forms. The most usual way is to modify in the file of the reference case ".adb" the values of the parameters upon which the analysis is to be done and to create a copy with a different name. Another way, is creating new study cases ".ldbs", also based on the reference case ".adb". Additional details regarding these operations will be found in the User's Guide of MESSAGE IIAEA (2007).

Recommendations for the use of MESSAGE in Energy Planning in LAC

Since MESSAGE is a model that generates processes for optimization and equilibrium in markets, this model is recommended to determine, under a minimum cost optic, the paths for supplying a projected demand of energy. Therefore, the MESSAGE model may be used in LAC to carry out more sophisticated energy integration analysis and to identify regional opportunities for the mitigation of GHG. Restrictions in investment capacity can be modeled also using restrictions of the maximum capacity to be installed, which in turn can reflect limits in the productive chain or the import of a determined technology (policies of a local content).

VI.3.8. ENPEP (Energy and Power Evaluation Program)

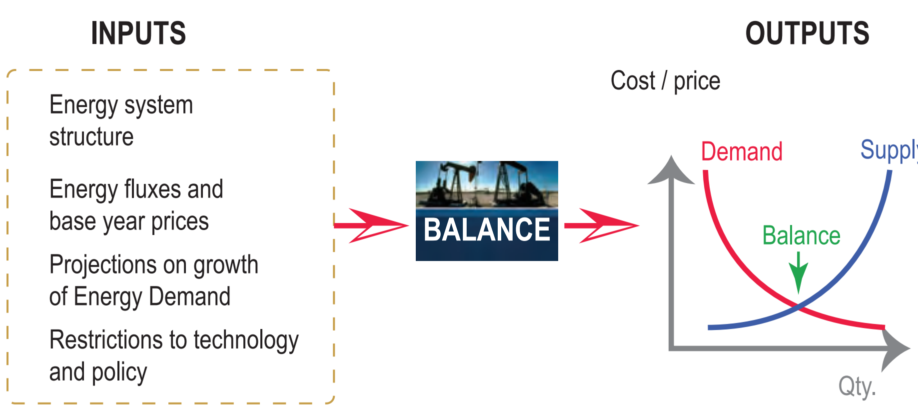
The *Energy and Power Evaluation Program* (ENPEP-BALANCE) may be classified as a simulation model based on the market focused on non-lineal equilibrium (top-down), the purpose of which is to determine the response of various segments of the energy system to changes of energy prices and the levels of demand. The model depends on a process of decentralized decision-making in the energy sector and may be calibrated under different preferences of energy consumers and providers.

ENPEP-BALANCE was developed by CEEESA with the support of the Department of Energy of the United States (DOE). ENPEP-BALANCE permits users to evaluate the entire energy system (supply and demand) and the environmental implications of different energy strategies.

Structure, input variables and results of the model

Basic input parameters include information of the structure of the energy system; energy statistics of the base year, of levels of consumption and production, as well as prices; growth of the energy demand; in addition to some technical and policy restrictions (Figure VI.).

Figure VI.7: Principal inputs and outputs of ENPEP-BALANCE



Source: Designed on the basis of ANL (2013).

In this process, an energy network is designed to trace the flow of energy from primary sources to the demand for useful energy. The ENPEP-BALANCE network is constructed using different nodes and links that represent various components of the energy system. The nodes in the network represent renewable and exhaustible resources, several conversion processes, refineries, thermal and hydroelectric plants, units for cogeneration, rates and subsidies and energy demands. ENPEP-BALANCE is very versatile in view of the fact that the analyst begins with an empty work space and constructs a duly configured energy system with nodes and links.

The powerful graphic interphase of ENPEP-BALANCE makes it easy to carry out actions such as “drag and drop” to construct regional, national or multinational scope networks. There are also displayable menus to directly show data of the model and its results on the energy network. By making a double click on the nodes it is possible to have access to more detailed input and output information.

The model uses an algorithm of *market share* to estimate the penetration of different supply alternatives. The user defines restrictions as limits to capacity (where it is possible to consider criteria of maximum investment capacity or the capacity of the industrial chain), governmental policies (rates, subsidies, priority resources for national products with imported resources, etc.), consumer preferences, and the ability of the market to respond to price signals in time.

The use of the algorithm of *market share* distinguishes the equilibrium focus from other modeling techniques. The focus of ENPEP-BALANCE simulates with greater precision the behavior of more complex markets that involve multiple decisions that optimization techniques cannot capture because these assume the making of decisions. Each sector (electric, industrial, residential, etc.) follows different objectives and may have different considerations as to what is the optimum. Equilibrium solutions are developed with a configuration of the energy system that balances the problem of demand, objectives and market forces without optimizing them in all of the sectors of the economy.

ENPEP-BALANCE simultaneously finds the intersection of supply and demand curves of all the forms of supply of energy and of all the uses of energy including the energy network. Equilibrium is reached when the model finds a set of prices that brings the market to balance and the quantities that satisfy all of the equations and inequalities set forth. The model uses the iterative technique of Jacobi in order to find a solution that falls within the tolerance defined by the user.

Simultaneously with energy calculations, the model calculates the environmental residues associated to the provided energy in the configuration of the system, in addition to the greenhouse effect gasses and conventional atmospheric contaminants such as particles, SO_x, NO_x, CO, CO_2, methane, volatile organic compounds, lead, etc. These calculations may be extended to the generation of residues, water and land contamination and the use of emissions of greenhouse gasses may be reported in a format that is compatible with the Inter-Governmental Panel on Climate Change.

The User's Manual of ENPEP-BALANCES provides further details of what has been previously highlighted, as well as the methodologies to carry out a sensibility analysis on the parameters that characterize demand (IAEA, 1995).

Recommendations for the use of ENPEP in Energy Planning in LAC

ENPEP-BALANCE is recommendable for LAC countries to cover the complete spectrum of issues to be found in present complex energy markets, such as: a) analysis of energy policy; b) projections for the energy market; c) forecast of electricity and energy demand; d) analysis of options for development of the electric sector; e) analysis of production costs, marginal costs and prices of electric energy in "spot" markets; g) analysis of natural gas markets; h) projections of carbon emissions; i) studies for the mitigation of GHG, among others.

VI.3.9. SUPER-OLADE (Unified System for Regional Electric Planning)

The *Model of the Unified System for Regional Electric Planning* (SUPER, in Spanish) is a product developed by OLADE with the financial support of the InterAmerican Development Bank, the first version of which was concluded in 1993. This model is used for the evaluation of the expansion of electricity generation and transmission of an interconnected system on a medium and long-term basis, optimizing the economic cost and minimizing energy risk (OLADE, 2013).

One of the characteristics of this model is that it includes stochastic models of flows that are used in calculating the optimum operative policy by means of dual stochastic dynamic programming. It also analyzes other conditions of uncertainty such as the growth of demand, the fuel cost and the period for the project construction.

The methodology for solution is based on the decomposition of the problem into a sub-problem of investment where the selected candidate plans are defined, and another of operation, where the operative costs associated with these selected plans are evaluated.

The feedback of the operative and investment sub-problems is performed by means of a linear restriction, the Benders decomposition. Coefficients of this restriction are the marginal costs associated to the technology that supports the candidate plan.

This model permits establishing and analyzing different options for expansion of the generation and transmission of the electric system, on a medium and long-term basis, calculating total investment and operation costs, operative costs of thermal plants, marginal costs of operation, financial costs of the availability of capital, energy balances at annual and monthly levels, marginal benefits from thermal generation, energy exchanges between interconnected systems, among others. Additionally it provides criteria for making decisions, both in the scope of the development of projects as that of the formulation of reference and normative policies (OLADE, 2013).

Structure, input variables and results of the model

The SUPER-OLADE model is composed by the following modules, each one of which performs specific tasks in the process to obtain an expansion:

- CONTROL MODULE: Classifies input and output information in studies and cases, assuring an orderly storage of data and results in the hard-disc of the computer; and in addition it permits access to the other modules of the model.
- DEMAND MODULE (MODDEM): Based on the historic data of hourly loads and annual projections of power and energy, it models demand curves for the period under study, pre-dispatches of non-optimized resources and simulates the effect of programs for the conservation of energy and the management of load (CEAC); and carries out the economic analysis of these programs.
- HYDROLOGIC MODULE (MODHID): Determines on the basis of historic information the average monthly flows or parameters of the operation of reservoirs, feasible scenarios of hydrologic availability for the different basins where they already exist or projects the use of hydroelectric facilities.

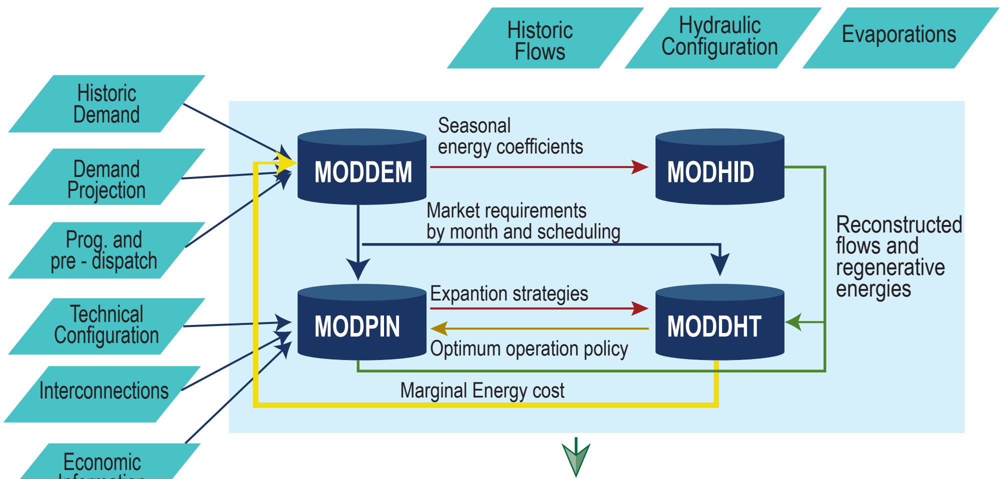
- MODULE FOR PLANNING UNDER UNCERTAINTY (MODPIN): This finds the investment strategies of less risk, under conditions of uncertainty in variables such as demand, hydrology, fuel costs and periods of project construction; it has the capacity to analyze several interconnected hydrothermal systems.

- HYDRO-THERMAL MODULE (MODDHT): Determines the optimum operation of interconnected hydro-thermal systems; finds the marginal costs of generation, the volume of used fuels, the flow of energy in interconnections and constructs annual and monthly balances of generated energy.

Additionally, this model has a Financial Module-MODFIN, for the financial management of the company that is integrated with expansion plans, as well as the Environmental Module-MODAMB, for the evaluation of environmental impacts and the minimization of such impacts on biotic, physical and population systems, etc.

Figure VI.8 illustrates the interaction between modules for the preparation of expansion plans.

Figure VI.8: Information Flow in the SUPER-OLADE model to prepare an optimum plan for expansion



Source: OLADE (2014).

In addition, the SUPER OLADE model permits performing the sensibility analysis, taking into consideration the parameters of uncertainty such as hydrologic risk, growth and hourly characteristics of demand, fuel costs, time for project construction, sets limits to fuel supply , among others. Additional details can be found in the User's Guide of SUPER OLADE.

Recommendations for the use of SUPER-OLADE in Energy Planning in LAC

This model is appropriate for planning at minimum cost and for the evaluation of energy policies for the expansion of the national electric system at generation and transmission levels. This model is highly recommended for hydrothermal systems that have a relevant participation with of hydroelectric power stations in energy production, due to the fact that its hydrologic modules allow the performance of stochastic simulation of hydrology. Additionally it carries out the dispatch of energy optimized at a monthly level, and therefore presents an advantage for medium-term planning. The environmental module also permits carrying out evaluations of environmental and social impacts of the generation projects, this being relevant for hydroelectric projects in view of local environmental impacts and populations that are displaced and for thermal power stations, in terms of emissions.

Restrictions in investment capacity can also be considered in the model through restrictions of the maximum capacity to be installed. A similar treatment can be established to model restrictions of the technologic offer or productive chain of some technology.

VI.3.10 SAME-OLADE (Energy Matrix Simulation and Assessment)

SAME is a bottom-up simulation model of technical coefficients which allows to construct different prospective scenarios of energy supply and demand for a given time horizon.

It is very versatile in its projection method. It can nimbly generate trend, evolutionary and break-off scenarios allowing to simulate politics on diversification of final energy consumption and electricity generation matrixes, measures to reduce greenhouse gas emissions and programs on energy efficiency.

Provides as comparative parameter between the implemented scenarios various energetic, economic and environmental indicators which are as follows:

- √ Renovability index of energy supply
- √ Index of energetic self-sufficency
- √ Average emission factor of GHG
- √ Average present cost of energy supply
- √ Structure of energy consumption
- √ Structure of total energy supply
- √ Structure of electricity generation matrix
- √ Prospective energy balances
- √ Outlook of GHG emissions
- √ Outlook of installed electricity generation capacity and other energy supply infrastructure
- √ Extent of the proven fossil energy resources
- √ Exploitation level of renewable energy potentials

Structure, input variables and results of the model

The SAME model is functionally composed of 6 modules: Configuration, Data, Outlook, Simulation, Reports and Graphs.

In the Configuration module is established the energy matrix structure, the actual as well as the projected one, defining the relationship between activities, resources, technologies and uses of energy, which are already occurring or which could occur in the future. It allows to define also the baseline year of the study, the project horizon and the hierarchic structure between the prospective energy scenarios. In this module are established some attributes of the energy flows as factors of GHG emissions and relative efficiencies in the final consumption.

In case that the energy demand projections are meant to be realized by analytical or econometric methods this module allows to define the exogenous variables involved and the mathematical expressions, which link them with energy consumption.

In the Data module it is possible to introduce data of the baseline year of the study and to visualize and edit the projected data once the outlook is done. The required input information is as follows:

- √ Energy balance flows
- √ Installed capacity of energy supply
- √ Unit costs of energy supply (variable, fixed and investment)
- √ Proven fossil energy reserves
- √ Renewable energy potentials
- √ Data of exogenous variables

The Outlook module supplys different projection alternatives of energy demand and supply, expansion of the energy supply infrastructure, unit costs of energy supply, demand of electric power and exogenous variables.

To project energy demand the following options are available:

- √ Average annual growing rates
- √ Time functions

- √ Correlation with exogenous variables
- √ Structural coefficients on useful energy

Energy supply is designed according to the technical coefficients of the supply structure obtained from the energy balance of the baseline year or determined directly by the user.

The installed energy supply capacities can be projected by two methods: a) automatically according to the energy demand (previously projected), the plant factors of each technology and a reserve margin defined by the user; and b) introducing an installation/withdrawal schedule for the energy supply infrastructure. Other variables, such as unit costs, electric power and exogenous variables are projected based on average annual growing rates.

Once the projections are realized, the Simulation module permits to realize specific changes in one or various years of the study's time horizon, which reflect the entering into effect of a particular energy development policy like for example: energy resource substitution in a specific final consumption, technologic innovation which leads to an increase of energy efficiency of a particular final consumption, input of new energy resources to the sectorial consumption, substitution of polluting by clean technologies in electricity generation, substitution of importation by local production, increase of local production to export energy, etc.

These changes can be done by a virtual control board, which shows instantaneously the effects of these means inside the equilibrium of the energy balance and some of the indicators of the total energy matrix. Then, these means can be spread automatically in the future horizon of the respective simulated scenario.

SAME allows to generate EXCEL reports on the main outcomes of the realized projections and simulations, such as:

- √ Reports on the energy balance for each year of the period of study
- √ Reports on GHG emissions for each year of the period of study
- √ Reports on installed capacities
- √ Reports on energy supply costs

Besides, it allows to get graphic reports on the main outcomes of the projections and simulations, of which have to be mentioned:

- √ Annual energy balance
- √ Time series of energy flows of the balance
- √ Time series of GHG emissions
- √ Time series of energy supply costs
- √ Percentage structure of final consumption
- √ Percentage structure of total energy supply
- √ Percentage structure of electricity generation
- √ Reach of the fossil energy reserves
- √ Exploitation levels of the renewable energy potentials
- √ Installed capacities vs. needed capacities
- √ Installed capacities of electricity generation vs. electric power demand

Advantages of the use of SAME-OLADE model for energy planning in LAC:

- √ Ideal for designing and tuning of sustainable energy development policies
- √ Allows to update energy prospective studies in light of the change of premises or exogenic and endogenous situations

- √ Build up explorative energy scenarios of consistent futures of the energy sector
- √ Build up road map type or advance scenarios
- √ Elaborate national energy development plans, integral as well as sectorial

VI.4. Examples of the applications of models in Energy Planning

VI.4.1. RETSCcreen

The RETScreen model was used to analyze policies of incentives for distributed electricity generation in Ecuador. The authors used as an input, the data of the III National Agricultural and Livestock Census to characterize five types of agricultural and livestock productive units (UPAs, in Spanish) according to the size (hectares). For each of them was determined the type and number of animals. RETScreen was used, in the first instances, to calculate the volume of biogas generated per year for each type of UPA. Later, the model was used to calculate the amount of electricity that could be generated each year, the levelized cost and the financial indicators of the project (IRR, NPV, and the payback period of investment). These results indicated that for the small UPAs the payback period is more than 10 years and their economic indicators (IRR, NPV) present results that are not very attractive. To the contrary, when the UPAs are of a medium or large size, indicators improve and the recovery time fluctuates between 6 to 7 years. On the basis of this analysis, guidelines were proposed for a national policy for biogas that would provide incentives: a) in small UPAs, the self-consumption of biogas for cooking and smaller thermal applications; b) in medium size UPAs, the operation of a centralized bio-digester of a large size, managed under a cooperative scheme, to which the organic residues of the associated UPAs would be delivered for the production of biogas, which in turn would be used to generate electricity for sale to the National Grid (SNI, in Spanish); c) in larger UPAs of greater proportions, the full load operation of a medium size bio-digester, whose biogas would serve as a fuel for a thermoelectric plant that would contribute electricity to the SNI.

VI.4.2. SAM

The System Advisor Model (SAM) was used to analyze policies for incentives for solar concentration technologies in Brazil. The authors simulated different configurations of CSP and PV plants in several regions of the country. Soria (2011) analyzed the viability of the implementation of plants using simple parabolic cylinders, with hybridization and with heat storage of 6 to 12 hours, located in the North East of Brazil. Two scenarios were tested: one baseline and an alternative that considered financial incentives. Results showed that in the short term technologies are not economically viable. Electricity thus generated still has a levelized cost of energy (LCOE) superior to the technologies used in the baseline (high participation of large hydroelectric plants complemented with conventional and nuclear thermoelectric plants). The alternative scenario showed that the financial incentives proposed would considerably diminish the LCOE, however, there would be the need of more aggressive policies, such as the implementation of auctions specifically directed to PV/CSP and/or for a specific region, with the objective of promoting their entry into the market with a lower cost for society.

VI.4.3. HOMER

With the objective of evaluating the economic potential of photovoltaic generation in the Amazon Region a study was carried out in four countries: Brazil, Bolivia, Colombia and Peru. The authors defined the economic potential as well as the optimal configuration of the system that would result in lower costs and a more favorable present value in comparison with the systems presently used (reciprocal diesel and fuel oil engines). For this purpose, the HOMER model was used, where simulations were made of conventional generation systems and of hybrid thermal-photovoltaic systems.

Initially, were collected the characteristics of the isolated generation units in the Amazon region country with the objective of classifying them by typical systems, that would represent the different ranges of capacity and the demand that they meet. Investment and operation costs provided by manufacturers and operators were used, and on the basis of real operating costs, the typical system was characterized.

The results of the simulation showed that some configurations of typical systems, specifically in those where diesel generators were of a smaller size, the hybrid systems presented lower costs at present value.

However, in view of small differences in costs, a sensibility analysis was performed in HOMER to evaluate the impacts of fuel prices on the configurations of photovoltaic systems (increasing or decreasing PV capacity in some cases). The results of the sensibility analysis showed, that in the majority of configurations, a small increase in fuel prices or a reduction of capital costs of the PV, represented a significant increase in the optimum capacity of photovoltaic.

Finally, the economic potential of PV in isolated systems of the Amazon region turned out to be 231 MW, and it was estimated as the sum of the optimum configurations of PV for each typical system for isolated generation. This sum was based on the quantity of generation units by ranges of capacity of the thermal power stations of the isolated systems in the Amazon region.

VI.4.4. WASP-IV

In Jamaica, investments for the expansion of generation capacity in the electric system must be carried out by means of development under the “Low Cost Expansion Plan for the year 2010” (LCEP-Low Cost Energy Plan) (OUR, 2010), which is under the responsibility of the regulatory agency OUR (Office of Utilities Regulation), and takes into consideration the strategic objectives of the National Energy Policy 2009-2030.

For the supply planning, the WASP model was used. The time horizon of the plan was of 20 years. The level of reliability required, is a LOLP (Loss of Load Probability) equivalent to two days per year (0.55%). The cost of the not served energy used was US$ 2,32/ kWh, the discount rate was 11,95%. The objective of the not served energy was expected to not exceed 1% in one calendar year, and a minimum margin of reserve was established at 25%. No environmental restrictions were placed for the undertaking of the LCEP.

The characteristics of the plants to be loaded into the model were defined on the basis of their historic performance in 2009. In Jamaica in 2009, approximately 95% of the production of electric energy was based on thermal plants using petroleum derivatives, with the remainder covered by small-scale hydroelectric and wind power plants.

Three strategies for expansion were considered for the development of LCEP: Case Natural gas, Case Natural gas/Coal, Case Business-as-usual. The difference between the three cases basically depended on the availability of LPG in 2013, and the availability of coal in 2016. The three strategies were simulated in WASP, and the optimum plan for each strategy resulted in costs of US$ 5.77 Billion, US$ 5.84 Billion, and US$ 8.17 Billion for the strategies of Natural gas, Natural gas/Coal, and Business-as-Usual respectively. Later the sensibility analysis was performed on the basis of optimistic and pessimistic demands, and different price scenarios.

The study concludes that the addition of a new core capacity is urgently required, but due to the restrictions of the time for construction, and the availability of fuels, there is little probability that such capacity can be commissioned before 2014. The most critical variable for the determination of the type of plant to be installed in the short and medium term, involves the availability of natural gas, in terms of price, quantity and time. The costs associated to not changing the strategy of the country, and continuing to depend on liquid fossil fuels, may be of approximately 0.5 MMUS$ per day.

VI.4.5. EEPPS

The EEPPS model was initially developed for the Chinese electric sector. In 2000, it was adapted to the Brazilian reality to analyze options for the generation of electric energy at minimum costs. The study made for Brazil established three scenarios. The first scenario was that “of reference”, that assumed that governmental policies of Brazil related to privatization would continue in the generation sector, which would mean that the expansion of the system would be the result-of the use of plants with low capital costs. The second scenario, called “environmental scenario”, supposed that environmental restrictions would, to a large measure, determine the technologies to be used, as well as the environmental costs of the alternative energy sources would fall with the passing of time as an effect of the technological progress and governmental incentives. Finally, the last scenario was called the “scenario of environmentally desirable technologies”, that assumed that Brazil would only install electric energy generation plants with a technology that would not have net CO_2 emissions.

The authors of the study identified some events of the simulation, institutional reforms that were under way at that time in the electric sector of Brazil show that they had a strong influence on how the demand for electricity was being satisfied as well as the emissions resulting from it. Emissions multiplied by more than five times in the base scenario. In this sense in the absence of alternative policies, future technologic alternatives for the generation of electric energy rapidly changed from hydroelectricity to natural gas combined cycle plants. Finally the study concludes that from the Brazilian case, as a minimum, there are several conflicts between the problems of local atmospheric pollution and the global climate change, if the country would decide to adopt commitments related to the emissions of greenhouse gasses (GHG).

For the case of Argentina, four scenarios were established, as follows: a) Reference scenario, that assumed a supply and demand of energy based on the trends of that time and on the availability of fuels; b) Emissions mitigation scenario, that provided an incentive for non-contaminating sources of energy such as hydro and wind; c) Scarcity of natural gas scenario, that made the assumption that the access to this source of energy of a low environmental impact was restricted; and d) Energy efficiency scenario, that tested the effect of Energy Efficiency policies on the demand side.

VI.4.6. LEAP

This model has been widely used in the world and in LAC. It will be described in a general manner in this section, with a similar application made by several countries of the Region by the Economic Commission for Latin America and the Caribbean (ECLAC). The principal objective of the studies was to prepare an exploratory energy prospective for Honduras, Chile, Colombia, Paraguay and Bolivia to analyze, under the hypothesis of an economic scenario and two energy scenarios, one of a trend and the other alternative, the consequences in terms of demand and supply of energy. Studies also incorporated the impacts of these scenarios on greenhouse gas emissions, as well as the requirements of different energy products and particularly those of biofuels.

The general structure of these studies is constituted by the characterization of the energy system in the base year, the description of energy scenarios and the projections of energy demand and supply, finally are presented the evolution of GHG emissions. The results of the studies did not have the purpose of presenting the consequences of a determined energy plan, but were directed to examining a series of hypotheses suggested by consultants. As well as their conclusions related to the total net consumption of energy, elasticity in energy consumption with respect to GDP, growth of the different sources of energy, a penetration set forth in the fuels scenario, greenhouse gasses, among others.

VI.4.7. MESSAGE

Several studies have used the MESSAGE tools for optimization, as well as to carry out the analysis of energy planning for medium and long-term projections relative to specific energy policies or to evaluate different impacts on energy systems. MESSAGE has been intensely used in Brazil since 2003 and adapted in different occasions to better represent the reality of Brazil. Among other applications, MESSAGE has been used to calculate the adaptation measures of the minimum cost under a series of possible impacts of climate change in the electric sector of Brazil. The methodology used has the advantage of finding optimum solutions that take into account the interactions between energy supply and demand. Results point out in the direction of an increase in installed capacity, principally based on natural gas, but also using sugar cane bagasse, wind energy and coal/nuclear power stations, to compensate the low reliability of hydroelectric production, among other impacts. It has been used to analyze the impacts of the promotion, through auctions, of centralized solar energy generation (generation by solar concentration - CSP, and photovoltaic panels-PV) in the electric system of Brazil.

Finally, in the Caribbean, MESSAGE has been previously used for the design of a sustainable energy plan for Cuba under the development of two scenarios for the period 2000-2025, that strive to answer the following questions: a) What is the full significance of all this for the energy future of Cuba? Which are the different options that could be undertaken? At what cost?

VI.4.8. ENPEP

Several countries and scientific studies have used the ENPEP-BALANCE model to carry out analysis for energy planning on medium and long-term basis or to evaluate different impacts on energy systems.

ENPEP-BALANCE was used for a study in the Slovak Republic for projects dealing with carbon credits that the country could potentially make available for sale, to analyze a project for joint implementation that included the repowering of an industrial heat plant with a new unit of combined cycle of cogeneration with natural gas in Slovakia. A team of Mexican experts applied ENPEP-BALANCE to develop several energy projections and to evaluate the different options for the emissions mitigation of carbon gasses. The Jamaica Public Service Company (JPSCo) used ENPEP-WASP to develop a minimum cost expansion plan for its system. The Ministry of Energy of Colombia used ENPEP-Balance for its projections on the annual market of gas and electricity (ANL, 2008).

VI.4.9. SUPER-OLADE

This model is used in different ministries and agencies in charge of the regulation of the energy sector in Latin America (OLADE, 2013). The National Commission for Electric Energy of Guatemala used SUPER-OLADE in its version 5.1 for the preparation of the Indicative Plan for Expansion of the Generation System 2008-2022 (CNEE, 2009). This plan had as its objective complying with the guidelines, actions and strategies established in the Energy Policy approved by the Ministry of Energy and Mines of Guatemala, granting priority to the guarantee of supplying electric energy by means of the optimum utilization of renewable resources, including environmental considerations.

This Plan made an estimate of what would be the optimum expansion of the system, considering restrictions or conditions such as investment costs, costs of operation, costs of fuels, minimum and maximum entry into operation of the different electric power stations. The models used to carry out the Plan were the SUPER-OLADE model for the Determination of the Optimum Plan for the expansion of generation, and the SDDP, for the simulation of the long-term dispatch operation for units and generating plants that were the result of the entry schedule that was the product of the optimization with the SUPER-OLADE model.

The data base survey was carried out with the SUPER-OLADE model, within which were included: demand, technical-economic parameters, projections of fuel prices, the hydrologic history and the preliminary parameters for design of the candidate projects; also incorporating criteria for the evaluation of the energy policy issued by the Ministry of Energy and Mines of Guatemala.

Considering the uncertainty presented by the times required for construction and entry into operation of hydroelectric projects, was taken into account in the SUPER-OLADE model the possibility of delays of entry into operation.

Finally, the emission of CO_2 that would be produced upon implementing the plan were also considered and these were compared with the baseline of emissions that was represented by maintaining the present energy Matrix.

The conclusion was that with the implementation of this Indicative Plan for Expansion, it would be possible to cease importing approximately 114 million barrels of bunker fuel that would substantially reduce the cost of production of electric energy in Guatemala (CNEE, 2009).

The SUPER-OLADE model has been used by the Council for Electrification of Central America (CEAC, in Spanish) to prepare studies for the expansion of the Central American Electric System analyzing the effects of an interconnection with the SIEPAC.

Other institutions of the energy sector of Latin American and the Caribbean have made use of this model to prepare their indicative and regulatory plans for expansion, such as: the Ministry of Energy and Mines of Peru, the National Commission on Energy of the Dominican Republic, the Council for Electricity of Ecuador – (CONELEC, in Spanish) among others.

VI.4.10. Summary of the applications of models in the different countries of LAC

The methodology for the preparation of this Chapter also considers the application of surveys to experts on energy planning that belong to the different countries of LAC. Results relative to the models used in the sample countries are presented in Table VI 4. In some countries, the teams in charge of energy planning affirm knowing a great variety of models, but recognize that few of these are really used for official energy planning (in Paraguay, Dominican Republic and Nicaragua). Based on the interviews carried out, it is difficult to affirm which is the model that is more frequently used for energy planning, especially when specific components of different models are simultaneously used to provide input data to more complete and complex models.

In the countries surveyed it was possible to determine that the capacities to be able to operate the mentioned models are the fruit of "self-learning" (in all countries), and also of cooperation projects and specific contracts for training between the countries and OLADE, the Economic Commission for Latin America and the Caribbean (ECLAC), the International Organization of Atomic Energy (IOAE), the International Atomic Energy Agency (IAEA), Universities and private companies (Fundación Bariloche, PSR, ENERINTER) and national organizations (CEPEL in Brazil, the National Commission for Atomic Energy in Argentina).

The model of greater dissemination in LAC is LEAP, in spite of the fact that there is not sufficient information to conclude that it is also the most used model by the organizations that are responsible for energy planning at national level. In the region there are several countries that formally use the models of the PSR Company (OPTGEN and SDDP) for planning the expansion and dispatch in the energy sector respectively (Guatemala, Panama, Ecuador, Peru and Colombia). The MESSAGE model is also known in the region and is one of the sectorial and optimization models most frequently used in Brazil and Argentina. Likewise, different countries of the region have been trained by OLADE in the use of the SUPER-OLADE model for the preparation of expansions plans of the electric sector, and to evaluate possible international interconnections. Finally, it is important to note that Brazil has developed great efforts to develop its own non-commercial models (DECOMP, NEWAVE, PLANEL) to carry out the tasks of expansion generation, transmission and dispatch in the electric segment, as well as models to simulate refineries, plants for natural gas and the transport of derivatives in the petroleum segment.

LAC countries present very different characteristics in relation to energy planning, so that it is not possible to generalize a recommendation for the sue of a determined model. However, countries that have small but specialized teams have expressed their interest in knowing and perfecting the use of the LEAP model (Ecuador, Panama and Peru). On the other hand, countries where energy planning is solidly institutionalized express interest in incorporating sectorial models for specific segments (Colombia is interested in the MoMo model for transport). In a similar manner, Brazil strives to develop models that can permit a better analysis of the penetration of generation technologies distributed in the electric Matrix and strategies to integrate the results of the different used models.

Table VI.4: Models applied in the countries of Latin America and the el Caribbean by experts in Energy Planning

Models/ Countries	Modelos usados para la Planificación Energética en:													
	Guatemala	Panama	Paraguay	Colombia	Dominican Rep.	Nicaragua	Brazil	Ecuador	Peru	Argentina	Mexico	Uruguay	Jamaica	Venezuela
OPTGEN	X	X		X		X	X	X						X
SDDP	X	X		X		X		X	X					X
LEAP			X	X	X	X	X	X	X	X	X	X	X	X
MAED			X			X	X							
MESSAGE			X		X	X	X			X				
FINPLAN			X											
WASP			X						X	X			X	
ENPEP				X							X	X	X	
MOPERD (MOPCSV3)					X									
DigSilent					X									
SUPER OLADE	X	X		X	X	X		X	X					X
DECOMP							X							
NEWAVE							X							
PLANEL							X							
Simuladores para GN				X			X							
PERSEO									X					
NETPLAN	X			X	X		X	X						
NEPLAN				X										
GEMME							X							
M-REF							X							
NEREUS							X							
NCP							X	X						

Source: Authors, based on surveys applied to experts in Energy Planning in some of the member countries of OLADE.

VI.5. Selection of models for Energy Planning

There is a wide range of different energy tools available, which has diversity in terms of the regions that they analyze, the technologies considered, and the objectives they comply with. Consequently, without going into detail, a general panorama of such tools can be understood through some of their applications.

Based on the objectives of energy planning, Figure VI. 9 and Figure VI.10 show the algorithm or the decision tree for the different organizations of energy planning in the countries of LAC that may select the model that is better adapted to their capacities and needs. Among the capacities that must be taken into consideration are the types of data that will feed the model, as well as the dexterities of the energy planning team to work with them.

Among the needs that must be evaluated are the following points:

- Which is the geographic scale for which energy planning is to be made? Options may be: global level, national level or at the local/regional level for a specific energy project.
- Which is the time scale for which energy planning is to be made? This may be articulated for short, medium or long term. As previously explained, classis micro economy states that structural changes in production factors are possible in the long term. In practice it is difficult to associate a number of years to each term. However, in function of the concept explained, the short term may be associated with a period in which the present structure of the energy sector does not change due to

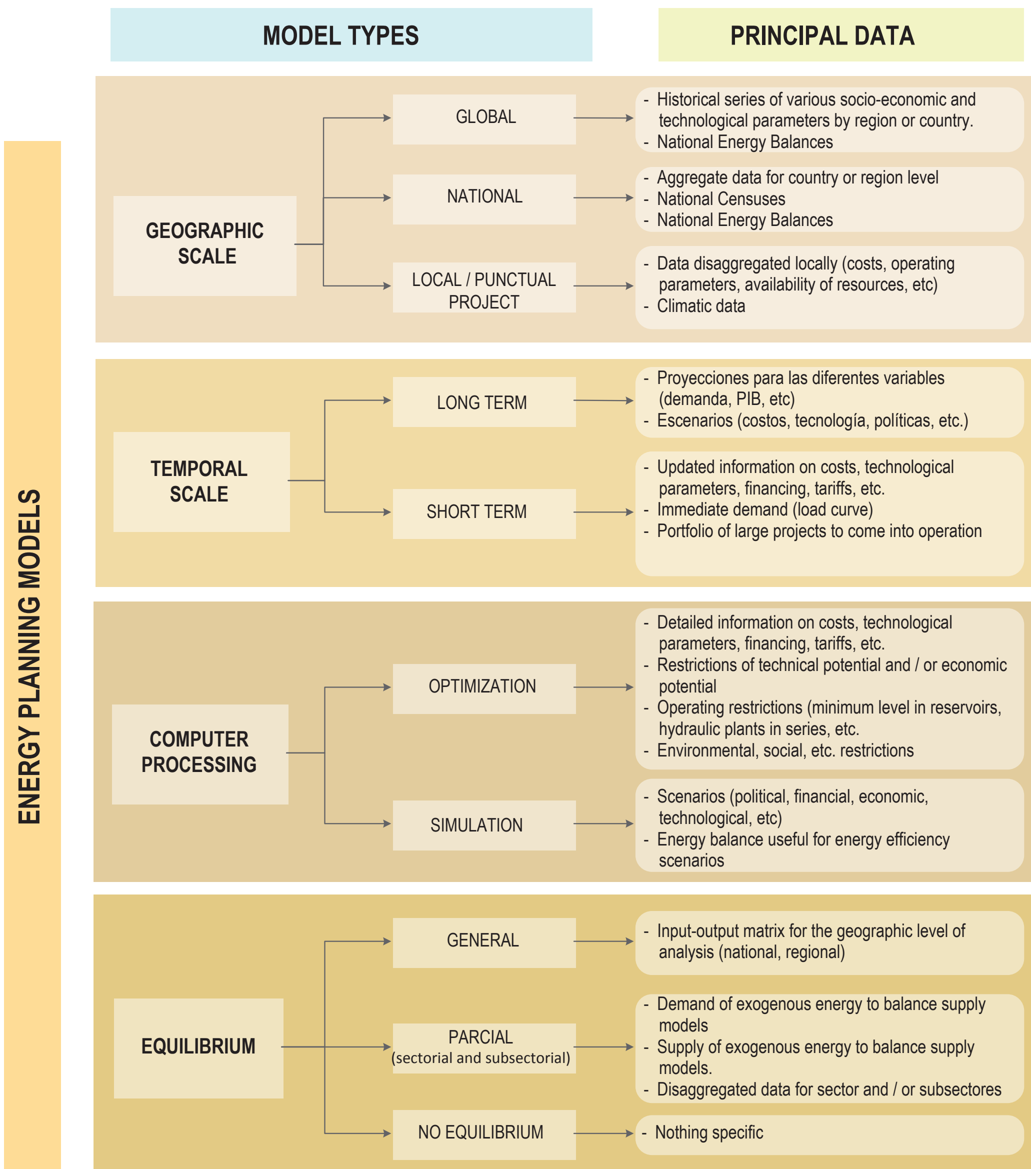
the existence of contacts that have been signed, auctions determined, works under construction, etc. Control measures, follow-up, re-powering and updating are possible in the medium term, with some degree of liberty. It is understood that a computation tool, that can permit long-term analysis, is also possible to execute an analysis for medium term periods.

- Which is the computational procedure that is most adequate for this energy planning? Basically, these tools may be of optimization or of simulation. An example of the use of models for optimization is that used for planning the expansion of generation systems subject to a minimum total cost. On the other hand, models for simulation are frequently used together with the technique of scenarios to carry out energy prospective.

- In function of what type of balance are we interested in carrying out planning? Balance refers to the fact that all demand from different consumer sectors must be satisfied by the supply, additionally including an analysis of the internal supply with the possibility of imports and exports. In function of this concept, in energy planning reference is made to models of general balance, partial balance (sectorial or sub sectorial) or models "without balance", that barely simulate specific projects.

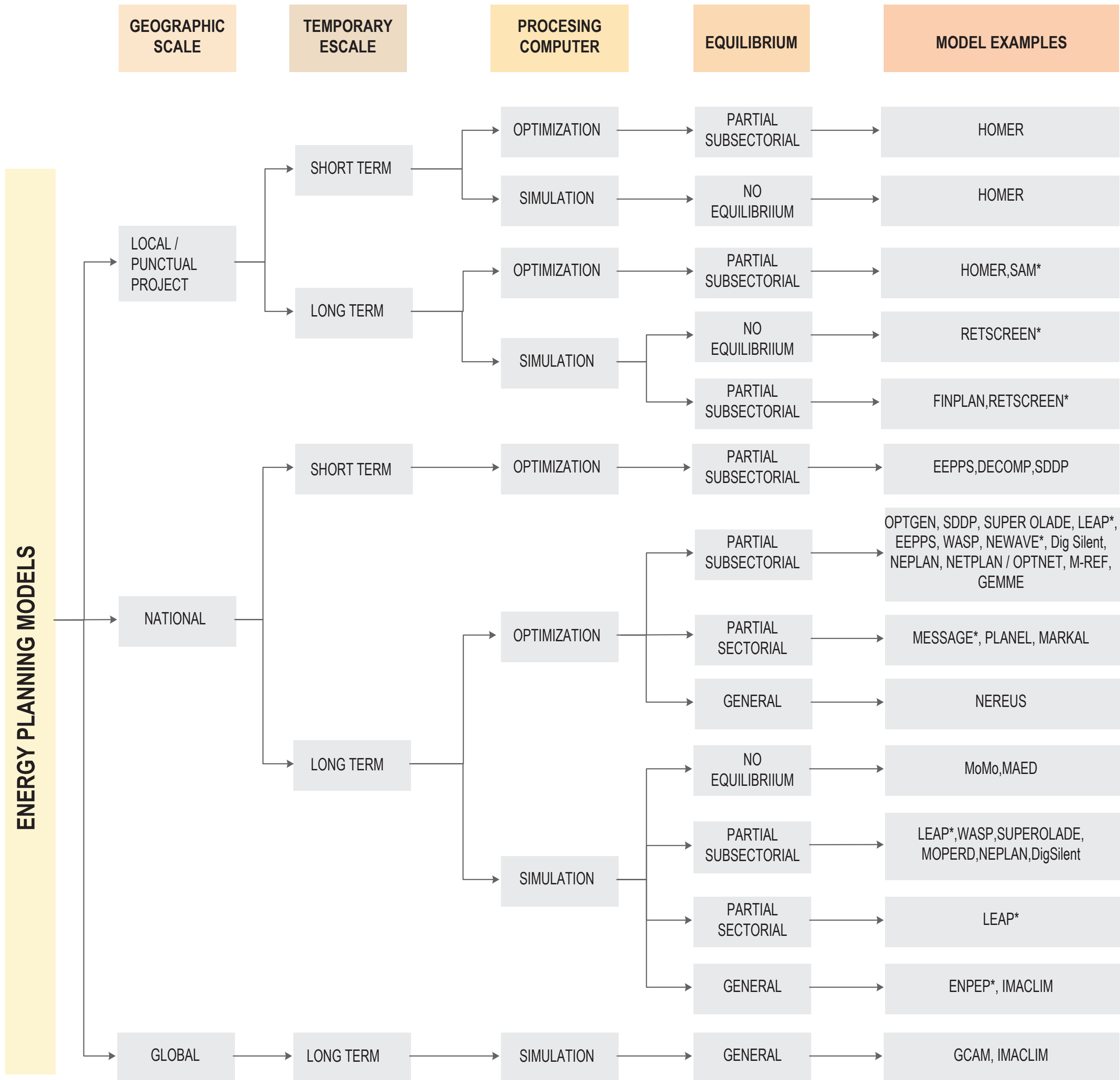
Depending on the type of pre-selected model according to a decision tree (Figure VII.10) it will be important to analyze if the data mentioned in Figure VI.9 are available.

Figure VI.9: Principal data for the different types of models for energy planning



Source: Authors.

Figure VI.10: Decision Tree for possible application to energy planning models in LAC countries



Source: Authors.

According to the logic of the decision tree presented in Figure VI.9, the description of some models may be done in the following manner:

RETSCREEN was classified as a model for the evaluation of specific projects at the local scale that permits the simulation of plants with different technologies and schemes of long-term operation (up to 50 years). When photovoltaic systems, with internal load and connection to the National Grid (SNI. In Spanish) are simulated, the model permits considering a load curve which when compared to internal production (of the home with photovoltaic systems) permits the identification of a deficit or surplus of energy, that determines it is consuming or not electricity from the SNI to satisfy demand.

On its part, SAM is a model used to evaluate specific projects at the local scale, testing different technologies at a relatively high detailing level of engineering, that simulates the operation of the plant throughout its useful life (long-term), and also permits the optimization of the operation and design of the components of the plant in function of achieving objectives such as minimum levelized costs of produced electricity, minimum consumption of water, maximum production of electricity, etc. In the case of photovoltaic systems in residential application with two-way meters, it is possible to introduce a load curve to analyze if residences with two-way meters must import or export from and to the SNI.

LEAP is a model that may be used for energy planning in a country, conceived for the long-term, using computational tools for optimization and partial balance that for the moment are barely applicable to the electric energy subsector, with the objective of undertaking an expansion of electric generation subject to the total minimum cost. Additionally, LEAP can also be used for long-term national energy planning, using computational tools for simulation that permit the evaluation of scenarios in the various subsectors of the energy sector.

MESSAGE is a model used for energy planning in a country or region (even at global level), for the long-term that uses computational tools for optimization, searching for the partial balance of supply in function of an exogenous demand. The model can be used at the disaggregate level of subsectors and even conversion technologies in accordance with the depth of the analysis, the availability of information, the training of the work team and time.

NEWAVE is a model designed in Brazil, officially used by the entity in charge of the dispatch of electric generation (ONS), that analyzes the medium term (up to 5 years, with a monthly spacing) the optimal dispatch of energy in hydrothermal systems in function of the immediate minimum cost (cost of operation of thermo electrics and hydroelectric) and future (cost of the energy deficit, cost of operation de thermoelectric due to a decrease in the hydroelectric generation).

Finally, ENPEP-BALANCE is a simulation model adapted to carry out medium and long-term analysis in a country, with a focus on general balance, the purpose of which is to determine the answer of various segments of the energy system face with changes in the prices of energy and the levels of demand.

CHAPTER VII

The Interdependence of Energy Planning and the Regulatory Framework

KEY WORDS

Regulatory Framework – Interdependence – Planning – Energy Integration

VII.1. Introduction

Energy planning, an essential tool for the application of energy policy, is instituted through government decisions on concrete actions needed to implement an energy model based on a country's needs, characteristics, interests, resources, and possibilities within a given subregional, regional and international context.

OLADE recognizes that, being an eminently sovereign exercise, energy planning can use tools of varying scopes and types, which is strongly influenced by the type of state and its priorities, principles and outlooks. However, most of OLADE's Member Countries, regardless of their type of state or system of governance, currently recognize the need to focus their energy planning on the promotion of sustainable energy development.

To ensure that efforts and aims are consistent with the opportunities that arise from enforcing the existing regulatory framework for the energy sector, this chapter of the OLADE Planning Manual seeks to provide doctrinal and analytical support for the importance of—and the need for—a comprehensive review of the existing regulatory framework for the energy sector before defining the energy planning instruments.

We explicitly acknowledge that it is highly sensitive to analyze an activity that is the exclusive domain of the Member Countries and their sovereign decisions. Therefore, the matters examined and described below are merely guidelines for discretionary application, references to be consulted and good practices that we hope will contribute to the energy planning of OLADE's Member Countries, specifically on the topic of this chapter—the relationship between energy planning and the regulatory framework.

Fully convinced of energy's impact on all aspects of national development, we acknowledge that there are no linear solutions, and that any energy planning instrument should respond to the specific situation of each country and subsector. Accordingly, this Planning Manual, prepared by OLADE and made available to its Member Countries, emphasizes the need for energy planning to reflect fully the specific situation of the country and, on that basis, to set long-, medium- and short-term horizons for its target activities in relation to the needs identified in each area.

In conclusion, we reiterate the importance of using these energy planning instruments in accordance with the needs and possibilities of each country to cover its citizen's energy demands at fair, competitive supply-side costs and affordable demand-side prices, in the interest of national economic development, while ensuring sustainable development, environmental preservation and emissions reduction by promoting the use of renewable sources and energy efficiency.

This being a manual of recommended procedures and good practices to facilitate energy planning among OLADE's Member Countries, this chapter will outline and describe the main factors that will strengthen the interdependence between energy planning and the regulatory framework for the energy sector.

VII.2. Doctrinal Review of the Interdependence of Energy Planning and the Regulatory Framework

Jurisprudence, as a social science and part of a paradigm defined by certain social, political, economic, and ideological scenarios, seeks to create a legal system for the functioning of society in accordance with the principles and provisions of a regulatory framework established by the prevailing public political power.

This explains the dynamism of jurisprudence and, consequently, its subjective, objective and formal expression. And although no law is an entire static entity, it is expected to remain relatively permanent over time to ensure what doctrine calls 'legal security and stability'.

Alluding only to its formal manifestation, the field of law could be defined as the legislative, regulatory and normative system of a given state or region, which regulates the relationships among people and between them and the State, based on principles and behaviors that are accepted as correct, appropriate and relevant under the prevailing model for the functioning of society.

The scopes and types of regulatory frameworks vary according to the forms, archetypes, needs, characteristics, and economic, political and social conditions of the type of state that enacts them. Therefore, they are strongly influenced by the will of both the government and the people, their interests, possibilities and perspectives.

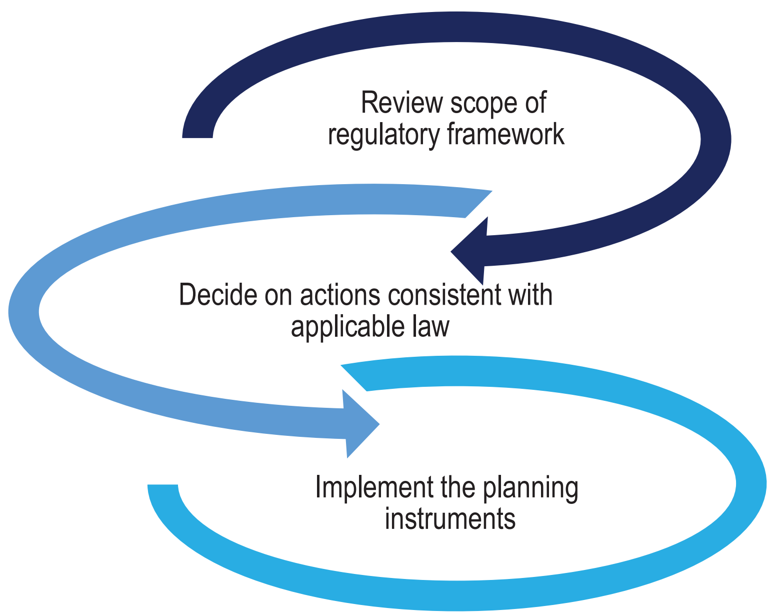
Ideally, regardless of the type of state or governance system, a regulatory framework will achieve the formal conditions for energy planning to be used as an energy policy instrument aimed at ensuring concrete actions to promote the present and future socioeconomic development of the nation. This it achieves through strategies that enable optimal energy use and universal access to energy products and services, thereby balancing energy supply and demand, and ensuring sustainable development, environmental protection and emissions reduction through the use of renewable sources and energy efficiency.

However, not all regulatory frameworks are fully consistent with the goals set through planning instruments such as strategic plans, action plans, generation expansion plans, transmission infrastructure plans, master plans for renewable resources, national energy plans, energy efficiency plans, oil and gas development plans, and others.

Therefore, before defining the energy planning instruments, it is essential to conduct a comprehensive review of the current legal framework for the energy sector, including a prospective study of potential scenarios for legislative, regulatory or normative development. Latin America and the Caribbean have seen concrete cases where energy policies or plans were entirely or partially inapplicable because they were not in accordance with the current legislation.

There is no doubt that a thorough, comprehensive review of the prevailing regulatory framework for the energy sector is vital to achieving consistency between the expectations and scope of national interests to be included in energy planning instruments.

Figure VII.1 Interdependence between Regulatory Framework and Energy Planning



Source: Author

VII.3. Legal Security and Stability

Legal security, as a fundamental principle of law, is based on the premise of the stability of a body of law over time. This makes it possible to study and predict the effects of enforcing a given regulatory framework over an extended period before decisions are made, in this case, by the actors involved in the energy chain.

Notwithstanding the advantages of the stability of a suitable regulatory framework, and no matter how advanced a given legal system may be, a society or state will always have groups that do not feel fully identified or satisfied with the effects of enforcing the applicable rules, and from time to time the need for change will arise, especially in such dynamic branches of law as the energy sector.

Ideally, these changes will tend towards greater equity and justice, but usually when the interests of only one group dominate, the prerogatives of others are harmed. Nevertheless, legal stability usually prevails, because when the conditions are right, a legal system undergoes major structural changes only on the medium and long term. This enables the intangibility of the basic principles of a given regulatory framework and, consequently, the predictability of the regulatory behavior of a state or sector—in this case the energy sector—over an extended period of time.

Aside from this human need to maintain legal stability for the good of society, reforming the law in most Latin American and Caribbean societies is cumbersome, being fraught with delays and difficulties.

It is clear, then, that given the formal and material conditions of law, planners should try to adapt their energy plans to the applicable law, and not vice versa.

One of the intrinsic characteristics of a law—besides being general, abstract and compulsory—is its relative stability over an extended period of time, during which a number of hypotheses apply and effects remain until, as a result of significant changes in the scenarios that originally led to its adoption, the conditions are ripe for it to be amended, replaced or repealed.

Legal security is a universal principle of law aimed at ensuring the certainty of its promulgation and enforcement and, consequently, confidence in what is decided, allowed or prohibited by the public political power. This means that the strength and permanence of the normative order enables the different social actors to foresee the effects of their actions, and prevents the exercise of their rights and obligations from being altered abruptly by structural changes in the regulatory framework. It is precisely to avoid this type of harm that the legal principle of non-retroactivity applies, although certain exceptions may be made, primarily in criminal matters.

Most legal systems of Latin America and the Caribbean are complex, sophisticated and, being a reflection of the practices, customs, values, idiosyncrasies and interests of the human groups creating them, deeply rooted and sensitive. Therefore, momentous changes are uncommon and, when they occur, are caused by major paradigm shifts in society, the restructuring of governance systems, or other events that revolutionize the status quo.

Therefore, it is important to assume that the stability of the legal system is the rule, and that significant reforms will be the exception. In no wise does this mean that the law is static; it must reflect human evolution and is therefore dynamic. However, this dynamism is seen more at the regulatory level than at the level of laws, much less in the constitution or basic principles of the State, which usually remain intact over long periods of time.

Referring to this dichotomy, the illustrious American jurist Roscoe Pound wrote, *"The law must be stable, but it must not stand still"*.[98] The renowned Cuban attorney and professor, Julio Fernandez Bulte, said this meant that *"...at the root of all major reflections on law has always been the contradictory need for stability and transformation".*[99]

With this in mind, we should emphasize the need to design our energy plans around the opportunities afforded by the current regulatory framework, in order to ensure full and prompt implementation of the action plan.

98 Roscoe Pound. *Las grandes tendencias del pensamiento jurídico*. Ediciones Ariel. Barcelona, 1950, p. 6.

99 Fernandez Bulte, Julio. *Teoría del Estado y el Derecho*, Vol. II. Editorial Felix Varela. Havana, 2005, p. 132.

VII.4. Relationship between Energy Planning and the Regulatory Framework

Planning aims to identify specific elements of a desirable scenario for a country or sector, on which basis concrete actions are planned to achieve measurable impacts to meet the goals set. To this end, following the appropriate forecasting studies, means are established, responsible parties appointed, and resources allocated for implementation.

This stage poses another intrinsic relationship between planning and the regulatory framework. In order to formalize the written plan and make it binding, and to appoint the actors responsible for implementing it and approve the necessary budget, certain formalities must be fulfilled through laws, decrees or resolutions, depending on the customary practices of different states. If a plan lacks legal force, it will be hard to enforce, will have little or no mandate for implementation, and will be easily diluted as time passes and administrations change.

In sum, the interdependence of planning and the regulatory framework is evident before and during the identification and application of the various energy planning instruments. Two crucial stages can be clearly identified: an initial stage of a comprehensive review of the regulatory framework before defining and implementing the actions; and a subsequent stage of legally formalizing the various planning instruments to afford them legal, binding force for all actors of the energy chain.

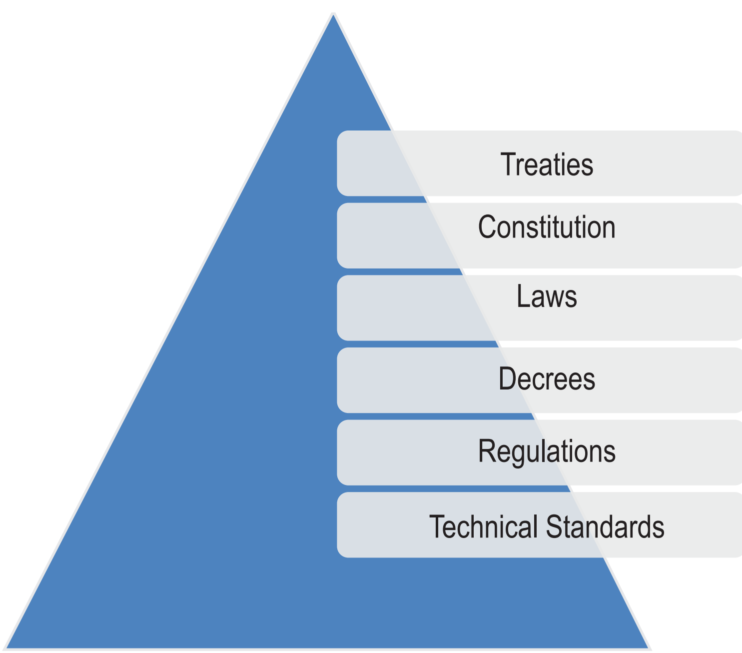
Planning includes four basic, clearly identified phases: analysis, planning, implementation, evaluation and control; and the interdependence between planning and the regulatory framework is evident in each.

VII. 5. Parameters for Examining the Interdependence of Planning and Regulatory Framework by Type of Norm

Review by Type of Norm

For a proper, comprehensive review of the current regulatory framework, once the parts of the energy plan have been defined, it is advisable to use the 'Kelsen pyramid' to lend a logical, hierarchical order to the review of the existing national legal order, including international undertakings under treaties that have been signed and ratified.

Figure VII.2: Kelsen Pyramid



Source: Prepared by the author, based on theories of the jurist Hans Kelsen.

Despite the structural differences among diverse legal systems, the hierarchical order is a common denominator in the French Roman and Anglo Saxon systems that converge in the Latin American and Caribbean region. Likewise, the supremacy of the constitution over other legal, regulatory and policy instruments is a common trend among the Member Countries of OLADE, in some of which, under the influence of neo-constitutionalism, it is not necessary to pass special laws to implement constitutional principles.

To illustrate the above, we will now refer to the various components making up the typical regulatory frameworks of most of OLADE's Member Countries and their interdependence with energy planning.

VII.5.1. International Treaties: The process of signing International Treaties comprises a number of formalities that in most cases require the approval or endorsement of the congress or parliament of the country involved. This compulsory formal component of international public law greatly benefits the legitimacy of such agreements, but is highly complex and delays the process of limiting or amending the commitments made, not to mention opting out of a signed agreement completely.

Virtually all current integration processes in Latin America and the Caribbean include energy integration guidelines, agreements and commitments. Some are fully binding, such as the Decisions of the Andean Community of Nations in the field of electrical interconnections between its members, and others are mere formalities. In any case, a thorough review of State undertakings is required before starting to make planning decisions.

It is important to note that some Latin American and Caribbean states rank international treaties even higher than their Constitutions. This means that before defining energy planning guidelines, it is necessary to review a state's international energy commitments to ensure consistency and avoid contradictions.

VII.5.2. The Constitution: A constitution has a basically dogmatic and organic function. Its hierarchical precedence over the rest of the regulatory framework ensures that all laws are drawn up in accordance with its guidelines. That is why the constitution must contain all of the fundamental principles underlying the legal system. Its status as a formal and material source of law requires the legislature to develop laws that ensure proper application of its principles, without contradicting or limiting its postulates. The constitution also determines procedures for drafting and enacting laws.

Including energy among the strategic areas that States enshrine in their constitutions is a starting point for developing laws, plans, programs and projects for the sector. Therefore, before energy planning begins, it is essential to analyze the constitutional principles governing the energy sector of a given state, in order to center the planning guidelines on the constitutional regime as it applies to the energy sector. Lacking such a review, you run the risk of basing the plan on unconstitutional elements, which would make it impossible to implement.

The Constitution is the means by which some states limit the intervention of certain social sectors with regard to energy, given its importance in and influence on the economic, social, political and environmental spheres. It is also the legal instrument by which certain states set guidelines for sustainable energy development, energy sovereignty and others as the starting point when making policies and plans for the energy sector. In addition, the constitution creates protected areas where the extraction of energy resources is prohibited.

We can conclude that it would be a chimera to assume that in case of contradictions between the regulatory framework and a planning instrument, the constitution would adapt to the plan and not vice-versa. The constitution is the expression of the people's will regarding the doctrinal and structural elements of the State, is designed for the long term, and is only interrupted when profound changes arise in the norms governing the relationship between state and society, for which constitutional assemblies are appointed.

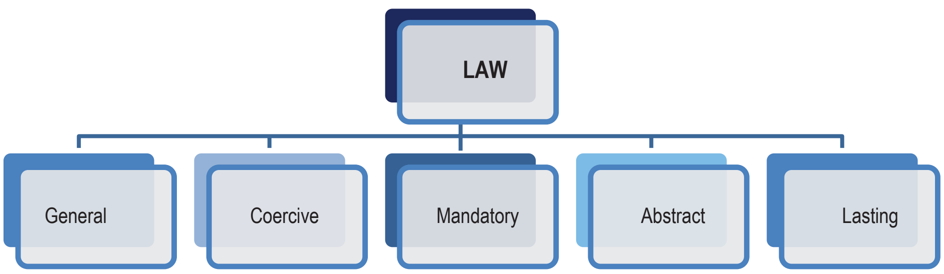
VII.5.3. Laws: The function of laws is operational. They are passed for an indefinite period, cover any number of hypothetical situations, and lose force only when abrogated, subrogated or repealed through the same formal process followed to adopt them. As regulatory instruments, they establish guidelines for the operation of the energy sector by means of legislative provisions adopted by a national congress or legislative assembly.

Laws have certain basic features; they are mandatory, general, abstract and permanent over time. The matter of permanence in time was studied in detail in the doctrinal analysis at the beginning of this chapter. This intrinsic characteristic of law is the cornerstone of legal security, as it prevents sudden changes in the conditions set by the regulatory framework, in this case for the energy sector, which could abruptly harm acquired rights or decisions made by the parties involved in the energy chain.

Therefore, the basic premise is respect for the game rules established beforehand through legislation. Again we should be clear that this legal principle does not mean that laws are immutable, and much less perpetual. Regulatory frameworks are products of society and, as such, can be perfected as societies change and evolve, which reaffirms that laws are simply the expression of social evolution, but this evolution is slow and complex.

We reiterate, then, that planning instruments should be based on existing legislation, as it is unlikely that laws will be changed to adapt them to a planning instrument that is inconsistent with the provisions of the prevailing legal framework. Furthermore, the dynamism of the energy sector could be hampered by the lengthy formalities required in most of OLADE's Member Countries to amend a law.

Figure VII.3: Characteristics of Law



Source: Prepared by the author based on the international doctrine of the characteristics of law.

VII.5.4 Decrees: In many of OLADE's Member Countries, the difference between laws and decrees is basically the body issuing them: a law is passed by the Congress or Assembly, and a Decree by the executive branch. In the latter case, although 'emergency decrees' may pass through Congress, depending on the national law, due to their urgency they will have tight deadlines and expedited procedures. However, in most countries lower-ranking norms are subordinate to the constitution and the laws. Being purely administrative acts, their normative content is usually regulatory. There are also legislative decrees and supreme decrees, whose scope is quite similar to that of a law in some countries.

In terms of planning and its interdependence with the regulatory framework, should it be necessary to amend or create provisions to achieve regulatory consistency with an energy plan, it would be less cumbersome to do so via a decree than through a law. In view of the above, since their provisions are mandatory, it is essential to review all decrees relating to the energy sector before embarking on the design of plans and programs for the energy sector.

VII.5.5 Regulations: Their main function is procedural, to facilitate the enforcement of laws. Being lesser or sub-legal norms, they always depend on the existence of a higher law. Regulations exist to enforce a law and, given their degree of specificity and technicality, processing and approving them is usually the competence of ministries, institutes and other public offices related to the law being regulated. Given their lower hierarchical level, the process for approving, amending or repealing them is much less complex and more expeditious.

VII.5.6 Administrative Resolutions: These are binding rules whose scope is limited to the context of a given service or area, at almost the lowest stratum of the Kelsen pyramid. However, they are highly important to the energy sector, whose dynamism imposes the need for immediate regulatory decisions, put in practice through resolutions. In most cases, the Ministries of Energy have the authority to regulate certain technical, operational and administrative aspects by adopting resolutions. In this case also, given the lower hierarchical process for approval, amendment or repeal, it is much less complex and more expeditious. This makes resolutions important instruments to be considered when developing and implementing plans and programs for the energy sector.

VII.5.7 Technical Standards: This is the very base of the Kelsen pyramid. Being sub-legal, their main function is to establish guidelines and standard procedures for the quality of products and services, based on the outcomes of scientific research and technological development. Technical standards, whether mandatory or voluntary, are approved by technical bodies of the public administration in charge of standardization. It is important to analyze their scope and effects for the energy sector, especially in the case of mandatory standards, before deciding on energy planning instruments.

VII.6. Planning Focused on Sustainable Energy Development

Due to the vital role of energy as a means for a country's economic development and social well-being, it is essential to ensure public availability of safe, reliable, accessible, affordable energy based on environmental sustainability, covered by a consistent regulatory framework for this purpose, and supported by a suitable institutional framework.

To fully tap these dynamics for the energy sector, policy as a guide to state principles and guidelines, and planning as a path to concrete actions to materialize the policy provisions, both play a fundamental role in ensuring coherence between what we hope to achieve, what can be achieved given the country's situation, and how to achieve it through concrete, measurable actions.

When we speak of using energy as a factor in a country's balanced, harmonious development under conditions of equity; ensuring the sustainability of energy products and services; understanding the need to take climate change mitigation and adaptation measures; valuing the benefits of diversifying energy matrix by including renewable sources; promoting energy efficiency and rational resource use; avoiding wasted energy resources; ensuring access to continuous, safe, reliable and environmentally friendly power supply; and promoting socioeconomic development and industrial competitiveness, then we are referring to the integral concept of sustainable energy development.

To move towards models of sustainable energy development, it is essential to have energy policy and planning instruments for that purpose, based on a regulatory framework that is conducive to taking specific actions designed to reach the desired horizon. Working in conjunction with the Andean Parliament, OLADE has established the following definition of sustainable development:

Sustainable Development: *An approach for achieving socioeconomic progress and quality of life for the people by covering present-day needs, preventing irrational resource depletion and avoiding unwittingly undermining the possibilities of future generations. It involves the sustainability of extractive and industrial activities in harmony with the natural environment and its components.*[100]

In this light, regardless of the conditions, characteristics and interests of the state, and with full adherence to respect for the sovereign rights of each nation, integrated energy planning should focus on the basic principles of sustainable energy development referenced in the parameters suggested below:

1. Harnessing the use of renewable energies to diversify and balance the energy mix, valuing elements of socio-environmental responsibility and technical/economic feasibility
2. Ensuring, on an ongoing basis, that the people's energy needs are covered through rational resource use, respect for natural regeneration cycles, intergenerational socio-environmental awareness and commitment
3. Taking environmental protection measures for appropriate mitigation and reduction of the adverse impacts associated with the energy industry
4. Contributing to climate change adaptation and mitigation by taking action and making efforts to reduce greenhouse gas emissions

100 Andean Parliament, Regulatory Framework Sustainable Energy Development. Bogotá. 2015. Article 5, section b).

5. Strengthening energy security to ensure the national energy demand is covered to the extent possible with domestic sources, thereby reducing dependence on imports and other externalities without compromising a suitable energy integration policy
6. Ensuring universal access to energy products and services with an emphasis on alleviating so-called ‘energy poverty’, and assessing the impact of energy on the human development index
7. Encouraging energy efficiency on both the supply side and the demand side, driving a paradigm shift that will reverse current patterns of consumption, and promoting rational energy use without sacrificing comfort and the benefits of technological development
8. Promoting the role of energy in industrialization through capacity building to develop and improve the infrastructure involved in the manufacture of energy products and the provision of energy services
9. Enhancing the institutional framework of the energy sector as an integrated coordinating body for full implementation of energy policies and plans aimed at consolidating sustainable energy development, promoting social welfare and economic progress
10. Enhancing energy sector governance by ensuring inclusive, participatory processes of public policy making and planning, and encouraging the engagement of the private sector, the academia and civil society, in addition to the State.
11. Supplying the process of implementing energy policies and plans with suitable transparency and accountability mechanisms
12. Promoting regional energy integration with due respect for the principles of sovereignty and self-determination, and using complementary strengths and options based on proper management of national asymmetries

VII.7 Assessing the Behavior of Regulatory Framework in LAC over the Past 40 Years

In order to preserve the validity of this manual as a guideline, it is not advisable to include a detailed assessment of the status of different regulatory frameworks currently in effect, since changes would make this document obsolete or require constant updating. Accordingly, the following is an overview of the behavior and evolution of the energy regulatory framework in Latin America and the Caribbean over the past 40 years, to contextualize the actual application of the doctrinal principles of law outlined in sub-sections above.

This overview shows a clear confluence between legal stability and the evolution of law discussed in the doctrinal part of this document.

VII.8 Overview of the Evolution of the Energy Regulatory Framework in the member Countries of OLADE since Its Creation

Over the past 40 years, the LAC energy sector has seen major institutional, technical and administrative transformations, and changes in the principles governing the energy business, which have carried over to each country’s legal situation. This explains why every so often, most of OLADE’s Member Countries have made substantial reforms to the existing legislation, without adversely affecting the legal stability of the region.

In any case, it is a matter of achieving legislative innovation to link the energy situation of each country to its regulations for practical application of its norms, eliminating obstacles, repetitions, contradictions and unspoken exceptions, and thereby adapting the law to the reality of the sector and avoiding the existence of so-called ‘dead laws’.

VII. 8.1 Hydrocarbons

With regard to resource management, over the past 40 years the legal, regulatory and policy framework of the oil and gas subsector has undergone several stages involving significant legal amendments. By the time OLADE was created, several countries already had large state enterprises, and many more followed suit in the 1970s due to such companies’ historical record of significant contributions to the development of national energy sectors and economies as a whole.

During the 1990s and early 2000s, neoliberal policies in the region gave way in some countries to a trend towards private sector participation in the oil and gas industry, which in some cases clashed with the full exercise of resource sovereignty and the socio-economic development of producer countries. Over the past decade, some countries have reversed this through policies to protect natural resources (deemed strategic) for use in promoting national development, and some have even nationalized those resources and increased state shares in the subsector.

As for exploration and exploitation, the trend has been to diversify the modalities and increase state revenues by restructuring the contract and royalty systems, thereby fostering local development through proper distribution of oil revenues.
As the oil and gas industry has extended its range into areas inhabited by indigenous peoples, states have developed 'prior consultation' regulations for granting oil and gas exploration and exploitation concessions. They are currently implementing concepts of corporate social and environmental responsibility. Legal instruments have also been issued to establish procedures for citizen participation in decision-making regarding projects, initiatives and measures likely to affect the interests of civil society.

VII. 8.2 Electricity

Regulatory developments for electricity in Latin America and the Caribbean overwhelmingly reflect the direct correlation between increased power demand and economic development. The positive impact of access to basic services and their implications for social development have shown that electricity plays a decisive role in the human development index. In this sense, the regional tendency has been to consider access to public power utilities a constitutional principle, a state duty and a right of all citizens.

Much of the region has tended towards recovering the state's leading strategic role in the development, planning and implementation of power projects. This has required the creation of institutions and the redistribution of duties to implement electricity expansion plans. However, in the 1980s and 1990s, some countries' open market policies caused energy crises for various reasons, and the measures taken to overcome them included policies to increase state shares in the sector.

Currently, national regulatory frameworks in the region tend to safeguard the interests of power utility users through measures designed to ensure market transparency, enhanced service quality, profitable but fair tariffs with special rates for vulnerable social sectors, new rural electrification funds, and consolidation of the power industry with the infrastructure needed to meet the domestic demand and ensure universal access.

VII.8.3 Energy Efficiency

The recent enactment of laws for efficient, rational resource use in the region has fostered a culture of sustainable energy use in harmony with the environment—including traditional fossil fuels and their products—thereby minimizing climate change impacts and establishing strategies for sustainable development and resource savings without sacrificing industrialization and comfort.

These norms have focused on adapting the market to energy-efficiency innovations through compulsory labeling of energy-consuming appliances, rational energy use plans for state institutions, energy efficiency awareness programs at all educational levels, efficient construction standards, national programs to replace incandescent bulbs and inefficient home appliances, among others.

OLADE's Member Countries continue to take measures and pass regulations to reach State–business–consumer agreements that enforce the regulatory framework for energy efficiency and rational energy use, and to monitor compliance with such plans and programs. They are also continuing in their efforts to drive a paradigm shift with regard to consumption patterns.

VII.8.4 Renewables

Since the early 2000s, OLADE's Member Countries have seen a surge in the number of regulatory frameworks for renewable energy sources, given the region's clear intention to promote government policies that encourage renewable energy use, reduce greenhouse gas emissions, promote clean and sustainable development, and improve the trade balance of oil importing countries. For example, some have introduced in their Constitutions the principle and state duty of promoting clean technologies, non-polluting energy alternatives, and renewable, diversified, low-impact energy sources that do not alter the ecological balance.

Although some countries of the region already had regulations in place for the use of renewable sources since the 1990s, they were often scattered and strongly biased towards electricity generation. These regulations are currently encoded in special laws that cut across the entire energy sector.

Legal provisions that promote renewable energy tend to focus on creating incentives and benefits to attract their use, such as income tax exemptions for energy sales, value added tax exemptions on goods purchased for this purpose, import duty exemptions on equipment and parts for renewable energy projects, and other measures that promote investment in such initiatives. They also include provisions to expedite the procedures for granting concessions and permits to implement projects based on renewable energy sources. Most of OLADE's Member Countries have established and are currently implementing policies, programs and plans with strategies and guidelines to promote medium- to long-term development and use of renewable energy sources, which consider all technical, social, economic and institutional aspects. Their common aims include protecting the environment, improving the trade balance, reducing fossil-fuel dependency and others, to ensure clean, sustainable development.

Although to date not all OLADE Member Countries have laws on special renewable energy sources, all have references or provisions relating to its use in other regulatory instruments. In some cases, all things concerning this subsector are contained in the electricity law or those creating ministries, commissions or other institutions related to the energy sector. There is also a tendency to enact specific regulations designed to address such sources, as in the case of countries with laws that establish national wind, solar or geothermal power systems.

VII.8.5 Energy and Environment

Among OLADE's Member Countries, the current regulatory framework for energy and the environment reflects a concern to promote state policies that require environmental licenses, controls and audits, regulate judicial proceedings for environmental reparations, and other regulatory measures for energy chain projects and activities, thereby contributing to the protection of ecosystems and ensuring the quality of the environmental components needed for life to develop by controlling pollution, reducing greenhouse gas emissions and promoting clean, sustainable development. Special attention should be paid to countries whose Constitutions include the principle and state duty of promoting clean technologies, non-polluting energy alternatives, and renewable, diversified, low-impact energy sources that do not harm the ecological balance. The region has also seen progress in the recognition of nature as a holder of rights. The LAC region has had a strong presence at the signing of treaties establishing principles, mechanisms and incentives to prevent and remedy environmental damage, and has made them binding building them into domestic laws. By the early 1990s, there were over 900 legal instruments related to the environment, most enacted subsequent to the United Nations Conference on the Human Environment (Stockholm 1972). OLADE's Member Countries are still fine-tuning their enforcement of regulations created to reduce the negative impact of energy use on the environment, and are moving towards reducing their fossil-fuel dependency and diversifying their energy mixes.

Of special interest is the emissions impact of implementing their undertakings on November 4, 2016, under the Paris Agreement or United Nations Framework Convention on Climate Change, adopted by the parties in December 2015 to strengthen the global response to the threat of climate change within the context of sustainable development and the efforts to eradicate poverty. This agreement seeks to keep global average temperature increases well below 2°Cover pre-industrial levels, and to continue efforts to limit temperature rises to 1.5°C relative to pre-industrial levels, with the understanding that these measures will considerably reduce the risks and impacts of climate change. It further seeks to enhance the ability to adapt to the adverse effects of climate change and to promote climate resilience and low-emissions development without compromising food security. Finally, it purports to increase financial flows to levels consistent with a curve leading to climate-resistant development with low emissions of greenhouse gases.

While legally binding, this agreement has certain coercive restrictions with regard to defining and monitoring national emissions reduction targets. A highly important mechanism in this regard is periodic review of commitments, which is legally binding due to the accountability obligation. Although the agreement will be applied in a way that reflects equity and the principle of shared but differentiated responsibilities and capabilities, in light of the diverse national circumstances, it is essential to take these commitments into account before adopting national energy plans or programs. Several of OLADE's Member Countries have already filed their ratification instruments, thereby reaffirming their emissions reduction commitment to address the effects of global warming.

VII.8.6 Nuclear

Nuclear power is a limited source in Latin America and Caribbean, but the countries including it in their energy mix have developed appropriate regulatory frameworks aimed primarily at establishing security measures and strict compliance with treaties signed to ensure its peaceful use.

VII. 9 Relationship between Integration and Planning

The following is to emphasize the importance of linking the needs, goals and objectives of the national energy sector under state plans with actions embedded in or liabilities arising from each country's position in the energy integration context.

To this end, it is essential for national plans to review and value all commitments, impacts and other referents relating to and deriving from each country's position vis-à-vis existing energy integration initiatives and processes at the bilateral, subregional, regional or international level, in order to achieve consistency among the expectations and scopes of national interests with regard to energy integration.

As for OLADE's role in the process of regional energy integration, as an agency for cooperation, coordination and consultation with legal status, its basic aim is the integration, protection, conservation, rational utilization, marketing and defense of the region's energy resources. As set out in Article 3 of the Lima Agreement, the founding treaty of OLADE, the fundamental aims and duties of the Organization include the following:

- To join efforts in promoting the independent development of its Member States' energy resources and capabilities;
- To promote effective, rational policies for the development, processing and marketing of its Member States' energy resources;
- To promote and coordinate direct negotiations among its Member States to ensure stable, adequate energy supplies for the their integrated development
- To support the industrialization of energy resources and the expansion of industries to make energy production possible;
- To encourage its Member States to implement energy projects of common interest;
- To contribute, at the request of all parties directly involved, to understanding and cooperation among Member States to facilitate proper development of their shared natural energy resources and avoid significant harm;
- To promote the creation of a Latin American energy market, starting with the promotion of a pricing policy to help ensure its Member Countries a fair share in the benefits derived from energy sector development;
- To promote the creation and development of common energy policies as a factor in regional integration;
- To foster technical cooperation, the exchange and dissemination of scientific, legal and contractual information, and the development and dissemination of energy-related technologies among its Member States; and
- To encourage its Member States to adopt effective pollution prevention measures when transporting, storing and using energy resources within the region, and to recommend any measures deemed necessary to prevent pollution due to energy resource development, transportation, storage and use within the region in areas not under Member States.

Based on these goals and aims, OLADE defines energy integration as any process or project that involves a long-term facility, interconnection or transaction, whether binational or multinational, backed by coordinated national policies, based on a common regulatory framework, focused on more efficient use of energy resources or infrastructure, and aimed at meeting energy demands regardless of the geographical location of the various supply and demand centers.

For OLADE, therefore, capacity building in energy planning plays a key role in furthering energy integration in Latin America and the Caribbean, given its direct impact on developing interconnection infrastructure and distributing energy resources, among other key elements to be taken into account in bilateral or multilateral energy complementation projects.

In line with the above, national energy plans should view integration as an option to ensure that domestic demand for energy products and services is met and to allocate surplus energy for export to neighboring countries.

In conclusion, to reach higher levels of energy complementarity, the LAC region needs to develop policies that include national energy planning for market integration. Meanwhile, current energy integration processes and initiatives in Latin America and the Caribbean should include defining and establishing regional energy policy-making and planning guidelines focused on making progress in terms of:

1) Security of energy supply
2) Integration of energy markets
3) Infrastructure for interconnection
4) Sustainable energy development
5) Environmental protection
6) Research and technological development

VII.10 Final Considerations

By way of closing this chapter, it is important to emphasize that a proper review of existing laws before defining concrete energy planning actions is key to achieving consistency among the expectations and scopes of national interests with regard to energy planning. To meet the aims of the plan, it is also crucial to establish an energy policy instrument with a long-term horizon, whose technical, social, regulatory and political legitimacy is sustained by the broad support of diverse social sectors.

This energy policy will serve as an unavoidable guide to energy planning, with particular emphasis on the characteristics, needs, and real prospects for the different components of the energy chain and their interactions in the spheres of production, transformation plants and consumer sectors, valuing sustainability as a component that cuts across all energy sub-sectors, economic, social, political and environmental.

Furthermore, to establish an effective procedure for preparing and implementing national plans, it is advisable to have a high-level institution in the energy sector responsible for energy planning and maintaining channels of coordination with integration organizations and other international energy initiatives to which the country is a party. Most of OLADE's Member Countries have institutional frameworks that are specifically responsible for developing and implementing energy planning instruments, whether ministries, sectoral planning institutions, subsectoral public enterprises, etc.

With regard to planning for energy integration, the duties and powers of these entities include energy integration consultation and coordination with other countries in the region, and assessing their cost-benefit ratio, among other commitments and responsibilities resulting from participation in energy integration processes and initiatives. They are also responsible for including integration options in documents containing electric expansion plans. In terms of integration, it is important to emphasize the need for synergies between national goals and the potential for complementarity and cooperation at the bilateral, subregional, regional or international levels.

With regard to the regulatory framework, it is vital to study and understand the range of possibilities allowed or prohibited by the law at the national, subregional, regional and international levels, taking into account the commitments made under international treaties. Is also essential to know the appropriate legal devices to improve current energy legislation in accordance with the characteristics of the energy sector at the national level and its subregional or regional projection. Finally, we should highlight the invaluable benefits they bring to regional energy integration by reducing legal asymmetries and harmonizing the relevant regulations as a basis for the application of supranational frameworks, to which end a continual exchange and dissemination of legal information and good practices in energy regulation is essential.

CHAPTER VIII

Institutionalization of Human Resources

KEY WORDS

Human Resources, Training, Development of Capacities, Planning, Energy Policy.

“Notwithstanding the reassessment of the role of governments in the economy and society that took place during the 1980s, there is now a broad consensus among development thinkers and practitioners that a “capable government”, able to perform key functions effectively, is a precondition for development. Thus, most capacity development analyses and strategies, and much donor support for capacity development, remain focused on the public sector” (UNDP, 1999).

VIII.1. Introduction

As it is mentioned in Chapter I.2, the development of capacities should be considered as a component of the planning process to be able to obtain the results expected from energy policy. As such and in turn, it requires a policy and strategies that permit the training of resources at the individual, institutional and systemic levels. The needs for the creation and strengthening of capacities, and the long-term vision that such a process requires, must be part of the energy policy objectives and be as well linked explicitly into energy planning.

In this sense, generally, energy planning achieves the best results and fruits when it is undertaken with the intervention of national experts representing the local energy sector and pursuing a national agenda. This last is true because a deep understanding and knowledge of national energy systems are necessary in order to accomplish a correct diagnosis of the energy sector and a leading proposal development that can solve detected issues, evaluate the validity of the results, and build consensus to manage the stakeholders in the sector. Ultimately, these groups of experts are the ones who will carry out the designed strategies based on methodologies, prospective studies and models, and according to real life decision-making processes and energy policies. As well, they are the ones that are in the best position to develop the diagnosis identifying the problem situations in the energy system that can help to prioritize the goals. [101]

In other words, the fact of having the assistance of experts and endogenous institutional capacities in energy planning or available in other national institutions, public or private, constitutes a necessary condition for the adequate design and implementation of policies and strategies. However, the key component human resources is usually not considered when pursuing public policies to face the problems of development in general and of energy development in particular.

The importance of awarding attention to the development of capacities, especially for the design and implementation of public energy policies, becomes evident when it is observed that the goals set forth are not achieved or that system problems persist. Ex- post analyses reveal that the lack of adequate results was due to failures in policy implementation (Ortegón Quiñones, 2008; Cadenas, 2007), the absence of adequate diagnostics or difficulties in identifying the public agenda of problem–situations or the most adequate mechanisms for intervention.

Within this context, human resources constitute a critical factor both at the level of planning of programs and actions, as well as in its leadership and concrete achievement. Consequently, energy policies and those processes associated to planning, must consider in an explicit and detailed manner the development of the human resources that are necessary to be able to carry forth a determined energy plan or program that will answer to the objectives set forth. For this it is necessary to identify the necessary human resources to be able to adequately face the planning of the energy system and to develop a diagnosis of the resources that are available.
The determination of the gap between resources and the implementation of programs to “close it” is particularly important since human resources cannot be generated in the short-term, even though many efforts may be made in that direction, since they require many years to reach maturity.

On the other hand, it is necessary to have the human resources that are not only technically capable to face specific circumstances, but it is also necessary that they have an adequate motivation in line with the general objectives of the process of energy policy to which they are linked, a matter that implies an adequate mix of specialists and generalists.

101 It is also important that these national experts come not only from the universities of the region, but also from the companies, preferably from the state, and from public agencies in the region to combine the “theoretical” with the “practical” ones.

VIII.2. Preliminary considerations relative to the development of capacities

In an ample sense, "capacity" refers to the ability of individuals and institutions to develop and implement proposals, decision making, and execute actions in an effective, efficient, and sustainable manner. The paragraph brings together three important aspects: (1) it indicates that capacity is not a passive state but rather a part of a continuous process; (2) it highlights that human resources and the way in which these are articulated are in the center of the development of capacities and, finally; (3) these require that in the general context and in that of the institutions and their organization these concepts should be central in the design of strategies for the development of capacities.

Within this framework for the development of capacities, it is possible to understand it as a process of creation, mobilization, improvement and conversion of abilities based on experiences, institutions and contexts for the implementation of adequate planning processes. Such a development recognizes individual, institutional, systemic and organizational levels (Bouille and McDade, 2002).

Answers to the needs of the creation of capacities are formal and informal training programs. Mobilization refers to the full use of the existing potential. Improvements are essentially linked to the processes that lead to up-dating knowledge by means of short courses, workshops, seminars and other training services. *Conversion* refers to the structural adjustment of existing capacities for the treatment of new problems[102].

At the individual level, an effort is made to change attitudes and behaviors, through the development of knowledge and abilities, which in turn maximize the benefits of sharing and exchanging knowledge. Institutional focus is made on the performance of the organization as well as its capacity to adapt to changes. The institution is considered as a system that must link together individuals, groups, departments or areas and of the organization itself for compliance with its function. Finally, the intervention at the systemic level not only includes a "strengthening of institutions" but also an interaction between them and the global political frameworks.[103] Within this framework, institutional aspects are of particular importance in terms of: organization, the different actors, functional rationality of the sector, structure and levels of integration, interference and jurisdictions, and, finally, roles and functions.

These three levels transversally cut across the temporal dimension: capacities are relevant in the short- (capacity to face an imminent problem) and in the medium- and long-term (the ability to create an environment in which one of more specific changes must take place.[104] Thus, the strengthening of capacities in each one of these levels are discreet elements of a *continuous process for the development of capacities*.

The objective of the development of capacities and of priority issues to be approached in training activities depend on the role or functions of the energy system and the inter-relations that exist among them.

In the case of energy, the most critical public areas in the development de capacities are macro-planners, policy developers and regulatory entities, in the restructured systems. Energy reform processes, global dynamics and the perception of facing a process of energy transition[105], justify the already expressed need of developing capacities in areas of public policy and energy regulation to be able to reach the objectives that are expected from energy systems.

VIII.3. Challenges

The first challenge to be faced when approaching a proposal for the development of capacities goes through a recognition of the heterogeneous nature of the countries of the Region, relative to the level of development, objectives and their policy for development, as well as those of the energy policy, energy sources, existing capacities, aspects relative to regional integration, social and environmental conditions, the functioning of energy markets, among other aspects.

102 In this context, the link between "theory" and "reality" is essential. It implies not staying in the academic but interacting with the organisms that carry out the energy policies and the Planning and the sectors of consumption.

103 For example, energy efficiency admits the energy authority as the guiding unit, but the implementation of energy efficiency actions must recognize the transversality of the issue and the need for the concurrence of the areas of industry, transportation, housing, education, etc., Without whose concurrence and coordinated articulation few results can be expected.

104 Although in the planning framework, the capacities are oriented in the long term, the decisions of conjuncture can condition the future and hamper the long-term objectives. The coherence between conjunctural and structural actions is therefore vital and must be guaranteed in the coordinated action of those responsible for one and other actions.

105 Energy transition is understood as the change of state from an energy system to a different state, in terms of quantity, structure of energy services, sources and quality, considering differences in space (where) and time (when). (Grubler, 2006)).

On the other hand, the challenges are associated with the multiple dimensions of energy activity. These dimensions are not limited to the three basic pillars of sustainability (economic, social, and environmental) but include as well aspects that can be constitutional and legal, cultural and social, strategic, spatial and territorial, institutional, health, technological, and temporal. Furthermore, they admit natural resources geopolitics which is increasing in importance.[106]

In consequence, proposals relative to Human Resources must be interpreted as guidelines that must be adapted and specified, in accordance with national circumstances and the objectives of energy policies considered in the short-, medium- and long-term ranges.

The role of teachers with experience and that are aware not only of theoretical aspects but also of the realities experimented in energy systems, is a necessary condition for a development process of human resources in energy. An adequate and fluid relation and communication between the trainer and trainees, in view of the characteristics of courses, especially at the post-graduate level, at time generates a reversal of roles, which is another necessary condition.

VIII.4. Transversal competencies and abilities of human resources in the planning team [107]

The conditions and capacities of human teams (personal or individual capacity) constitute generic aptitudes that must contribute to the achievement of objectives and results that are pursued by the institution or area under which they are articulated.

Such aptitudes or conditions admit being associated to the competencies that fit under different dimensions, among which we can highlight the following:

1. *Instrumental Capacities* are those that have the nature of a tool with the final purpose of adequate and leading procedures and recognize that:

   √ Capacity for Analysis and Synthesis: Capacity of understanding a phenomenon starting from the differences and to systematically disaggregate its parts, establishing its hierarchy, the relations between the parts and their sequences. Analytical thought is the thought of detail, of precision, of enumeration and of the differences. Synthesis is the opposite capacity. It consists of being capable of uniting different elements into a significant whole. It implies the virtue of distinguishing that which is essential from that which is an accessory or superficial. To establish a difference of the diverse elements and their interrelations of dependence. Capacity for planning and organization: This is the capacity of efficiently determining the objectives, goals, and priorities of the task to be undertaken by organizing the activities, terms and resources necessary and of controlling the processes. It requires to work in a systematic and orderly manner; foresee the times required for each thing; establish feasible terms and point out the indicators of monitoring.

   √ Communication Capacity: Is the capacity of being able to express oneself and of understanding ideas, concepts and feelings in an oral and written form that are comprehensible. It requires the ability to express concepts and ideas both in an oral form as well as a written one, in a clear and comprehensible manner, express our own understanding on an issue, developing abilities of communication and presentation of ideas. It is inevitable that, in the present context, similar abilities of communication in a foreign language are also required. Especially important in the search of a sustainable and integral energy development and in the growing process of globalization that demands dialogue, negotiation and the incorporation of understanding and articulation of challenges and objectives that transcend national and even regional frontiers. Especially the knowledge of a technical/scientific vocabulary that corresponds to the matter, and in line with the multiple dimensions that energy has.

   √ Capacity for the management of information: This is the capacity to search for, select, order, relate, and evaluate information forthcoming from different sources. This refers to the capacity to be able to distinguish between valuable sources and value added secondary sources and of the awareness of the different values of different types of information. It includes the use of information and communications technology (ICT) as a tool for understanding, expressing and communicating, accessing source of information como medio de data files and documents, presenting assignments, learning, research, and cooperative work.

   √ Resolution of problems and making decisions: This is the capacity to identify, analyze and define the significant elements that constitute a problem to resolve it with criteria and in an effective manner. This implies the capacity of defining the problem with precision. To analyze it from different points of view. To identify the principal questionings, as well as searching for the information that is required for understanding it better.

2. *Capacities of the work team, those that tend to facilitate and favor processes of interaction and cooperation*. These refer to personal capacities and social dexterities related to interpersonal abilities such as:

106 The importance of the multiple dimensions of energy in terms of human resources training will be discussed later.

107 According to the proposals of different authors in CINDA (2000).

- √ Capacity for criticism and self-criticism: This is the capacity of examining and judging something with internal and external criteria. Self-criticism is the capacity of analyzing our own actions applying the same criteria. It recognizes objectivity, the use of criteria, capacity for analysis and self-analysis.
- √ Capacity to integrate and to communicate with experts of other areas and in different contexts. Capacity of integration into a group or a team, collaborating and cooperating with others. Capacity to work with experts and professionals of other disciplines and areas. It entails accepting ideas forthcoming from other areas. It is synthesized in a willingness to have an interdisciplinary aperture.
- √ Recognition and respect for diversity, is the capacity to understand and accept social and cultural diversities as a component for personal and collective enrichment in coexistence. It involves admitting and understanding information relative to the conditions of social, economic and political context, capacity that permits seeing different opinions as an opportunity for an enrichment of individual proposals.
- √ Abilities in interpersonal relations: Is the capacity of establishing positive relations with other persons by means of an empathic listening and a clear expression of what one thinks and/or feels, by verbal and non-verbal means.
- √ Ethical commitment: Behavior that is consequent with personal values and the code of ethics. Integrity and rectitude before any situation, including in situations that run counter to a person’s own interests. Honesty, both in academic activities and in the profession as well as in other aspects of life. Respectful with norms through self-regulation.

3. *Comprehensive capacities* concern systems as a whole. They require, besides instrumental and interpersonal competencies capacities that permit the individual to have a vision of the whole, to anticipate the future, understand the complexity of a phenomenon or of reality.

- √ Capacity of autonomy, that permits identifying knowledge and learning that feed a positive function as a component of a team that is directed to compliance with objectives and results of the area. It involves initiative and the development of the personal, academic and professional autonomy, capacity of managing time, selecting priorities, meeting established deadlines, responsibility towards that which has been agreed.
- √ Capacity of adaptation to changing situations, modifying conducts to become integrated, with versatility and flexibility. Requires capacity to identify changes, capacity to adapt to an environment that is not always favorable, adapt to a work methodology for independent and autonomous work, capacity to work different areas in a simultaneous manner, adapting the different audiences.
- √ Creativity capacity that offers new and different solutions when facing problems or conventional situations. Possibility of generating original proposals, capacity to identify problems. Diverging thought process by means of which there is developed an expansive, generative, exploring, discoverer of options scenario that strives to understand the problem in its entirety and not on a superficial manner.
- √ Leadership to exert influence upon individuals and/or groups anticipating the future. It implies a guide to shared goals and a process follow-up. As well, it implies commitment to personal and group development of the members of the team, delivering support in higher and institutional instances. It generates trust in the team, a state of transcendence and achievement of goals, and the ability to detect the strong and weak points of collaborators to attain maximum performance. Finally, it allows delegation capacity and favors the development of the leadership qualities of other members of the team.
- √ Initiative and enterprising spirit: willingness to act in a proactive manner, putting ideas into action in the form of activities and projects in order to exploit opportunities to the maximum. Searching for new opportunities and for information forthcoming from different sources.
- √ Aperture to new learning and knowledge throughout life in order to favor its personal and professional development, modifying in a flexible and continuous manner personal mental schemes in order to understand and transform reality. Implies an updating of knowledge and values every activity that will contribute to personal and professional development, permanent attitude of learning and improvement.
- √ Commitment with the identity, development and professional ethics: capacity to recognize and value oneself as a professional that practices a service for the State and is concerned with a permanent personal updating respecting and drawing upon ethical and professional values.
- √ Orientation to quality, performing and maintaining a work of quality in accordance with norms and using quality indicators for a continuous improvement. Implies correctly planning and executing activities. Strives to permanently improve everything that is undertaken. Participates in self-evaluation processes assuming responsibilities as an evaluator or the person being evaluated. Understanding quality as a process of continuous improvement and not as a bureaucratic requirement.

VIII.5. Institutional structure for the development of energy planning

As described in Chapter VII, energy systems in LAC underwent reforms that affected their institutional structure and gave rise to new organizations of the system, in particular, of the industry of the sector and its regulatory mechanisms.

In this component, of special interest are those that refer to:

a) Those that affect the legal nature of companies and/or property rights;
b) The productive organization of the sector or some of its energy chains.

In the first case, it is possible to establish a difference between the following situations:

√ Modify the legal nature of companies and/or their rights and obligations, without changing the property of assets. The modification in the legal nature has generally implied a greater autonomy of companies with respect to the administrative apparatus of the State. The change in rights and obligations has referred to the following relations:
  - o between the State and public companies;
  - o within State companies themselves;
  - o between companies and third parties (keeping the integrated State company as the central stakeholder).

√ Change in the property regime (privatization) that may have had the character of being partial or total. Such changes had significant repercussions on the economy and society of a country. In particular, it implies deep changes in the control of decisions for the assignment of resources and in the rational nature itself of such decisions. As a consequence, it obligates the use of indirect mechanisms of intervention and planning instruments of another nature.

In second term, are those that refer to the productive organization of the energy subsector (the structural organization of the energy industry).

One of these situations is that of an integrated monopoly (very frequent in energy industries), but an alternative figure is the dissociation of the company, even in the hands of the State. This would imply:

√ Virtual separation of business units and/or effective of marginal activities.

√ Vertical accounting segmentation according to the links in the energy chain.

√ Vertical entrepreneurial separation.

√ Horizontal segmentation of activities of different nature in a same link of a productive chain (relative to the processes for distribution and marketing in the industries of the network).

√ Changes in the degree of concentration in the different links of energy chains).

√ Regional division (by areas within a country).

Another alternative of the structure would be the presence of other companies (players):

√ As third parties for the supply of certain services and products (partial opening) a single buyer, on the basis of contracts (establishing or not mechanisms that tend to introduce some degree of competition by and/or in the market).

√ As equals in a scheme of competition due to the elimination of entry barriers.

Each one of these situations presents different challenges and implies an institutional structure of planning that must provide answers to the different situations that are linked to each one of the possible cases.
Throughout this Manual, it has become evident that the State must perform a leading role upon all stakeholders in the energy system. In particular, the entity of the Executive Power that is responsible for energy policy in accordance with the institutional structure and the Ministries Law of each country, must lead such policy and carry out an articulation with the stakeholders in the Energy Industry, other State organizations, that are necessary players in an activity of high mainstreaming and even those players of civil and productive society as recipients and generators of the needs that must be answered by an energy policy and also as recipients of the consequences of the strategies and measures that may be implemented.

This institutional structure must be adequately provided for, not only with its powers, but also with physical, technical and human resources, in addition to budgetary resources that will permit it to adequately perform its role. The strengthening of all of these aspects of the planning entity in a country are essential to develop and implement long-term actions that are coherent and sustainable.

In this sense, the institutional structures existing in the Region answer to a set of factors that condition or determine them, as well as the role that must be complied with in the process of the development and implementation of policies, strategies and energy planning.

Among such factors that in turn, are mutually conditioned, worthy of mention are the following:

- Energy resources available.
- The legal, normative and regulatory framework determined for the different energy productive chains.
- The institutional structure and organization of the energy industry.
- The main focal points and basic principles that govern energy policy and establish the vision and mission of the energy system in the context of the social and economic system.
- The character assigned to energy planning and the “model” for planning defined for the country (indicative, normative).

Energy resources available and their link with energy sustainability

Although in LAC there is an ample diversity of situations with respect to the availability of the resource in countries, on a schematic basis, the following are recognized:

√ **Surplus countries**, for which their priority objectives are directed to cover with their own resources their internal energy demand, and eventually, maximize profits by placing the exportable energy surplus.

√ **Deficit countries**, for which their priority objectives center upon the maximum possible development of the exploitation of their energy resources that are available and to assure reliable sources for external supply at the lowest possible cost.

√ **Balance countries**, for which their energy objectives tend to combine the reliability of priority internal supply, strengthening the exploitation of available resources and at the same time consolidating their foreign relations of supply.

On the other hand, there are social and economic factors such as income levels, social inequality, degree of productive integration, and the role of the energy industry in the external sector that would permit the identification of very diverse situations that, naturally have an influence upon the objectives of energy policy and on planning.

The challenges set forth by sustainability that admit certain indicators such as, energy autarchy, robustness when facing external events, energy productivity, energy coverage and use of renewables, will define the objectives of policy, and again, the nature of intervention and of planning.

The legal, normative and regulatory framework determined for different energy productive chains.

As developed in chapter VII of this Manual regarding Regulatory Frameworks, these answer to different starting conditions and diverse objectives of energy policy. However, as highlighted in that chapter: “The institutional energy framework in Latin America is principally characterized by having an entity, whether it be ministerial, a secretariat or a direction entrusted with the formulation of energy policies and the definition of the roles and responsibilities of the players in the sector in each one of the energy chains. Complementing the functions of policies, there are agencies that are in charge of the regulation and auditing of the different energy products, entities for the coordination of markets and stakeholders of industry, public, private or combined companies entrusted with managing and administering each one of the links along the productive chain, in accordance with existing policies and regulations.”

Under such circumstances, the responsibility for planning, as a tool of energy policy, rests upon the Ministries or Secretariats of the Executive Power that have not delegated such functions to any other organization of the State.

Basic lines and principles that govern energy policy and determine the vision and mission of the energy system within the context of the social and economic system.

Beyond this sectorial characterization, countries can define and have their national general strategic objectives that involve social, economic, geo-political and other aspects. These may be such as: the development of certain territorial spaces or population nuclei, the promotion of determined productive activities, protection given to certain environmental territorial aspects or determined resources, integration with other countries of the Region and others.

These national objectives of a structural nature and by definition considered as strategic, constitute important input information for energy planning. They will have a substantial incidence upon the results of planning, on strategies and on the consequent energy agenda and its ulterior application.

In some cases, such objectives are reflected in a **vision** as a referential framework for energy policy and planning that condition or even determine the institutional structure. [108]

The character assigned to energy planning and the "model" of planning defined for the country

The adoption of one or another modality of planning has influence upon and conditions the institutional nature as well as the qualification of human resources and the material means to put into operation the function that the state planning entity must play.

In chapter II, reference has been made to the different models for planning, recognizing:

Normative Planning: planning focus that privileges economic aspects, following technocratic criteria and that does not pay attention to questions of viability.

Indicative Planning: this refers to the formulation of a plan that represents, both at the global sectorial level as well as the sub-sectorial one, in its physical an economic aspects (production, investments) the desired evolution of the energy system from the perspective of the entity in charge of planning. This is a directive type of planning, for decentralized players.

Strategic Planning: With a different approach than the previous planning modalities, this focus includes mechanisms to continue constructing the political viability of the plan with its *strategies and actions and having a binding nature* in the sense that its implementation and execution will be verified in an effective manner.

VIII.6. The situation of human resources capabilities in the energy systems of the region

The evolution produced by global political actions generated energy transitions that have marked the evolution of knowledge requirements, methodologies and models able to face the challenges imposed by the real-world and the appearance of new problem-situations and of context.

In this sense, the development of human resources has been linked to energy policy strategies, in relation to the structure of the energy matrix, the objectives of independence and self-supply, the eventual technological niches identified and, of course, the different degrees of social and economic development, only to mention some of the most important elements.

Although the situation is quite different in each one of the countries, in that which refers to the productive chains of supply, it is possible to state that the availability of human resources in the electric sub-sector is in most cases superior to that existing in the fossil fuels sub-sector. Nevertheless, some countries have developed excellent capabilities in the area of hydrocarbons and are at the frontier of the state of the art in technologies associated to that industry. Others, likewise, in accordance with the provision of resources, have incorporated knowledge and the management of deposits and the technologies associated to mineral coal.

The case of nuclear energy is very special, since the complexity of the technology and the need of a prolonged maturation time on the matter to reach the phase of commercial installation of nuclear power plants implies that only a few countries have accomplished high levels of suffiency in corresponding human resources. However, in some cases, erratic policies on paper of this technology have produced setbacks in regard to individual and institutional capacities available and/or the need of a generational replacement in human resources.

In regard to non-commercial sources of energy, especially biomass, in spite of the importance of this source in the energy matrix of the Region, the available human resources are even less abundant than in the case of non-renewable conventional sources. Except in the case of those countries that have developed commercial programs for the advantageous use of bioenergy (especially related to transport), most countries still show incipient human-resources capacities in the set of vegetable fuels and their sub-products.

108 An example of a vision of the role of the energy system could be: *"The energy system will tend to secure domestic supply through the best use of locally and regionally available resources, contributing to the country's sustainable development (economic, social, environmental and political) under The guiding role of the State. Accordingly, special attention will be given to energy efficiency and to the search for a greater diversification of the energy matrix, incorporating indigenous resources, of a renewable character, with a greater use of labor, a greater impact on the productive activity, attending To preserving the environment and boosting regional integration. At the same time, the legal and institutional instruments for the development of the energy system will be adapted, taking into account the specific national characteristics.".*

In that which refers to new renewable sources of energy, their importance has grown. However, if it is desirable that renewable energies reach their true potential and impact the regional energy matrix,, it is necessary to carry out and/or deepen programs of investigation and development and for market stimulation and above all, to define "its own agenda" regarding the role of New Renewables in the energy matrix. That is to induce the market, and on the other hand, form and train human resources for the development of investigations and management of new technologies in the area. Importing technologies on renewable energy leads the country to be dependent on whom they import from, and the way to have control over the management of such technologies, is to clearly determined their niche and promote a greater local integration of its components.

Although in the Region exist training programs on renewable energy, there are multiple questions that must be answered so that the courses offered are useful to further the regional strategies for promotion of such types of energy. Consequently these should deserve a special and priority treatment regarding the strengthening and/or development of capacities.

On the other hand, the analysis and planning activities for every energy source and supply sector and the transformation and consume within the energy system as a whole require increasing strengthening. Therefore, it is necessary to have available, in quantity and quality, the necessary human resources to diagnose the structure and functioning of the energy system, in the global and regional contexts, for the purpose of implementing the processes of a comprehensive energy planning. The multidisciplinary complexity of the energy field makes it an obligation that the knowledge and contents of training plans and programs include all of the thematic areas and dimensions identified.

Although there do exist positive situations relative to the offer of training in basic sciences, it is necessary that the social, legal and environmental sciences play a more important role in energy planning (economists, lawyers, sociologists, anthropologist, biologists and other social and environmental sciences).

On the other hand, considering the diverse origin of those that face comprehensive training in energy planning, it is necessary to guarantee a leveling among those that come from different disciplines. Training programs must include for them, especially in the cases of masters programs or integral courses on energy, the topics in the basic aspects of each discipline so that the students coming from other areas of knowledge may also benefit.

Recent documents directed to the definition of an energy agenda for the Region (CAF, 2013), identify the challenges of the social and economic space to which energy systems must provide an answer. Among them, for example, it can be found the transfer towards emerging economies as the engine for economic development, the articulation of Latin America and the Caribbean to the global market with growing exports, and the rise of new paradigms for economic and technologic development, referred to as the Green Economy. Furthermore, in a region where 80% of the population inhabits in cities, the notion of "sustainable cities" implies the important need of an industrial and technological reconversion and a growing role of the renewable energy sources and of territorial organization. Likewise, energy efficiency, as an immediate option and the most cost-effective one in the short-term (CAF, 2013), is a priority issue to be addressed. Finally, these factors represent some of the challenges that require capacities and knowledge to be able to identify answers that are viable, feasible and above all, sustainable.

Relative to the energy systems of the Region, identified as necessary are human resources to manage the development of infrastructure facing a growing demand –especially in electricity- a deepening of opportunities and the potential for integration based upon the role that non-conventional sources would play (CAF, 2013).

These challenges are a real demonstration of the need of having a comprehensive vision and not a segmented one of energy systems, both from the analysis of energy services to satisfy as well as the possibilities of supply. There is only one energy, it is manifested in different forms and its content is in different sources, this does not imply isolated analysis that do not consider its integral nature, the multiple interactions, and its mutual conditionings.

In this sense, Latin America is able to achieve a more relevant role in the global economy and is able to substantially improve the quality of life of its inhabitants, an comprehensive development is required. Energy infrastructure must be a part of that focus. Among the multiple necessary lines of work, the strengthening of institutions in their various dimensions has been identified as well as the need for a comprehensive vision of the sectors, both of which have been identified as shortcomings of the Region.

We can initially conclude that the possibility of designing and implementing effective and viable public policies that will rest on the processes that energy planning requires under a systemic vision, and later capabilities in multiple disciplines that permit overcoming or avoiding imbalances or the potential imbalances existing in all of those components that comprise an energy agenda (consumption and supply, institutional nature of the system, different productive chains of industry, energy efficiency, social aspects, innovation and technological development and regional integration).

Although there has been considerable progress, there is still work to be done (CAF, 2013) that is related mainly to the politic definition processes and the elaboration of energy planning. In a greater or lesser measure in the different countries, the approach to all of these challenges shows limitations and determines the need for more capabilities development that can be individual, institutional and systemic in order to face the above mentioned challenges.

VIII.7. Development of capacities and potential of the Region

The challenges that the Region faces permit the identification of the principal factors that must be resolved or improved, relative to capacities in order to comply with the conditions for expansion and improvement of the infrastructure and its services.

Capacity development should provide an adequate answer to that which refers to: improvements in institutions and policies that regulate infrastructure sectors, in issues such as planning or institutional coordination and an adequate consideration of environmental and social aspects in the planning and execution of projects for infrastructure, as well as providing attention to the mechanisms for citizen participation (Ideal, 2011).

In this sense, the training of human resources for the energy system is expected firstly to be directed to consolidate formal and informal educational systems of the countries of the Region. Additionally, there should be a maximum use of existing capacities in the Region, taking advantage of the existing degrees of development in different countries and of the offer generated by regional organizations, such as the case of OLADE.

Training and development of capacities outside of the region is an instance that should also be considered, with an adequate selection of destinations and institutions where such training could take place. A prior period of contact and development of activities that signify an immersion in reality of the energy and other specific problems of the host country may assist in the selection of destinations and the answers that must be found. These guidelines in training refer, as in the case of energy, to those disciplines or activities in which the interaction with social and cultural and environmental conditions of the system to be applied to, are more pronounced and relevant.

It is clear that if there is the intention of forming specialist in a specific technique that is highly developed for its application in a concrete field (advanced exploration for petroleum, design of reactors for the nuclear industry, etc.), it may be convenient and necessary to have access to the most developed centers in the world, independent of their location.

If what is necessary is the development of experts in the approach and treatment of the energy needs of the Region, social-cultural conditions that have an influence on or condition the consumption of energy or the penetration of a new technology, the possibilities of developing a new technological niche or implementing structural reforms conditioned by the size of the market, perhaps the experience that exists in another country of the Region may provide the necessary formation to face the challenge and find an answer. This does not imply an isolationist or self-sufficient approach, but rather emphasizes a situation and reality that permit making a more advantageous and effective use of the different opportunities for training that exist in the Region and beyond it.

During the last two decades, the offer of training has significantly grown in LAC and together with pioneering institutions many public and private institutions have joined by offering graduate and post-graduate formation with excellent academic levels. This includes as well in the actual thematic training programms that are linked to environmental issues concerning climate change and aspects related to the social dimension of energy in the region. On the other hand, the global thrust of renewable sources, added to the endowment of different resources of the region, reveals a growing offer for training in this area[109].

Both in formal as well as non-formal education, the offer of courses, specializations, masters programs and the possibilities of development of doctoral thesis, it is possible to identify opportunities in the different countries of the Region to have access to training in any of the multiple dimension of the energy thematic, covering a high percentage of the needs for knowledge. In this scenario, there are multiple institutions of the Region that have developed and incorporated curricula for investigation, teaching and training including the different dimensions of energy matters, as well as its close link to other disciplines or areas of knowledge.

It is possible to state that, in what refers to abilities and knowledge necessary for energy planning, LAC may consider itself as self-sufficient, regarding the availability of such capacities in public and private training institutions., it is necessary that this specific knowledge is shared and transferred to the stakeholders and institutions responsible for the design and implementation of public policies. There is also the possibility of actions for cooperation and joint actions between institutions of the Region and also at the extra-regional level, which represent another instance that has become consolidated but continues to offer varied and diversified opportunities.

What has been previously stated does not imply ignoring the fact that since this is a continuous process, it requires a permanent updating of trainers and trainees (object of the development of capacities), that is to say a strategy for the training of trainers, in accordance with the evolution of knowledge, plus the challenges and new problems that the Region could face.

The location of the experience and capacities in permanent institutions, such as Universities and other independent institutions of the State, as well as those of the private sector, constitute a guarantee for the maintenance and sustainability of such resources, as well as their availability not only in the implementation of training activities, but as technical assistance and advisory entities for government agencies.

109 These aspects are addressed again later.

According to the needs, opportunities, possibilities and target groups, there are different options that must be considered. The available offers admit a first classification as formal or informal.

Formal education, also known as regulated formation, is the process of a correlated integral education that comprises from primary education up to high-school education and higher education that includes the deliberate and systematic intention that becomes concrete in an official curriculum, applied with a defined calendar and schedule.

There is an abundance of specialization courses and, in general, these are directed to knowledge linked to some of the components associated to energy systems, different segments of the productive chain, economy of regulation or the development of scenarios and models for prospective.

In the case of Masters Programs especially, these are formal degrees that have different orientations in line with the objectives or needs identified by the potential candidates. There are programs directed to a general formation in energy policies and planning or energy management, as well as other directed to specific productive chains. The Region has an abundant and varied offer[110], especially concentrated, by countries of a larger size and relative development. The great majority are located in Public and Private Universities and include varied curricula that reflects their orientation as well as the training objectives determined by such offering institutions. These courses are developed under one of the three most frequent modalities: face-to-face, semi on site and distance education.

In the case of non-formal education –a group of learning periods that are provided with the assistance of processes, media and specific institutions and under differentiated designs in function of the explicit objectives for training or instruction, that are not specifically directed to obtaining the degrees that correspond to the institutionalized educational system -, there is an abundant offer.

VIII.8. Modalities for training

There is a varied offer of different types of training: intensive; extensive; face-to-face; semi-on-site; at distance. These are available by countries; regions; dedicated to specific issues; short courses; seminars and workshops.

In general, masters programs are within the category of extensive training, in view of the number of teaching hours and the need of the development of a thesis, imply dedication during four to six semesters. A formation basically directed to policy and energy planning generally answers to the format of masters programs with an extensive nature. These can be face-to-face, semi-on-site or at distance. As previously mentioned, there are several Universities of the Region that offer this format directed to policies and planning or to the different energy productive chains.

Intensive training programs are directed to specialization courses in determined topics or introductory courses in matters of greater scope– Economics of Energy or the link between Energy and the Environment. In general, these are short courses lasting from one to two weeks and there is also an abundance of face-to-face courses, although also admitted are the categories of semi-on-site and at distance courses.

Short courses fall within one of the three modalities that are most frequent, where training at distance has been gaining favor, especially in that which refers to courses. Of course, all of the alternatives for training admit, as well as those that have taken place, the on-site and distance modalities.

The growth of virtual training (e-learning) offers even greater opportunities to access knowledge, especially linked to certain components of energy systems. Distance learning courses offer the possibility of taking advantage of the tools provided through the web and expand the access, reduce costs, maintain a permanent presence, expand the links between the experts of different countries and institutions and the access to trainers in the entire Region, among other advantages.

However, it is necessary to highlight that there is a permanent that regarding the convenience of resorting to educational models that do not demand presence. Far from attempting to resolve this debate, a comparative chart may set forth some of the elements that may permit us to adopt a position, and eventually, to make a decision. It is necessary to point out from the beginning, that from a more flexible position, it is not a matter of replacing traditional institutions by radically modifying the teaching paradigm, but rather to incorporate new alternatives to complement education, when the models that have been known for a short time, turn out to be insufficient. The following Table makes an effort to highlight the advantages and disadvantages of each modality[111]

110 In Annex I some of them are listed just by way of example to show the abundant supply of the region.

111 Analysis, discussions and disputes about distance education are very abundant and there are many documents on this subject. Consequently, of the concepts incorporated in the table must be considered some among many. However, they are considered to refer to the most important elements.

Table VIII.1: Advantages and disadvantages of the various training modalities

On-site Modality	
Advantages	**Disadvantages**
• Use of educational forms and models widely used and tested. • Permits an interaction with different members of the group. • Possibility of direct feedback from the professor (in real time). • Stimulates and develops dexterities and abilities for group work, as well as rules for coexistence.	• The quantity of information is limited to the resources available in the educational center and may be insufficient. • Although the relation with the professor is direct, it is not always individualized. • Implies the presence and travel of the student. • There are no sources available to be able to clarify a doubt or erroneous concept that may appear at the moment.
Virtual Modality	
Advantages	**Disadvantages**
• Surpasses the limits of the classroom. • Stimulates the use of new and different forms of learning. • Have excellent support tools for collaborative work, design, development and evaluation of projects, investigation, experimentation and interdisciplinary work. • Stimulates the development and use of dexterities for collaboration, communication and interaction. • There is available an extraordinary amount of information from the most varied sources. • Promotes self-learning and self-management, based on collaborative models. Study periods can be adapted to personal schedules. • All students have access to teaching, and are not affected by those who periodically cannot attend classes for reasons of work or distance. • Optimization of significant learning: at the same time assimilates other types of learning. • Saves time and money. The student does not have to go to the educational institution. • The student can receive a more personalized attention. • Expansion of coverage that improves the access to education, eliminating barriers of place and time, characteristics of a traditional education.	• Interaction only by virtual link reduces the communication band to a single channel, resulting in interpersonal relations that are shallower and incomplete. • May be slow, therefore a loss of motivation. • The quantity and quality of circulating information may turn out to be excessive. • The time that the professor and student require to navigate increases the demand. • The stability of the internet connection is not always possible. • Work methodologies are still immature. • Lack of evaluation of educational experiences with the use of Internet as a medium. • Lack of visible maps that permit the user to be guided in the information and avoid a saturation of information diversely presented, called cognitive fatigue. • For many persons that are accustomed to in presence education it is difficult to become accustomed to the virtual management of information. • If the student does not have experience in managing computer equipment it may be frustrating for the beginner. • There is access to sources in internet that at some moment may help to solve a doubt, but there are many sources that are not reliable or have been made public by persons that have errors in certain concepts, a matter that distorts the learning. • At times systems cannot be trusted to support the quantity of information that is sent in the form of videos or through a computer server that causes loss of signals or system failures that produce delays in the case of a videoconference or loss of data of the so-called “on line” exams. • Also since virtual education permits access to many more persons as is the case of a videoconference or a web page, it is also true that it is much more difficult for the teacher or facilitator to take care of all students when a doubt or discussion arises.

Source: Authors.

It is clear that both systems have positive and negative points, and it is also true that the applicability of each modality depends on the disciplines, the target group, of the knowledge to be provided, of the controversial aspects linked to public policies, of the specific needs of the environment and making an effort to get the best prepared professionals, with a critical spirit and a sense of responsibility.

On the other hand, the semi-presence modality is an intermediate point that has been adopted by many institutions, both in formal as well as non-formal education, with the objective of expanding its scope and facilitating access to the educational offer.

A not less important topic refers to the necessary didactic material. At the global level, there exists an abundant bibliography that includes all of the dimensions pertaining to the field of energy. This abundant literature includes a wide range of subjects: technical-economic and social aspects relative to the process of production-distribution of the different sources; conservation of energy; economy of natural energy resources; the manner to conceive the process for energy planning; the management of public companies of the sector; investment, price and tariff policies and those related to financing; the relations between energy and economic development; and more instrumental questions that range from the accounting models for the systematization of information to the more sophisticated models to forecast demand and the planning of supply.

However, it is not easy to find within this very extensive literature, works that lead to a reflection of the nature of what has been called the “Energy Economy”. Neither will it be a simple task to determine which will be the true object of that scientific discipline and which should be the theoretical and methodological principles that will guide its study. Also, the economy of natural resources encompasses a much wider set of problems that refer to those natural resources that can be advantageously used to produce energy. Consequently, this type of problems are not a part of the specific object of the Energy Economy, which must turn to the theorems and principles developed in a general manner within the framework of Political Economy.

Additionally, there is even less didactic material developed in and for the Region that is specifically directed to the social-economic, environmental, political, institutional and structural characteristics, among other aspects of the Region.

Therefore, the formation of human resources must include the development of didactic material for each one of the subjects, taking into account the “state of the art” and of knowledge at the global level to evaluate its applicability, the needs for adapting it and the development of new documents. The matter of language must not be forgotten, since this has become a growing demand in all areas of knowledge. Disadvantages associated with the use of materials in a different language than the mother tongue or training carried out in another language is notorious and lead to situations that can be considered as discriminatory.

Finally, it is necessary to remember that the training process is carried out not only through courses (formal or non-formal) or masters programs. The existence of networks[112] observatories, workshops, seminars, visits, and similar activities offer the possibility of having access to information or new knowledge following a less formal mechanism. Consequently, opportunities that are identified under these formats should be considered in the portfolio of potential training programs.

The offer of e-learning education provided by OLADE, deserves special attention, inasmuch as through these programs of courses, it covers an ample spectrum of the needs for the development of capacities of the Region.

CAPEV courses are offered in a coordinated manner, taking into account the different sub-regions, languages and schedules of the Member Countries and are principally directed to personnel working in Ministries and Secretariats of Energy of each one of the 27 States of the Organization. However, virtual training courses are also provided to personnel from companies, universities, labor organizations and other private agents involved in the energy sector.

VIII.9. Recipients of training

Reform processes in the energy sector that were implemented in many countries had two key effects on the structure of the State. In the first place, they created the need for new knowledge and abilities in relation to the new economic framework, new functions, a new scope of the decision-making process and new problems. In the second place, the process itself frequently diminished the capacity of the Government, especially in human resources, due to a contraction in governmental infrastructure and precipitated the transfer of the most highly qualified profiles to the private sector (Bouille and McDade, 2002).

In energy, as in other sectors, government agencies must guarantee the effective administration of policies. As will be later stated, the implementation of energy policies requires individual, institutional and systemic capacities directed to: the evaluation (diagnosis), identification of problems, definition and priority of objectives, identification of goals, development of strategies and a framework of shared power, to propose instruments, the implementation of actions and means as well as the management of tools to develop and

112 OLADE-driven networks for efficient use and access to energy are two examples of these means as a source of knowledge and training horizontally, based on mechanisms of cooperation and sharing information.

make analyses effective. Especially in those developing countries, it is possible that it may be necessary to re-evaluate the assistance provided to development and direct it towards the development of capacities for the design, implementation and monitoring of public policies.

We know that the planning process as an instrument of public policies, is an area of natural concern for the public sector, four important players are the potential addressees of the efforts deployed in the development of capacities, in accordance with their functions.

Macro-economic and development planners.

The aspirations for sustainable development of countries should be reflected in their strategies for development and in their macro-economic frameworks. Different interrelated policies must promote economic matters and compliance with the different objectives of aggregate policies (employment, stability, industrialization, etc.) that harmonize the opposing objectives of economic agents by privileging the common good. The need of achieving a sustainable growth and the role of the environment and of natural resources, both as inputs or due to the impacts that are received from such expected growth, run through all of these aspects and energy alternatives –especially those related to the sources, technological paths and systems for the provision of energy services -, due to different reason must be considered by planners at the macro level. These include the critical impact of energy in the performance of the social economic system, the interrelation between energy and natural resources, as well as the local, national, regional and global environmental effects of energy. Energy is essential to satisfy the needs of final consumptions and of productive activities and may be a critical factor in aggregate planning. To merely consider energy as an input in the functions of production and profit, is a very narrow approach that must be sophisticated within the global macro-economic context undergoing rapid growth.

Ministries or Secretariats of Energy

This corresponds to the area that is responsible for the definition of policies. The incorporation of economic, social and environmental aspects into such policies– exceeding the mere objective of energy supply – is a key challenge. The multiple links between energy and sustainability must be the primary objective of knowledge at the individual and institutional levels of the responsible agencies. The transfer of productive chains of the energy industry to the private sector, does not absolve the ministries from generating the guarantees and conditions so that those segments of the productive chains will efficiently comply with their functions in relation to the objectives set forth in policies. The consideration of the different energy sources and associated technologies represent a critical factor to satisfy energy services

The central executive area, although being the primary responsible and critical agent, is not the only stakeholder of the objective. Many policies require actions at other levels (Provinces, States and even Municipalities) that generally are to be found in a state of asymmetry and imbalance in regards to the central power. They do not have the same functions, capacities or responsibilities in relation to energy. The importance of each agency and its needs for the strengthening of capacities will depend on the specific legal systems of each country. In many cases, the local agencies (provincial) and their ability to act as such agencies providing support to national policies will depend on the assignment of central resources to the local levels, including training. Local authorities may be especially important in the implementation of certain strategies to achieve determined objectives, -rural electrification, -. Goals envisaged at the national level and the plans to achieve them may fail if there is no adequate capacity at the local level where such programs must be implemented.

Regulatory entities

The functions of regulatory entities are linked to the monitoring of compliance with regulatory norms. The regulatory framework must define the institutional characteristics and the roles of the different energy institutions. Conflict resolution between different stakeholders, interpretation of norms, the organization of public audiences to resolve conflicts or to socialize regulatory changes or tariff adjustments, constitute a part of the functions of these entities. These functions depend on the legal frameworks and jurisdictions established in federal systems that govern the energy system. Regulatory frameworks are an instrument or tool of energy policy, and consequently these must converge and be coherent with its objectives. The fact that these are relatively new functions and within a dynamic and changing framework, identifies them as priority stakeholders in focusing on the development of capacities.

Agencies for market coordination

Especially in the electric sector (and eventually in that of natural gas) market administrating agencies –in general wholesalers- have taken over new roles, responsibilities and mandates. The administration of the electric wholesale market –a function that not only affects the electric sector, but that also has direct impacts on other energy chains and the efficient functioning of consumption productive sectors, assuring thus the stability and predictability of a basic input for the production of goods and services. These functions must be clearly specified in the corresponding regulatory norms that have been determined by other stakeholders

Compliance with the objectives of sustainability requires new capacities, both in public as well as in the private sectors. That is, the development of these new capacities is not only a responsibility of the public sector. It will be necessary to establish public-private associations for the development of human resources, especially when facing the introduction of new technologies, clean and efficient, both in the supply as well as in the consumption of energy.

Public Energy Companies

Public companies must be considered as a means or an execution instrument for sectorial policies. A, perhaps significant portion of the policies to be defined, could be instrumented through the public companies of the sector. In consequence, the capacities themselves are important not only regarding knowledge linked to that specific area of action, but should be interpreted and made viable the strategies and actions that are defined in the corresponding area but that are implemented through companies.

An adequate harmony and coordination constitutes a part of the so called systemic or organizational capacity and if companies are the working arm of public policies, it is they who must screen and make viable the proposals that identify them as the principal stakeholders.

Therefore, their economics and energy policy staff training will facilitate the dialogue with the authorities responsible for the design and implementation of policies, permitting a common language and the necessary interpretation to cooperate in the implementation of such measures.

VIII.10. Abilities and knowledge required to face the challenges of energy planning: A tentative curriculum

The structure by chapters of this Manual could be taken as a milestones of the relevant knowledge and curriculum to approach the challenges presented by the design and implementation of an energy planning process.

In this sense, at least on a partial basis, such chapters can be considered as a list of issues and subjects necessary to comply with the different stages of planning. With this in mind, this section will include what can be considered essential training.

In addition to the training directed towards a specific policy and energy planning, it is necessary to recall that there exists basic knowledge on more general or connected issues that act as enabling elements that are necessary to be able to incorporate the tools and knowledge that are strictly connected with energy.

In this sense, it is necessary to consider contents such as:

- √ Elements of technology associated to the different sources, for those who do not have technical training
- √ Economy Elements
- √ Evaluation of Projects
- √ Statistics and Econometrics
- √ Economics of the Environment

The preceding list does not pretend to be exhaustive, and only has the purpose of highlighting the complexity and diversity of energy systems that require an initial introductory leveling and the search for a common language when it is necessary to approach matters relative to planning.

With regards to a directed curriculum, the following is a description of the most important subjects and components that should be taken into consideration, such as the capacities necessary to provide an adequate answer to the demands of energy planning.

Energy Economy

A multidiscipline called Energy Economy constitutes a conceptual framework of reference to be able to understand the functioning of energy systems. In addition, it may also constitute a necessary introduction to more ample or specific knowledge, that incorporate the initial structure to which such knowledge is articulated to, linked with the various dimensions of the energy field. Training in Energy Economy will imply a curriculum of basic titles that would include: the energy system and its link to the social -economic and environmental systems; energy accounting; requirements, energy consumption and demand; study of the supply of energy; price formation processes and revenues from Natural Resources; sustainable development and energy.

Energy-Environmental Information Systems

The basis and possibilities of action upon an energy system rest on a reliable information system and database that are kept up-to-date and complete the availability and management of an information system that implies having the necessary knowledge, especially for its management and the gathering of information. Directed to maintaining a fluid dialogue with the experts in Information Systems, the stakeholders responsible for planning must manage a set of knowledge, amongst which we could point out the following: types of energy information systems; conversion of energy and units; concepts and definitions relative to energy balances; different types of Energy Balances; links between the energy balance and energy prospective; accounting systems relative to environmental effects and climate change.

Economies of Energy Sources

Strategies, interventions and actions for planning have as a target group and important object, the productive chains of each one of the sources. Therefore, it is necessary to understand their principal characteristics, technical as well as economic and environmental.

Petroleum Economy: The most elementary titles in this area recognize: the Economic Geography of Petroleum; the Petroleum Chain: segments and links; the Petroleum Market and its evolution; the cost of crude petroleum and its revenues; institutional mechanisms for the exploration and development of oil fields; the Economy of Exploration and Development; the transport of crude oil and the market of its derivatives; distillation and the transport of by-products; the economic value of crude oil; financing of the petroleum industry; the environmental impact of the hydrocarbons sector.

Natural Gas Economy: Similar to the case of Petroleum, there exist some basic knowledge that should be incorporated, such as: the industry of natural gas and liquid gas in the world; the requirements of Natural Gas; the supply of Natural Gas; reserves, production and supply; the dry gas chain; distribution; programming of equipment for a gas system; determination of incremental costs; gas revenues; tariffs.

Electricity Economy: Electricity is the most dynamic secondary source, therefore its management and guarantee of supply is a matter of high sensitivity that requires a deep knowledge of the challenges associated to the different segments of its productive chain, as well as the dimensions associated to them. An introductory program to the Economy of Electricity could incorporate the following: Electric Energy in the World and in Latin America; characteristics of the Electric Sub-sector; demand of Electric Energy; Equipment for Production; transmission and distribution of Electric Energy; regulation of the system.

Renewable Resources Economy: The spectrum of sources and technologies associated to new renewable sources is quite ample. Without pretending that energy planners have a deep knowledge of each one of them, it is necessary that they acquire the knowledge that enables them to establish a fluid dialogue with the experts of the area.

Energy of biomass: The approach to Biomass requires a treatment that include issues such as: the competition for the land resource, social, environmental, economic and regulatory aspects; the forest chain; energy crops; solid Bio-fuels; Biogas and solid urban residues; Gasification of biomass; Bioethanol; Biodiesel.

Solar and Wind Energy: Together with Biomass, new sources of growing importance are making their appearance in the Region, as well as those of greater global growth, therefore, these constitute a component and an inevitable option in planning processes that strive to identify options for diversified energy matrixes. Minimum knowledge is associated for each one of them relative to: basic concepts and principles, identification, description, quantification of resources; state of development and perspectives; comparison with non-renewable resources; forms of use; potential; stakeholders; technologies; investigation and development, social and economic impact, environmental impact, strengths and weaknesses; integration; costs and financing; estimation of the solar resource, technologies, photovoltaic installations; isolated applications and those connected to a network. Costs. Present State and perspectives. Environmental Impact. Barriers. Likewise in wind sources: wind as a resource; aero generators; isolated installations and those connected to a network; wind energy and a calculation of generation; water pumping and other applications; costs: present state and perspectives. Environmental impact. Barriers.

Hydraulic Energy: Hydraulic energy is one of the most abundant energy resources in the Region with still limited levels of exploitation (less than 30% of the potential is being used). In large scale uses these have acquired a relevant dimension due to the social and environmental viability of such undertakings, as well as their vulnerability to climate change, considering the greatest impacts of this phenomenon in LAC that will affect water resources, the generalities of small sources of hydraulic generation and their uses; the evaluation of the resource; the generalities and functioning of a turbo engine; economic evaluation and environmental aspects.

Social-economic and energy scenarios, Prospective and energy models

Scenarios: The corresponding topic is full of the importance of the development of scenarios and the relevance that these have acquired as a method to conduct energy analysis. Therefore, this is a knowledge that must be incorporated to the planning teams, the minimum contents curriculum of which should include: procedures for the construction of scenarios; Types of scenarios and their applications; the elements of a scenario and its driving and dependent variables; techniques and tools for the construction of scenarios; methodologies for the construction of regional scenarios and global and sectorial economic aspects in the construction of energy scenarios.

Prospective and models: The development of scenarios, the methods of the prospective and associated models, constitute tools directed to reducing the inevitable uncertainty associated with the future and to identify robust options in the planning processes. An introduction to Prospective as an Energy Policy tool, as well as the information required for the preparation of such prospective and knowledge of the available models, are elements that compose this focus.

Energy Policy

The persons that are responsible for the energy planning teams, and consequently, central players in the design and implementation of public policies, will need to incorporate knowledge relative to: the nature of Energy Policy and its link to sustainable development, principles and criteria for the formulation of Energy Policy; its objectives, Instruments and tools; the process for the formulation of Energy Policy and the principal problems that energy policy presently faces; Public Companies and Private Companies. A material complementing this Manual is the “Practical Guidelines for Energy Policy Elaboration” which can be considered as a milestone for the training content on this topic.

The regulatory dimension

Regulation, prices and tariffs constitute two central instruments of energy policies. It refers to sensitive matters that require an adequate management on the part of planners. In this sense, the required knowledge by the economy of regulation is associated to: economic aspects of regulation; market failures (barriers to entrance, externalities and public goods); economic costs of energy industries; the costs of the use of non-renewable resources; the theory of disputable markets; theoretical framework on which are based the regulatory principles applicable to the industries of the energy sector. Likewise, it is important to keep in mind concepts linked to: the nature of the functions of costs that correspond to productive energy activities and of the factors that have incidence upon the structural efficiency of productive chains of the sector; use of the regulatory principles applicable to the different markets that comprise energy productive chains, as well as; criteria and methods used for the determination of tariffs and the costs pertaining to the links of Transport and Distribution of electricity and natural gas; analysis of international experiences and critical problems of the de-regulation of markets, among others.

The Law and legal components

Although legal aspects have a major specificity and are strictly linked to the experience of professionals, there are elements that must have a crosscutting level of knowledge, always imbued with the intention of facilitating a dialogue when faced with the multi-dimensional nature of energy. An introduction to legal aspects and of the energy law; the constitutional principles; energy and social rights; the role of the State; the doctrine of public service; the juridical regime of the different productive chains. Specificities and legal aspects of the segments and links and the specific aspects of Bioenergy will constitute the necessary knowledge.

Environmental law regulation

The environmental dimension has been comprised as a gravitating variable in the decision making process of energy policies and strategies. It is not possible to think about a planning team that does not incorporate environmental matters among its professionals. A review of the link between energy and the environment requires the approach to issues such as: concepts and scope of the environment as a system; the economic function of the environment and its links to legal frameworks; the constitutional principles; local environmental matters, national, regional and global; legal frameworks. The situation in Federal or Unitary States. Laws on minimum budgets. Environmental policies and management. Sectorial environmental laws and their application. Comprehensive management of residues. Norms. The management of Radioactive Residues. Environmental Liabilities and actions for remediation. International Environmental Law. From Stockholm to Johannesburg. The nature of the problem of climate change and its ethical dimension: justice and law.

Policies for prices and financing

Since energy is a base industry, its prices affect the total social and economic system, as well as the viability and sustainability of the energy industry itself. In consequence, price policy is a matter of significant importance and it is impossible to avoid its approach. Some of the elements to take into consideration on this subject are: the analysis of energy price policies; elements for a diagnosis of price policies; objectives of such a policy and the criteria for the determination of such prices; application of the marginal cost principle for determining electricity tariffs and their meaning and hypotheses; aspects linked to financing and the analysis of the effects of the different sources for financing, as well as the origin and magnitude of the investment fund, the role of development banking and special investment funds; external financing and the financing of public investment and its macroeconomic effects, among others.

Energy Efficiency

This is considered as the hidden source, the potential that it offers is very important and it is presently used in a minor portion. The consideration of efficiency in its widest sense. Opportunities offered in each sector. Barriers and their identification by categories. Autonomous efficiency and that which is induced. Institutional instruments and modalities.

Energy and poverty: Access to energy services

Social inclusion is a matter of growing importance. The role of energy in the alleviation of poverty is a matter that has an abundant bibliography but with results that are not in accordance with the level of the study of the issue. It is evident that proposals that will consider its cross-cutting magnitude are required as well as the acceptance that the contribution of energy is positive, provided that there exist other social conditions and other actions and social programs that incorporate the dimension of incomes, but that do not forget the needs of access to assets (housing, education, infrastructure, health, etc.) a matter that requires a complex design of policies for which it is necessary to be adequately trained.

Energy, environment and climate change

This is a systemic approach to the environment and its link to energy. Multiple interactions. Climate change and energy. Responsibility, emissions and principal sources. Mitigation: its meaning and possibilities. Opportunities for Latin America and the Caribbean. The vulnerable nature of energy systems and their adaptation. The instruments of energy policy directed to the environment and climate change. Global conventions and energy systems.

VIII.11. Potential profile of an energy planning team

The development of the chapter makes evident the need for multi-disciplinary profiles to face the complexity of energy planning.

As a matter of fact, the transversal nature of the subject, the multiple dimensions associated to the field of energy, the need of incorporating concepts of sustainability, the importance of planning under situations of a changing climate, a growing uncertainty within a global context of a greater dynamic nature, structural ruptures and of paradigms, the impression of finding ourselves in a process of energy transition, obligates us to incorporate themes, abilities and varied knowledge into a team that will provide an adequate answer for the planning of an energy system. Within the framework of its limitations, this section should be considered as a preliminary reference, and even a theoretical approach to the profiles that are required.

With the purpose of facilitating its presentation, a schematic matrix provides a summary of the experience necessary to face a planning process and to generate the results expected.

Table VIII.2: Matrix of profiles, experience and responsibilities

Task	Sub-task	Profile	Experience	Responsibility
Design and implementation of Public Policies		Energy Economist / Energy Expert / Development Expert	Vision, mission and objectives of energy policy process and stages. Sustainability and border conditions	Clarify the context of policies that serve as a framework of the planning process
Information Systems		Expert on Information Systems	Experience in the design, implementation and management of energy information systems	Development, maintenance and up-dating of energy information systems. Coordination Committee for Energy Information (See Chapter III.8)
Global and regional social and economic Scenarios		Macro-economist with experience in the design of scenarios	Global social economic trends, geopolitics, role of developed and emerging economies. Downscaling of global scenarios. Regional and national effects.	Define global hypotheses of growth and development and important social and spatial trends.
Global and Regional Energy Scenarios		Expert in Energy	Global energy trends, geo-politics of energy, evolution of resources and reserves, prices, expected tech-no logical development, structure of consumption by primary source of energy. Pro-ductive Energy Chains and their control. Potential processes for Integration.	Define global hypotheses of the evolution of energy systems, according to different scenarios.
National social and economic Scenarios		Macro-economist	Economic Development and Regional Development	Define hypotheses and growth guidelines of the National social-economic system in the regional and global contexts
National Energy Scenarios		Energy Expert / Energy Economist	Energy Matrix. Resources, reserves and energy technologies. Structure of Productive Energy Chains and expected trends. State of the Art.	Propose options for diversification of the energy Matrix. Hypotheses of scenarios by consumption by sector.
Design of Field studies and Surveys		Statistics/Econometrist	Design of samples, criteria and test statistics.	Assist in the development of surveys to supply and consumption sectors.
Analysis of Energy Consumptions	Residential Sector	Expert in that sector	Expert in energy services for the sector and equipment used.	Development of studies and surveys to determine consumptions by sources and services in useful and net energy.
	Industry Sector	Expert in the sector	Expert in energy services for the sector and equipment used.	Development of studies and surveys to determine consumptions by sources and services in useful and net energy.
	Transport Sector	Expert in the sector	Expert in energy services for the sector and equipment used.	Development of studies and surveys to determine consumptions by sources and services in useful and net energy.
	Rural Productive Sector	Expert in the sector	Expert in energy services for the sector and equipment used.	Development of studies and surveys to determine consumptions by sources and services in useful and net energy.
	Commercial and Services Sector	Expert in the sector	Expert in energy services for the sector and equipment used.	Development of studies and surveys to determine consumptions by sources and services in useful and net energy.

Task	Sub-task	Profile	Experience	Responsibility
Energy Prospective		Expert in Prospective	Methods and methodologies of energy prospective	Proposal of a prospective in line with different scenarios and hypotheses. Identification and definition of explanatory variables
Energy Models		Expert or Experts in Models	Models for simulation, technical and optimization coefficients. Integral, Sectorial or sub-sectorial Models.	Define the models to be used according to the objectives of the prospective and results expected.
Economy of Sources	Economy of Electricity	Sectorial Expert	Expert in the different components of the sectorial productive chain, its particularities, technologies and options by sources.	Analysis of technical, economic, financial, legal and institutional components, of the different segments of the chain and their link to energy consumption
	Petroleum Economy	Sectorial Expert	Expert in the different components of the sectorial productive chain, its particularities, technologies and options by sources.	Analysis of components of economic, financial, legal and institutional techniques of the different segments of the chain and links to energy consumption
	Gas Economy	Sectorial Expert	Expert in the different components of the sectorial productive chain, its particularities, technologies and options by sources.	Analysis of components of economic, financial, legal and institutional techniques of the different segments of the chain and links to energy consumption
	Coal Economy	Sectorial Expert	Expert in the different components of the sectorial productive chain, its particularities, technologies and options by sources.	Analysis of components of economic, financial, legal and institutional techniques of the different segments of the chain and links to energy consumption
	Nuclear Economy	Sectorial Expert	Expert in the different components of the sectorial productive chain, its particularities, technologies and options by sources.	Analysis of components of economic, financial, legal and institutional techniques of the different segments of the chain and links to energy consumption.
	Economy of New Sources	Sectorial Expert	Expert in the different components of the sectorial productive chain, its particularities, technologies and options by sources.	Analysis of components of economic, financial, legal and institutional techniques of the different segments of the chain and links to energy consumption.
Energy Efficiency: Technologies	Consumption sectors	Engineer	Expert in different technologies, uses and customs that are viable to improve the efficient use of energy.	Identify opportunities and technologic options and processes that permit improving productive efficiency and assignations.
	Supply Sectors	Engineer	Expert in different technologies, uses and customs that are viable to improve the efficient use of energy.	Identify opportunities and technologic options and processes that permit improving productive efficiency and assignations.
Energy Efficiency: barriers and instruments	Consumption Sectors	Engineer or Energy Economist	Expert in Public Policies of market Intervention.	Study and identification of barriers and development of strategies, programs and measures to overcome them.
	Supply Sectors	Engineer or Energy Economist	Expert in Public Policies for market Intervention on energy productive chains.	Study and identification of barriers and development of strategies, programs and measures to overcome them.

Task	Sub-task	Profile	Experience	Responsibility
Effects on Natural Environment		Environmental Expert	Knowledge of the effects of supply activities and consumption of energy upon natural and human environments (negative environmental externalities).	Identification of environmental effects of different options and strategies of planning that are proposed to reduce or prevent such undesirable effects.
Social Aspects		Energy Economist	Expert in the links between poverty and energy.	Incorporation of the social dimension in energy plans and proposals for strategies to facilitate access.
Energy and Climate Change		Expert Climate Change	Knowledge relative to the responsibility and vulnerability of energy systems facing climate change.	Incorporation of impacts of climate change on the energy system expected to reduce vulnerability (adaptation) and identify options de for mitigation.
Legal and Regulatory Aspects		Lawyer	Knowledge of legal and regulatory frameworks that have incidence on all the activities of the energy system.	Harmonization of the legal framework of energy plans or proposals for legal or regulatory changes that answer the proposal for structural changes in the system.

Source: Authors

It is evident that the preceding proposal should be only interpreted as indicative, since the structure and profiles of an energy planning area must be adapted and articulated to the characteristics of the energy systems of the country and the objectives of sectorial policies and their development.

VIII.12. Institutional aspects and implementation

On a similar basis as other subjects relative to public policies, the development of capacities to act upon energy systems requires planning, a fact that implies intervention.

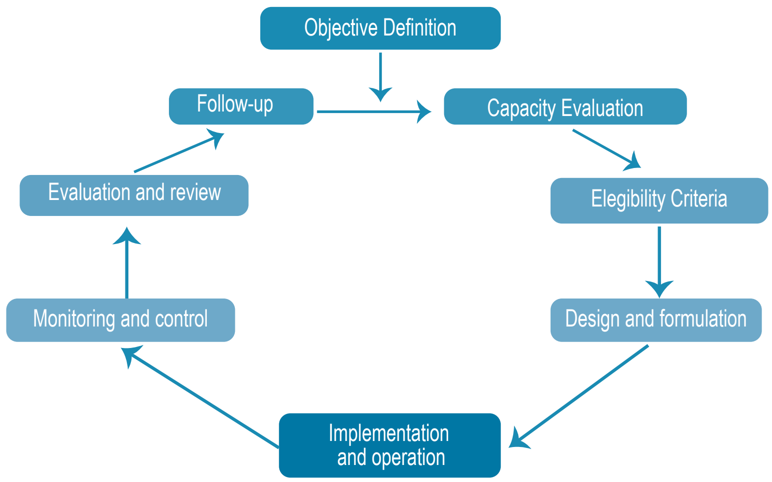
Training processes imply acting upon the teams in charge of policies, introducing new approaches and methods, demanding from them investigation and innovation and changes in perceptions and culture to improve making decisions and facing challenges. Any attempt to apply new concepts and methodologies, to attack the problems of development, in groups that have their own visions, experiences and interests is going to be met with a degree of natural resistance. Consequently, the development of capacities is a part of a long-term process and requires the commitment of the public sector throughout time. Short-term training activities will permit certain changes in the definition of policies or the development of analysis, but only a permanent and long-term attention will be able to produce the necessary changes in the energy systems.

A program for the development of capacities must be seen as a continuous process, that obviously must consider the context and environmental conditions in which it must produce changes. It must therefore identify barriers and restrictions that hinder such changes.

Such programs are quite complex from the technical and administrative point of view and require a comprehensive management framework. These may involve multiple institutions (Government, donating agencies, academic, NGOs) that must design and implement actions as a part of an integrated training plan. Such integration involves coordination, articulation, continuity, recognition that this entails a dynamic and dialectic process, as well as flexibility to introduce the necessary changes and the development of efforts as a part of a cyclical process. Figure VIII.3 illustrates the iterative process that has short-term as well as long-term dimensions[113]

113 The explanation of each of the components has been taken, in part, from the reference chapter.

Figure VIII.3: Cycle for the implementation of capacities



Source: Authors based on Bouille and McDade, 2002.

The starting point is the definition of objectives, that the clearer and more specific they are, so will be the concrete and positive results. Even though it may seem as a simple matter, this is perhaps the most challenging aspect of the process. If the expected results are clear, it will be much simpler to identify the stakeholders and the objects of the training, as well as the institution that could provide such formation[114] If we start with the expected result, instead of only strengthening the institution or the target group to be trained, the design process will be able to identify that which will be required in the training program that includes several stakeholders, and even more so, multiple institutions. It is evident that the definition of clear objectives requires a diagnosis that identifies the present situation of the area or topic, if there are failures or a lack of knowledge relative to consumption patterns (energy services) of rural residences, it could be possible to define a training program that addresses rural electrification, ignoring or misinterpreting the importance of thermal services –cooking and/or heating- and the needs of agricultural processes. The program would therefore be directed towards actions that would not address the priorities of the target population.

The *evaluation of capacities is* the next step in the process, with the purpose of determining the capacities that exist among the stakeholders identified. The country may have capacities in different institutions (academia, institutions for investigation, consulting groups). The evaluation could also identify the gaps at the individual and institutional levels and the needs for the creation, mobilization, improvement and conversion of the already mentioned abilities and/or experiences. A failure in this step could misdirect actions, and lead only to the creation of capacities where there is room for the mobilization and/or reconversion of existing abilities. This stage will generate a double result, to identify the subjects of training, that is the target group, but also the capacities with which they would be endowed, that is the means for the transmission of knowledge.

The *eligibility* stage refers to the establishment of criteria to be able to determine the range of participants in the program, in order to achieve the greatest impact of the effort. Criteria of eligibility will depend on the results expected (Objectives) and the minimum prior capacities required from the subject of such training. A training directed to individuals that have been poorly educated will probably not provide the expected results. Criteria may also generate a co-benefit of increasing the capacities by self-effort, and even increase the institutional commitment. On the other hand, these may serve as elements for the verification and evaluation of such training programs.

The *design and formulation* of such programs require the contribution of specialists in training, development of human resources and institutional management. The most relevant components in this stage refer to the selection of the institution that will provide the training, the budget and how this will be covered, and also an adequate calendar. As in the stage of the definition of objectives, the design and formulation will be simpler, when the expected results are clearer and concrete.

Implementation and operation may demand different degrees of experience. In this stage, the role of local institutions and experts, as well as regional experience are crucial. Implementation starts from the assumption that there is a good knowledge relative to the existing capacity offer at the national, regional and global levels, as well as the alternatives for financing. A lack of knowledge regarding capacities existing at the national or regional levels may imply a sub-utilization of existing capacities and a loss of the opportunity to increase and deepen south-south cooperation. It is understood that the demands for training rise from the needs identified in the countries (demand driven) to which the existing capacities for formation (objects) provide an answer.

Monitoring and control are essential in order to evaluate if the right path is being followed and if the correct effects are being produced

114 Potential products or outputs could be: introduction to instruments that improve the quality, accessibility and coverage of energy services, establishment of a new regulatory framework, mechanisms to expand rural electrification or to introduce new clean technologies, etc.

or if it is necessary to introduce adjustments and/or changes of direction. It is possible that the circumstances that gave rise to the demand for training may have been modified, and it may be still necessary that even good programs have to be changed. It is possible that the instruments that have been put into practice to achieve the objectives of the policy that gave rise to the training, have failed in complying with the expected results and must be mobilized or even drastically modified. This stage must be linked to the management of training budgets and resources, if there are changes in the policy or in the conditions of the environment, in order to introduce mid-term corrections.

Evaluation must involve those institutions that are not related to the process or program and that are not primary and directly responsible for the program. This does not mean that the evaluation must be totally independent, but it does imply that parties that do not have specific interests in the program may better analyze difficulties or the ensuing lack of success. Evaluation must specially analyze the stage of design and implementation and which were the results or changes produced. Evaluation is directed to immediate or short-term changes, but also must consider the long-term re-design of the program. It is needless to say that it must take into account processes to achieve maturity and the terms necessary for the materialization of the training results in changes of policies.

For the design and implementation of good training programs, it is useful to examine the type of problems that with certain frequency are encountered by such programs.

Potential difficulties that training programs face

√ Inadequate identification of needs and priorities (absence of an agenda that addresses the specific needs of training).

√ Acceptance of training "packages", in many cases offered without cost, but that do not have a direct relation with the necessary critical changes in a country or the priorities that must be dealt with.

√ Absence of a priority and consequently of a budget to maintain training actions in a continuous manner, offering sporadic and isolated actions or with a "stop-and-go" behavior.

√ In view of the crosscutting nature of many of the challenges faced by energy systems, answers must be coordinated among several institutions. The absence of coordination of policies generates an absence of coordination in the development of capacities.

√ Absence of a determination of areas of specific concern for government institutions, or the definition of a responsible or coordinating entity. In consequence there is the generation of management, policies and actions on a parallel basis but devoid of coordination, implying a waste of capacities, sub-utilization of such and a lack or poor definition of training needs.

√ In the search for external funds for the financing of capacities, there is an absence of collaboration between different government institutions that generates competition to obtain such foreign funds, and in many cases, this thwarts the access to such funds.

√ Inadequate assignment of resources due to a lack of a proper identification of existing capacities at the national or regional levels, directing the search to extra-regional institutions and "importing" knowledge, methods or instruments that have been designed for foreign realities.

√ Inadequate management of funds from financing or non-reimbursable, very often linked to the perception that since these are free goods, an efficient assignment of them is not made.

√ Lack of cost-effective evaluations in the selection of the subjects or objects of training.

√ Access to training offers, that under market conceptions, pretend to reach the greatest number of subjects, providing very wide approaches, which in many cases can only provide marginal contents of what the specific stakeholders require, in accordance with the problems they must tackle.

It is possible to conclude that programs for the development of capacities must be directed to strengthening the role of the State in the management of sustainable development, considering the relevant role of energy in such sustainability. In this sense, a key role is associated with institutional aspects. The development of capacities is particularly important in the design and maintenance of appropriate institutional frameworks, compatible with existing structure and practices in the process of policy decisions. However, it is necessary to provide training for new institutions that are required by the dynamic nature of the energy system and its link to sustainable development.

The institutional articulation stands as one of the critical factors in the implementation of effective policies for sustainable development. In reiterated opportunities and reports the institutional framework is considered as one of the most relevant barriers to achieve objectives of different categories (penetration of renewables, access to energy, substitution of sources, incorporation of clean technologies, etc.). Even in the existence of institutions with defined regulatory frameworks and roles, it is possible to observe a significant gap between the infrastructure and its functioning in reality. The effective functioning of inter-institutional coordination[115] and the governability of the system is a condition to assure coherence in efforts deployed and results expected.

An aspect with special significance to assure that the results of a process for the development of capacities is successful, is to guarantee clear mandates and spheres of authority within the government structure to assure that the relevant "staff" are competent and have the profiles and knowledge necessary to develop sustainable energy programs and follow the proper paths leading to development. A competent team is the result of a process that includes knowledge and experience to guarantee results and the governance of the system.

VIII.13. Sustainability, monitoring and periodic evaluation

As a dynamic and continuous process, the sustainability of the training development should be guaranteed with the corresponding financial resources and an adequate institutional framework that guarantees the permanence of the institutions where it is "installed" as well as the permanence of its duly trained human resources. The follow-up and evaluation of training processes is a complex task and has the influence of many factors that escape government controls and cannot be provided for at the start of programs.[116] Keeping the human resources or installing capacities in institutions that guarantee a long-term permanence, represents one of the greatest challenges.

Monitoring is a complex matter because it deals with an *ex-post* evaluation that must include more qualitative and quantitative elements, the quality of policies, and includes the quality of the process through which it is undertaken, the degree of obtaining consensus and the consequent acceptance of the policy. If the evaluation is only limited to the number of officials that have been trained, it will have little effect to contribute to determining if the results of the training have become concrete in policy proposals and if such policies achieved the results expected.

Indicators or benchmarks should be designed without forgetting that the design of a program in itself and the results expected, can condition the possibility of defining those indicators that measure the effectiveness of actions. A sufficiently ample program and without concrete and clear objectives, will find great difficulty in accepting indicators since these could "isolate" the project from other favorable or unfavorable circumstances for the achievement of specific objectives. The possibility of evaluating the appearance of events that were originally foreseen, could provide an opportunity to re-direct the intervention, in line with such changes of context that originally were not envisaged.

"In the development of national programs, a great deal of emphasis must be placed on the need of having a phase for evaluation and in the analysis of the reasons why problems have appeared. It is also essential, to pay special attention to the use of qualified personnel, the framework of incentives and the necessary management capacity for an effective linkage, motivation and keeping in office those duly trained persons" (UNDP, 1999).

VIII.14. Final considerations

The development of capacities is an iterative process that requires a long-term commitment, implemented through many short-term actions, including the dedication of resources and personnel from the public sector. To be effective, the efforts dedicated to the development of capacities must consider from the beginning, well defined results, objectives and goals.

The strategies for the development of capacities require realistic time horizons considering that this is a long-term process. The process implies recognizing the multiple levels that affect the actions of policies, including stakeholders not only beyond the public sector, but in addition to those that are outside of the energy system, in order to take into account those factors that may affect the restrictions of capacity and problems that will finally affect energy results.

The environment of enabling policies to support the effective functioning of the energy industry, technological innovation and the establishment of frameworks to achieve the social, environmental and reliability of supply objectives, cannot be created and maintained unless they receive special attention, funds and public policies to establish an adequate institutional framework and to form the necessary human resources for such enabling conditions. The needs for the creation and strengthening of capacities, and the long-

115 On the other hand, the range assigned to the policy-making authority conflicts with the barrier of inter-institutional dialogue and coordination, if the actors to interact have a different hierarchy in the ministerial structure. It is probably difficult for a Minister to accept receiving indications or requests from a Deputy Minister or Secretary of another government sector, considering that the dialogue should be in pairs. This situation is an obstacle for the implementation of actions that require the participation of more than one sector.

116 Expensive institutional development and capacity building projects have been frustrated when human resources (subjects) subsequently and for various reasons abandoned the institutions that sheltered them and left behind orphaned content institutions created for the implementation of certain public policies.

term nature that such process require, must be an explicit part of any successful strategy that is directed to the purpose that energy is an instrument leading to sustainable development.

The public sector, at the national and local levels, is the object and recipient of the development of capacities for the purpose of energy planning. The need of having a “Capable State” with enough capacities is not only a central matter in that which refers to sustainability and governance, but it must be a central objective of the energy system.

It must not be forgotten that compliance with the objectives of sustainable development is not resolved only through an improvement of the capacities of the public sector, but as well, since the private sector must also introduce substantial changes. The private sector must be considered under an ample focus, not only in the energy industry, but also other players, especially in the financial sector as well as equipment suppliers. The development of capacities in the private sector does not constitute a full responsibility of the public sector, but it must be necessary for the development of public-private actions leading to a convergence in the viability and feasibility of actions.

The definition of priority areas in the planning process must find its complement in training priorities, access to energy services in rural areas, by means of modern sources of energy, and it constitutes a matter that is still pending in many countries of the Region. If this was a priority objective, the need of creating and strengthening technical, institutional and even entrepreneurial capacities to provide support to actions, must be implemented. It could be necessary to plan the development of alternative programs or actions specifically directed to such objectives of development that may require special abilities and knowledge and even the contribution from other disciplines of knowledge, that perhaps are not usual in urban areas or for other productive sectors. The matter of gender, of growing relevance, could be another of the elements that make necessary very specific capacities, in accordance with social and cultural conditions, as well as other aspects.

The traditional approaches to the development of capacities in the scientific and investigation community are generally focused on education and training, which when narrowly defined could be inadequate to generate the necessary profiles to innovate, adapt and apply new technologies directed to promoting development and growth.

Present pressing needs set forth at the global level to develop, adapt and incorporate technologies to mitigate the emissions of GEG and to adapt systems to the new conditions arising from climate change, are finding a barrier of great magnitude in the design of adequate public policies. This situation reveals that the knowledge upon which are based the proposals to overcome barriers, are perhaps not the necessary ones. A better knowledge and application of new tools, methods and methodologies could contribute to a better approach of proposals and policies.

It is necessary to reiterate that training is a continuous process, where discreet short-term actions feed this process sustained through time. The agenda must have a proper nature, domestically defined and if possible, financed with the state´s own resources. The follow-up process and indicators of verification of compliance with objectives should be a part of the design of the training program in order to guarantee that it is possible to evaluate the contribution of the program to sustainability.

The different stakeholders involved in the necessary process, must be identified and their role clearly established as subjects (purposes) of training, as well as the objects (means) of it. If limited resources are available for this identification, it is important to define priorities and direct the training towards those agents that are considered as more capable of providing a greater contribution to compliance with the long-term objectives defined.

A favorable framework and positive contribution to the development of capacities may be found in the networks that presently exist in the Region or in the generation of new institutional networks. The examples of existing networks that have been driven by OLADE, in efficiency, renewables or access to energy have proven to be an efficient mechanisms for horizontal cooperation that should receive a greater support and contribution from international cooperation.

Precisely when referring to international funds, the contribution of regional development entities should focus on those institutions and stakeholders that are capable of incorporating the necessary changes into energy systems, surpassing the dues and contributions focalized on. Support provided to permanent institutions and to their strengthening, especially –but not only- to those which are the object (means) of training, will represent a solid contribution to the development and maintenance of the capacities in the Region. In many opportunities, contributions associated to projects emphasize the aspects of the selection of technologies and, if they contain training components, they are well directed to the technologies that are the object of the project. Especially, those multilateral agencies that provide assistance to development, must expand the scope of their actions, supporting the development of capacities for the design of viable and feasible policies that will contribute to sustainable development. Aspects such as the link between energy and poverty, environmental aspects, not only global, but also local, the identification of technological niches that broaden the effects of the development of the energy industry, the development of infrastructure and other aspects identified by the countries as of a priority nature.

Finally, and as a strong guiding principle, the identification of the needs of the countries must rise from the countries themselves.

GLOSSARY

Air Contaminant: Any substance directly or indirectly introduced by man into the air environment that may have noxious effects on human health or the environment as a whole.

Analysis of Sensitivity: Consists in evaluating the impact of the variation of a parameter (input data) on the results. In the event of evaluating a thermoelectric installation, it is possible to evaluate the impact of the variation of fuel prices on the leveled cost of electricity.

Analytical Method: This is precisely characterized by being based on a structural approach that strives to establish a difference of the sets of consumers in function of the set of space-environmental, social-spatial factors, energy supply conditions and social conditions.

Approaches to the Planning Process: Taking into consideration that in the social and historic stages different conceptions existed in favor of the policy for intervention and/or for planning, going through a normative, indicative approach, also the total negation of said intervention and the need of undertaking a strategic planning.

Availability: Certainty of producing power at its full capacity at the precise moment when the load dispatch so demands it.

Best techniques available: The most efficient and advance phase of activities and their modalities of exploitation, that demonstrate the practical capacity of certain techniques to in principle, constitute the base line of the limit values of emissions destined to prevent or when this is not possible, to reduce in general the emissions and their impact on the entire environment and the health of persons.

Biomass: Organic material mass of a non-fossil biologic origin that may be advantageously used for energy purposes of for the generation of electricity. Although the different forms of from biomass are always considered as renewable, it must be indicated that its index of renovation is variable, since it is conditioned by seasonal cycles and daily solar flows, weather variations and the growth cycle of plants.

Bottom-up: Prospective energy analysis, approached with models for which it is necessary to have available information on energy consumptions, in a disaggregated manner at the level of a homogeneous group of consumers, that is: energy services, technology and energy source used.

Capacities of the Work Team: Those that tend to favor the processes of interaction and cooperation.

Census: Determination of the number of individuals that comprise a statistical population, defined as a set of elements of reference upon which observations are carried out.

Co-generation: Simultaneous production of electric and thermal energy, using a single fuel. This type of combined production of electricity and heat achieve a much higher Energy Efficiency than the traditional systems.

Construction of Viability: This is the process of an analysis of the viability of the planning process and/or energy policy, examining the possible reaction of the pertinent principal stakeholders.

Contamination: Direct or indirect introduction, by means of human activity, of substances, vibrations, heat or noise into the atmosphere, water or soil, that may have detrimental effects on human health or the quality of the environment, or that may cause damage to material goods or deteriorate or hinder the enjoyment of other legitimate uses of the environment.

Continuity Scenarios: Are those that can be constructed by means of a reasonable projection of present trends. In these scenarios there may exist certain discontinuities that are not able to affect significant variables.

Control of the Planning Process: Analysis deviations of the concrete actions of stakeholders that are entrusted with planned actions and potential reformulations necessary with respect to strategies, instruments and goals.

Cost plus: Cost plus a margin, using the general formula that adds a margin (Mark up) to the base cost, as a starting point for the decision of the determination of prices.

Delphi Method: This is a technique for the selection of scenarios that consist in the ex-ante evaluation of a set of conditions that assigns conditions of bands of probability to infer the possibility of occurrence of determined events. It makes an effort to express a quantitative order the appreciations and preferences of a group of persons relative to the set of previously constructed scenarios.

Demand Management: Actions or measure leading to the reducing the concentration of demands in a specified hour band with the purpose of increasing the load factor in a system.

Development of Capacities: Process for the creation, mobilization, improvement and conversion of abilities and experience, institutions and contexts to achieve specific objectives, in this case, the implementation of adequate planning processes.

Dimensions of Energy Sustainability: Environmental; Constitutional/Legal; Cultural/Environmental; Economic; Strategic; Spatial/Territorial; Institutional; Material; Human and Animal Health; Social and Technological Security; Temporal, without this list attempting to be exhaustive.

Distribution: Activity dedicated to the distribution of electric energy or fuels, as well as the construction, operation and maintenance of distribution facilities.

Distributor: Mercantile society that has the function of distributing electric energy or fuels, as well as constructing, operating and maintaining the installations for distribution destined to place the electricity or fuel at the points of consumption and to proceed to their sale to final consumers that purchase energy at a tariff or from other distributors. Each distributor has assigned a geographic zone under franchise with monopoly conditions (strongly regulated by the State). Distributing companies are under the obligation of providing free access to their networks in exchange of access tariffs that are regulated by the State. This is of special relevance for the qualified consumer that exceeds the tariff and prefers to contract its supply from a different Marketing company that has a generator or has free access to the market.

Eco-rate: Rate established with specific purposes, as an instrument that permits the materialization of the principle, "he who contaminates, pays ", internal, that is including those that have their origin in measure for the protection of the environment in the total costs of the production process of a determined good or service.

Ecologic Damage: Any type of important physical, chemical or biological degradation of the Environment.

Ecology: In a very ample sense, it is the science that studies the mutual relationships between organisms with the environment, and investigates both the interrelation of the organism with the physical scope as well as the biological one.

Ecosystem: Area or determined natural set of lands. In its natural conditions, it is not an autonomous, static and in balance entity, even in the case that upon it there is no incidence of human factors. Its balance is of a dynamic type, existing a permanent exchange of material and energy among its materials and living communities.

Electric Balance: Summary of the principal flows of the electric sector in a specified period, such as: demand, exchanges, losses, generation and fuel consumption.

Electric Demand: Instantaneous requirement of an electric power system, normally expressed in Megawatts (MW) or kilowatts (kW). When the concept of electric demand is generalized to the quantity of energy during a determined period (GWh), the temporary information of instantaneous demand is lost.

Electricity spot market or cash market: Market in which the physical delivery of electricity negotiated is immediately carried out or during the first two days following contracting and simultaneously with a cash payment. It is also an in-cash market for raw materials.

Wholesale electricity market: This is an organized and a free market. The first operates on the basis of offers of supply-demand of energy made by market agents (generators, distributors, Marketers, external agents and qualified consumer). The second operates by means of physical bilateral contracts, between producers or external agents and qualified consumers or also external agents.

Emission: Expulsion into the atmosphere, water or soil of substances, vibrations, heat or noise proceeding from, in a direct or indirect manner from specific sources in a concentrated or disseminated manner or from the installation.

Energy Accessibility: Capacity of the energy system that allows the final user to have material access to energy.

Energy Accessibility: also means that the energy thus offered can be paid by the final user.

Energy Balance: Accounting system of the energy flows of a country or Region and includes all energy sources and all of the processes to which energy is subject to.

Energy Consumption: Quantity of energy that is used in a social and economic system.

Energy Dimension: Scope or reach within which a variable or group of variables characterizes the energy state of a country or Region.

Energy Efficiency: Quantitative relation between a productive performance (goods, services, energy) and inputs of energy.

Energy intensities or specific consumptions: Consumption of final energy final per unit of the explanatory variable.

Energy Resilience: Capacity of an energy system to absorb impacts/contingencies, and to provide a rapid response to interruptions in the provision of energy services. When it refers to electric systems, it refers to the capacity for rapid recovery from failures or eventual issues in its operation.

Energy Services: Activities and their results that are related to the use of energy to satisfy final or productive needs.

Energy: Energy may be defined as the capacity of a system to produce an external activity of performing work. The word is usually used to define the transporters of energy products such as electricity, fuels, vapor, compressed air and others similar.

Environment: Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, human beings and their interrelations. At a given moment, the set of all conditions and influences to which a subject or object are submitted to.

Environmental effect in the short, medium or long-term: That effect, the incidence of which can be respectively manifested, within the time included in an annual cycle, before five years, or in a longer period.

Environmental Impact Evaluation: Is the process of analysis directed to predict environmental impacts that a project or activity would produce in case of being undertaken, with the purpose of establishing its acceptance, modification or rejection.

Environmental Impact: Any change in the natural or human environment, be it adverse or beneficial, resulting entirely or partially from activities, products or services of an organization.

Environmental Quality Standards: Set of requirements established by applicable norms that must be complied with at a given moment and in a determined environment or in a specified part of such environment.

Evolutionary Scenarios: Include certain perspectives that are sustained on historically atypical behaviors, without reaching the point of being considered as “of rupture”.

Exogenous Data: Corresponds to the variables that are independent in a model. In models for optimizing the expansion of the electric energy generating, such as SUPER-OLADE or MESSAGE models, demand enters the model as data, once it has been externally generated.

Expansion: Indicates a forecast in the composition of the future energy matrix, it is directly related to the evolution of energy infrastructure (capacity to be installed) and the flow of investments. The expansion usually considers criteria such as minimum cost, diversification of the energy matrix, rational and efficient use of resources, energy security, etc.

Final Energy: Quantity of energy that enters a unit of consumption (home, establishment, vehicle, etc.) that is the energy that satisfies the needs of consuming sectors. It refers to Net Energy less that consumed in the Energy Sector itself.

Fixed Measurements: Measurements of contaminants that are taken at specific locations, either in a continuous manner of by means of random samplings, considering that the number of measurements thus obtained, are adequate to determine the levels observed.

Fossil fuels: Different types of carbons (local or imported o), derived from petroleum (gasoil, fuel oil, petroleum coke...) and natural gas.

Frequency of formulation of planning: As well as the characteristics of the entities of the offices entrusted with planning, the frequency of its formulation is different in the various countries. However, the most usual one is a five-year frequency.

Global Energy Analysis: This is an essential element of diagnosis for energy planning that determines a systemic vision of the energy sector, identifying the crucial elements for the planning process.

Goal: Defines in a qualitative manner the partial achievements relative to a specific objective.

Greenhouse Effect Gases: These are gases the presence of which in the atmosphere, contribute to the greenhouse effect. The most important ones are present in the atmosphere in a natural manner, although their concentration may be modified by human activity, but also included must be concepts relative to certain artificial gases, that are a product of industry. These gases contribute in a net manner to increase the greenhouse effect due to the structure of their molecules and in a substantial manner, due to the amount of molecules of the gas present in the atmosphere. The GHG are: Water vapor (H2O), Carbon Dioxide (CO_2), Methane (CH4), Nitrogen oxides (NO_x), Ozone (O3), Chlorofluorocarbons. Numerous scientists have warned that the global warming of the planet that is produced by these gasses is principally generated by the burning of fossil fuels, such as petroleum, natural gas and coal, for the production electric energy or the final consumption of energy.

Gross Energy: Is the total energy consumed by an energy system. That is to say that it includes all of the losses incurred in transformation, transport, transmission and distribution.

Holistic Capacities: be able to observe systems as a whole. Require instrumental and interpersonal capacities, and it is necessary that the individual must have the capacity of seeing the entire vision.

Horizon: Corresponds to the time limit for which are built projections and/or scenarios, it indicates the end of the period of study.

Hydroelectric Dams: infrastructure works constructed with the purpose of storing water for the generation of electric energy.

Hydroelectricity: Is that which takes advantage of water currents and differences in heights (waterfalls) to transform it into hydraulic energy; with which it is possible to generate mechanical energy (turbines), that serve to produce electric energy.

Image Objective: Characterizes the situation desired by the planner of energy policy and it includes the definition of the objectives that are desired to be reached by means of the political intervention.

Inmision: Concentration of contaminants in the atmosphere at the level of the soil (environment), both of noise, vibrations, light, heat and radiations as well as of other factors of the environment to which beings are exposed to, as well as animals, plants and other materials.

Implementation of the Planning Process: This is an examination of which are the stakeholders in charge of carrying out the specific actions of the process and their rational nature, compared to the strategic objectives proposed in the planning process.

Indicators: This is a quantification of the degree of compliance with defined goals in relation to a certain specific objective established by energy policy and/or for the planning process of a qualitative information linked to institutional aspects of the latter process.

Instrument: Element that provides operability for a strategic line related with a specific objective and indicates “by means of which” the transit from the present problem to the established objective is undertaken.

Instrumental Capacities: Those that have the nature of a tool with the end purpose of establishing adequate and leading procedures.

Integration of Plans: This is a task that consists in analyzing plans and economic, social and environmental projects and introducing into them the hypotheses regarding the variables to consider in the construction of scenarios destined to energy planning.

Interconnection: Electric connection between two areas of control, where it is generally possible to quantify flow. A term commonly used for the international links for electricity exchanges.

Interested Party: Individual or group related to or affected by the environmental activities of an organization.

Large combustion installations: Very general denomination that includes from incineration plants up to thermoelectric power stations.

Law: A norm that has been approved by the Courts, submitted to the approval of the President of the Government and duly sanctioned and promulgated and its publication ordered in the Official Bulletin of the State.

Level of emission: Quantity of contaminant emitted to the atmosphere by a fixed or mobile point, measured in a unit of time.

Level of inmission: Quantity of solid or gaseous contaminants, measured by unit of volume of the layer of air up to an altitude of two meters from the soil.

Leveled Cost of Electricity: This is the cost of energy generated (USD/kWh) if all costs are considered throughout the useful life of then plant for the generation of electricity. This is calculated by knowing the total energy and the total costs throughout the useful life of the plant, by using financial techniques to analyze costs.

Limit Value of Emissions: The maximum mass or concentration of an emission, the value of which should not be exceeded within one or several determined periods.

Limit Value: Level that must not be exceeded, determined on the basis of scientific knowledge, with the purpose of avoiding, preventing or reducing the negative effects on human health and for the environment as a whole.

Load Curve: Graphic representation of the evolution of the demand for power in function of time.

Load Dispatch: Diagraming of the operation of the different units of generation in order to satisfy projected electric requirements, maximizing the objective set forth (generally the minimum total operative cost) and subject to operative restrictions of the system and the availability of resources.

Load Factor: Quotient between consumption in a period and the maximum consumption that would have been possible considering the maximum demand load of the period considering the maximum load that would have taken place throughout the entire period.

Loads: Demands for power.

Long-term. Includes the time required to reach maturity of investment projects that are generally used for the expansion of capacity of energy systems when these are planned. A time period during which, production factors may vary.

Management Capacity: Refers to the ability of individuals and institutions to develop and implement decisions and actions in an effective, efficient and sustainable manner and be capable of transmitting them, as well as awakening the critical constructive spirit in relation to the proposals received.

Market of Emissions: Method to control the emission of greenhouse effect gasses of an anthropic origin. As a consequence of the Kyoto Protocol, there was the rise of an emission market that permits companies to buy and sell emissions credits between themselves; those companies that cover their obligatory quota may sell their surpluses to those that exceed their quota.

Marketing Agent: Legal person that has the function the sale of electric energy to those consumers that have the condition of having qualified or being eligible or other subjects of the system. During a transitory period, marketing at comprehensive tariffs (consumers that are NOT qualified) must be carried out by distributors in a regulated manner.

Marketing: Activity that is linked to the purchase of electricity or fuels on a wholesale basis (made to a generating company or in a wholesale market) and is sold on a retail basis (to a qualified consumer). This is an activity that is generally open to competition (free offer price + tariff to the access to the network).

Matrix of Reaction: This is a Matrix that translates in a qualitative manner the reaction of social stakeholders in relation to the proposal of policy and/or actions foreseen in the planning process.

Medium-term: This is an intermediate period between the long-term and short-term.

Model - Econometric: These are models that use statistical tools to explain a dependent or endogenous variable, demand for energy, based on other variables considered independent or exogenous, GDP, population, etc.

Model - Of partial balance: In view of an exogenous demand, this type of model strives to find a balance on the side of the supply, which is the reason for the name of “partial balance”. These models do not guarantee an inter-sectorial consistency, since alterations in the configuration of offer do not have an effect on the values of demand. These permit an evaluation of the evolution of the offer of energy (expansion of the energy matrix) in view of the evolution of the demand for energy (in the medium- and long-term) in a scenario that describes the hypothetical evolution of different economic, social and technological factors.

Model - Parametric: Parametric models are those that analyze a technology or an energy system with a high degree of detail, analyzing each technical, economic and environmental parameter in a particular manner. Parametric models simulate in careful detail, the components of an energy plant or infrastructure, the model of a photovoltaic system will consider the inclination of the panel, its direction, the efficiency of the panel, the type of photovoltaic cell, etc.

Models - Integrated Model: this is a multi-sectorial model where any variation in one of its sectors affects/has an incidence upon the other sectors modeled. There is the modeling of several sectors (energy, use of land, etc.) and sub-sectors (energy sub-sectors such as electricity, petroleum and gas, refining, bio-fuels, transport, etc.). Generally there is the modeling of all energy chains for each energy product. This way it is possible to select the optimum combination of energy sources to provide proper attention to the demand for useful energy. The results of the sub-sectorial models serve as input data for integrated models.

Models - Sectorial/sub-sectorial Model: A sectorial model is the representation of a sector of the economy, the energy sector. Sub-sectorial models are mentioned when referring to segments of the energy sector, electricity, petroleum and gas, refineries, bio-fuels, etc.

Models – Of General Balance: These are the models that guarantee that all of the demand of consumer sectors is satisfied by the supply, during the period of the horizon, including the analysis, in addition to the internal supply the possibility of imports and exports. In these models, supply and demand are endogenous and a variation in the configuration of the supply may also signify a change in the values of the demand. Generally, it refers to models of the type of Matrix inputs – product, and which guarantee inter-sectorial consistency.

Models - For Energy Planning: These are instruments or tools that permit the modeling of energy systems, whether it merely involves a technology or the entire chain for the transformation of energy, from its extraction at the energy sources up to its final use, throughout production, transformation, transport, distribution and storage. The results thus generated serve as an input for the decision making process during the properly said energy planning process.

Modifiers: Are those factors that could affect in quantity and quality the scenarios that serve as a basis for the adoption of prospective solutions within the scope of the energy field.

Modules – Homogeneous Modules: Relatively large groups of sets of consumers that present a reasonable characteristic of similarity in that which refers to their requirements, both in what pertains to their present conditions as well as their dynamic behavior towards the future.

Monotone or Orderly Load Curve: Representation of the evolution of power in a period that has been ordered from greater to lesser without awarding importance to the moment of its occurrence within such curve.

Natural Gas: Mixture of gaseous hydrocarbons (principally methane) that is produced from underground deposits and the production of which may be associated to that of petroleum.

Net Energy: Is the Gross Energy from which have been deducted all of the losses arising from transformation, transport, transmission and distribution.

Network Losses: These are the losses of electric energy that are produced by its transport and distribution principally due to the Joule effect of dissipation of conductors in the form of heat.

Objective: A situation that is projected to be achieved with the intervention of a policy. It constitutes one of the elements of the image of the objective.

Operation: The term operation is used to describe the functioning of the present energy system in the short-term. In the case of electric systems, this is related to the daily planning of the dispatch of the electricity generating plants.

Optimization: Consists of maximizing or minimizing an objective function subject to certain restrictions. In the particular case of an energy system, this technique is used to optimize the expansion, operation and/or investment. Optimization guides a combination of "preferred" technologies (or the assignation of production factors) in relation to the chosen goals for optimization (less cost or maximum private consumption) subject to certain restrictions (maximum investment capacity that can be modeled as a restriction of the maximum capacity to be installed, tax levels, etc.). The mathematical tools for optimization commonly used are lineal programming (LP) and dual dynamic programming (DDP).

Options- Reduced and Encompassing: These are the scenarios –not more than two or three – that the project team selects to present the visions of the future relative to which there is a recommendation to develop strategies. The scenarios, thus obtained permit the preparation of plans and their alternatives. This selection does not necessarily lead to the determination of hierarchies, and in certain cases the option is to select two, one is a basic scenario, with trends, and an alternative that is superior. In any event, the selected scenarios must be verifiable.

Parameter: This is data that is considered as essential and offers a guide to being able to evaluate or assess a determined situation.

Parties involved in the planning process: Social stakeholders that participate in the different stages of the process, highlighting public entities in the stages of formulation, control and revision; public and private stakeholders in the implementation stage.

Peak, or Point Load: Power demanded during the hours of maximum demand.

Perfect Foresight: Expression used to indicate the optimal evolution of an energy system until the end of its horizon that goes follows the only optimal path. This optimal path will vary in function of the analysis horizon.

Petroleum: Mixture of hydrocarbons and other components of carbon and hydrogen, and in lesser quantity, sulfur, nitrogen, oxygen and with the presence of other elements (Ni, V, etc.). It is found in underground deposits in a liquid state, impregnating permeable and porous rocks, generally subjected to very strong pressures.

Planning - Energy Planning: Process that leads to the operative specification and concretion of an energy policy of which it constitutes a fundamental tool for the achievement of the objectives set forth.

Planning - Integrated Planning of Resources (IPR): IPR is an ample approach to planning that involves the analysis of the minimum cost and actions for the management of demand. This approach considers direct and indirect costs, a multiple criteria analysis, examines the social, economic and environmental impacts of management and studies the expansion of supply by means of alternative scenarios. Additionally, IPR includes community participation during planning, the decision making process as well as the process for its application represents an important component.

Planning - Strategic Planning: This is an approach of a binding nature in the sense of defining a set of actions that must be carried out, either by the stakeholders that operate the system /or by a subsidiary action of the State directly and/or by means of its public companies.

Planning Scenario: Imaginative construction of the relevant structural context that will frame the energy reality under study, within a determined future horizon. This is a hypothetical construction, based on behavioral hypotheses of rationally possible structural behaviors. A simple and summarized expression, but requiring a complex preparation, that defines possibilities and not probabilities of occurrence. Permits reducing the uncertainty factor in making decisions.

Plant Factor (or of utilization): Quotient between the energy produced and the maximum that would have been possible operating at full power during the period of generally one year.

Policy Formulation Team: This refers to the persons who are entrusted with the formulation of the initial proposal for an energy policy.

Political Institutional Contexts: Refer to the characterization of the socio-historical periods of energy de where energy policies and planning answered to markedly different conceptions and/or modalities.

Power Reserve: Surplus power that is in excess over the maximum demand for a determined period only considering the available units in service (excluding programmed of forced periods of unavailability). Generally expressed in percentage terms with respect to maximum demand.

Power: Quantity of energy delivered or absorbed by an element in a specified instant of time.

Prediction (statistics): Refers to the estimation of time series or instantaneous data (more general than a forecast).

Problem Situations: These are the elements that comprise the Diagnosis for Policy and which define the starting point for the formulation of an energy policy. The purpose of such policy is to have an intervention on such situations striving to overcome them.

Project Team: Group of specialists fully dedicated to the task of building scenarios. One of which must be invested as the “project leader”.

Project: All technical documents that define or conditions in a necessary manner, particularly in that which refers to the localization, undertaking of constructions and other installations and works, as well as other interventions upon the natural environment or landscape, including those destined to the exploitation of renewable and non-renewable resources.

Prospective - Energy: Is the exploration of future possibilities to satisfy the energy needs of a country or Region based on present indications.

Prospective - Analysis: Constitutes a tool both for policy and well as the energy planning process. This is an exercise for the exploration of possible future trajectories of the energy system under analysis and its surrounding conditions.

Prospective: Tool that permits reducing the degree of uncertainty in decision-making processes.

Quality of Service: In general, it is defined as the condition of tension, frequency and form of the wave of service of electric energy, provided to users in accordance with applicable norms and regulations.

Renewable Energy: Corresponds to the energy forthcoming from renewable energy sources, such as solar, hydroelectric, wind and of biomass, that constitute a flow. In its use, the emission of CO_2 is nil, or in the case of biomass, it is neutral.

Renewables: In an abbreviated manner it refers to those sources of energies that have a renewable nature.

Robust Decisions: In the case that two well contrasted scenarios are elected and it is found that the sets of respective resulting supply decisions share common elements, the investment decisions that comprise both sets are referred to as “robust decisions”.

Rupture Scenario: Is that which assumes a discontinuity of one or more significant variables. It is not necessarily a negative concept.

Short-term. A time that is lesser than the long-term, linked to the partial maturity of planning and of the measurement of results in the development of a plan, program or specific project. Between 2 – 3 years. Also linked to “operative programming” (one year). A temporary period during which production factors remain stable.

Simulation: Is a technique used when the objective is to carry out parametric and even econometric evaluations, of energy scenarios and/or technological, without the explicit objective of the optimum assignment of resources.

Source of Emission: Factory, home, facility, combustion plant, vehicle, etc. that frequently emits contaminants to the air, without dismissing possible contaminations of waters and of soils.

Space for Solutions: This is the set of possible solutions resulting from the projection of relevant variables that will comprise the scenarios.

Starting Point of Energy Policy: This constitutes a characterization of the principal problems that an energy policy must face.

Strategic Environmental Evaluation: This is an instrument that provides support for the incorporation of the environmental situation in the process of taking strategic decisions, which are usually identified with policies, strategies, plans or programs, and as such is a procedure that improves these planning instruments.

Strategy: Indicates the how it is expected to go from the starting situation towards the corresponding objective that defines the desired situation.

Sub-sectorial Analysis of Energy Planning: As in the case of the global analysis this constitutes an essential element of the diagnosis of planning and it deals with a detailed characterization of each one of the productive chains that comprise the energy sector, highlighting the interactions between its links and the relations with other productive chains, as well as economic, social and environmental aspects.

Survey: Observational study in which the researcher gathers data by means of a previously designed questionnaire, without modifying the environment or controlling the process that is under.

Sustainable Development: Concept that strives to achieve the reconciliation between economic growth, natural resources and society, so that in the long-term, there is no substantive degradation of life in the planet, nor of the quality of life of the human species. A development that satisfies the needs of the present without endangering the capacity of future generations to satisfy their own needs (CMMAD, 1987).

Technological Blockade: Expression used to qualify policies, investments and other actions that prevent the development of alternative technologies. The construction of conventional infrastructure that requires a high cost of investment and an extended period of useful life, blocks the possibility that alternative technologies may enter the energy matrix, even if these are economically viable, due to the fact that the investment made in conventional infrastructure has not been recovered.

Tension: Is the magnitude that determines the potential of circulation of an electric current between two points, when there is a conductor that links them. It is measured in Volts; (V) residential tension may be at 110 V or 220 V.

“Top-Down”: Analysis based on models of general balance and which, in theory, are always consistent, however, these do not permit *per se* to undertake a detailed analysis at the level of each technology in an energy chain. It deals with technical progress in an aggregate form. The potential gains in Energy Efficiency tend to be underestimated.

Training Modalities or Types: Different manners by means of which it is possible to implement training actions. Intensive; extensive; in presence; semi-presence; at a distance; by countries; regional; addressing specific areas; seminars and workshops.

Uncertainty: Is the degree of the lack of knowledge or of information, since there are disagreements between that which is known and what could be known. It is the lack of exact knowledge regarding the future value or behavior of a determined variable.

Useful Energy: Is obtained by deducting from the consumption of final or net energy the losses in artifacts or equipment used by final consumers.

Uses of Energy: these are the needs that satisfy the consumption of energy (illumination, heat, driving power, cold, etc.), which are also referred to as energy services or final uses.

Variables - Exogenous variables: Are forecasts that are external to the sector, although they could also form a part of the scenarios, which comprise a group of exogenous parameters. These may be quantitative, such as population, GDP, prices; or qualitative, such as technology, penetration of new sources, rational use, etc.

Variables – Significant variables: Are exogenous variables that have a greater incidence and therefore permit a more adequate reflection of the phenomena they want to represent.

What if: This is a narrative exercise for the construction of possible futures or scenarios, where a test is made of what would happen in the case of What if...?

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ANNEXES

ANNEX III-A: ENERGY BALANCES

1. Energy Balances

1.1. Energy Balance Concept

The energy balance is an accounting structure which shows the set of equilibrium relationships that amounts the physical flows that produce energy, flows where the energy is exchanged with outside sources, transformed, consumed, etc..; this is calculated in a common unit, within a given country for a given period (usually one year). The energy balance must express and contain all the energy sources in a common accounting framework and show the relationship between the inputs and outputs of energy from the transformation process. This balance must be based on the first law of thermodynamics, which states that the amount of energy in a closed system is fixed and cannot be increased or decreased, at least a certain amount of energy is introduced to the system or sent out of it.

Energy balances can also be made for any energy product in particular, following the same structure as the overall energy balance.

The energy balance is a tool that facilitates the overall energy planning, always considering it together with economic, environmental, and social variables. This is, the balance on its own, only provides an image of the physical relationships of the energy system in a given historical period.

1.2. Objectives of the Energy Balance

The energy balance is a multipurpose tool that serves to:

a) Increase the relevance of energy statistics providing data and statistical information in a comprehensive and consistent manner on the national energy situation in a given country.

b) Provide relevant information on energy supply and demand of the country, in order to understand the situation of energy security, the functioning of energy markets to formulate energy policies and plans, and also meet objectives of public importance.

c) Serve as a quality tool for consistency, completeness of energy statistics.

d) Allow comparison of the energy situation between different reference periods of the same country, and the comparison between countries.

e) Provide data and information to estimate emissions of CO_2 in a given country.

f) Provide data and information for the calculation of energy indicators.

g) Calculate the efficiency of energy transformation processes taking place in the country (e.g., refinery, power generation using fossil fuels, etc.).

h) Calculate the relative shares of various products in terms of supply and total demand in each country (including renewable and non-renewable energy).

i) Provide input data for modeling and forecasting tasks.

1.3. Scope and general principles of energy balance

The scope of the energy balance is determined, in combination, by the limits of the territory, the product, and the energy flow:

a) Limits of the territory: defined by the boundaries of the national territory of the country or region on which the energy balance is performed.

b) Product Limits: defined by the scope of all energy products.

c) Limits of energy flow: defined by the scope of the energy flow.

The limits of the product and the energy flow are fixed in the short term. However, as technology advances, new energy sources may be available, and these should be reflected in the balance if any were used.

The scope of the energy balance does not include:

a) The passive nature of energy as heat gain in buildings and solar energy on the ground to irrigate crops, etc.
b) Removing any material not considered in the primary energy production.
c) Waste and Biomass used for other purposes different than energy purposes.

When energy balance is compiled, you should keep in mind some general principles that govern the scope and structure of the balance. These considerations are:

a) The energy balance is compiled over a reference period clearly defined. Thus, it is recommended that countries at least, compile and disseminate their energy balances, using annual time periods.
b) The energy balance is a matrix represented by rows and columns.
c) The columns represent the energy sources that are available for its use in the country.
d) The “Total” column contains cells which are the resultant of the sum of the input data of the corresponding row; however, the meaning of each of the cells in the “Total” column is not the same for all rows in the balance, as shown in the following literal.
e) The rows represent the different concepts of energy flows.
f) A separated row is reserved to calculate the statistical differences as the total supply of fuel, electricity or heat, and the use or total demand for this row.
g) Rows and columns must contain homogeneous information (related to the same products and flows as indicated in their headers).
h) The detailed energy balance should contain a sufficient number of rows and columns to clarify the relationship between inputs and outputs from the process of transformation (secondary energy production).
i) All input data should be expressed in a unit of energy (following the International System of Units it should be used the “Joule”, although some countries may use other energy units such as tons of oil equivalent, or tons of coal equivalent). Conversion between energy units should apply the appropriate conversion factors, and these should be reported along with the energy balance so any physical conversion to “Joules” or other units of energy can be transparent and comparable to any that are more common in the country units.
j) The net calorific value or lower heating value should be used to measure the energy content of energy products. If any country, for some reason, uses the gross calorific values, conversion factors and methods used for its calculation should be clearly established.
k) To set the primary energy equivalent of electricity produced from non-combustible energy sources, the method of physical energy content should be used. Information about the features of this and other methods can be found in reference (D. Bouille, 2004).
l) The production of primary and secondary energy should be stated clearly and separately, as well as imports and exports of energy, changes in inventories, and the final energy consumption in order to avoid double counting.

1.4 Energy balance information structure

Below is presented the logical structure of final energy balance by OLADE’s methodology.

The energy balances in terms of final energy (BEEF) have the limitation of not making an assessment of energy reserves and not reaching the stage of useful energy (BEEU). Efforts to bring the energy accounting from the stage of reserves to the stage of useful energy will further help the analysis and policy making, especially in the field of energy substitution.

While it is true that a comprehensive energy balance contains the elements of balance reserves and potential; net energy consumption by sector and uses; and useful energy consumption by sectors, sources and uses; these three items are not considered in view of the guide structure BEEF with OLADE’s methodology.

The logical structure of the energy balance is composed of three parts: a) Supply, b) Transformation Sector, and c) Final consumption. This logical sequence is known as downward energy balance. On the other hand, it is sometimes desirable to start projecting consumption somehow relating it with GDP's figure, structure, and distribution, with the total amount of consumer equipment and the likely technological developments in energy use calculating supply from the projected consumption. This logical structure leads to what is called the upward energy balance with the following general form: a) Final Consumption, b) Sector Transformation, and c) Supply.

The energy balance in terms of final energy according to the methodology of OLADE is presented in matrix form, and consists of the columns, representing the (primary and secondary) energy sources, and the rows represent the activities, i.e. the origins and destinations or energy consumption.

The basic components of balance in terms of data are: a) Primary and Secondary Energy Sources, b) Total Supply, c) Transformation Centers d) Final consumption.

It is recommended that in developing the reporting framework of energy balance common methodologies are followed in order to ensure consistency and comparability, as described below.

The cells in a column show the contribution of a given energy product to the specific energy flow.

The number of columns depends, among other things, whether the balance is intended as an information source to be spread where there are space limitations or to be used as a source of more detailed information. In the latter case, the energy balance can contain as many columns as necessary while in the first case the structure is more compact and contains columns that highlight the particularly important energy products for the country, as well as the columns needed for the international reporting and comparisons.

As for the grouping of columns, some different columns (except the "Total" column) represent various energy products, they can be grouped and sequenced so that add value to the analytical balance, therefore the following is recommended:

a) Energy product groups are mutually exclusive.
b) The "Total" column is the following to the energy products column (or groups of energy products).
c) Next to the "Total" column, it should be located additional columns containing additional subtotals such as "not renewable" and / or "Renewables". The definition and explanation of these subtotals can be performed in additional notes.

The number of rows and the sequence must be performed so as to clarify and facilitate the understanding of the relationship between primary energy products, processing, and final consumption; especially if the balance is presented in consolidated form.

It is recommended that the balance rows are grouped into three sections, as follows:

a) Upper block: It represents incoming energy flows in the country for the first time, the outgoing energy, and changes in energy stocks. The incoming energy flows consist of production of primary energy and imports of primary and secondary energy. The outgoing energy flows are exports of primary and secondary energy, and international bunkers.

   The item that results from this balance and changes in energy stocks represents the amount of energy that is available in the country during the reference period. This consolidated value represents the total energy supply:

   Total supply of energy = primary energy production + Primary and secondary energy imports - Primary and secondary energy exports - International Bunkers + / - Changes in energy stocks.

   Primary energy corresponds to the different sources of energy as obtained in nature, either: directly as in the case of hydropower or solar energy, wood and other plant-based fuels; or after an extraction process such as oil, coal, geothermal, etc.

   Those fossil resources exhaustible over time that have a long period of formation are considered non-renewable primary energy sources. The following are included: Crude Oil, Natural Gas, Coal, and Fissile Fuels or Nuclear energy.

   Renewable energies are those non-fossil resources with low carbon content and relatively short periods of the formation. In this category are the Hydropower, Geothermal, Wind Energy, Wood, Sugar Cane Products, and other sources such as biomass residues (vegetable waste, animal waste, industrial waste or recovered, etc.).

The different energy products that come from the various processing centers and whose destinations are the various sectors of consumption and / or other processing centers are called secondary energy. This area includes eleven sources of secondary energy: Electricity, liquefied petroleum gas or LPG, Gasoline / Alcohol, Kerosene and Fuel Turbo, Diesel and Gas Oil, Fuel Oil or Heavy Fuel, Coke, Charcoal, Gas, and other secondary energy that are not within the above types.

b) Intermediate block: it shows the manner in which energy is transformed, transferred and used by industries for their own use. The recommendations given in the reference (D. Bouille, 2004), are included in this block, the own consumption of the industries, and the losses in transmission and distribution segments.

Energy transformations describe the process by which energy is transformed into another product that, in general, is more suitable to be used in appliances and equipment of final consumers. The process of energy transformation is typically performed by energy companies. However, many economic units that are not part of energy companies (e.g. manufacturing industries) produce electricity and heat for their own use and / or sell energy to third parties (self-producers). When the self-production involves the transformation of primary energy products, it is recorded in a midblock balance row.

c) Lower Block: reflects the final energy consumption, and also the use of energy products different to the energy sector uses. The methodological guide SIEN (SIEN, OLADE, European Commission, 2004), losses in transmission and distribution segments, and own consumption are included in this group.

Registration of own energy consumption in the energy industry sector is defined as the consumption of fuel, electricity, and heat for the direct support of the production, preparation and use of fuels and energy. Typical examples of this are the consumption of electricity in power plants for lighting and ancillary services or fuels used in the refinery process.

The losses are those occurred in the process of transmission, distribution, and transport of fuel, electricity and heat. Losses also include venting and flaring of manufactured gas, geothermal heat losses after production, and unbilled energy.

A separate row is reserved to calculate the statistical adjustment. This row is mainly used to indicate the differences arising from the collection and statistical processing, and others to also replenish differences that are subtle and difficult to be found. In any case, the adjustment should not exceed 5% of the total supply, and it is recommended that the statistical adjustment remains explicit in the balance as it indicates the quality of the information presented.

The energy balances can be presented in aggregate or in detail manner. The degree of detail will depend on the purpose of the balance, and the availability of data and resources. The energy balance in its aggregated form is usually performed for dissemination in its printed format where the level of aggregation, i.e. the number of rows and columns, is restricted due to practical considerations (space). However, it is recommended that countries collect and compile the data arrived at a detailed level. When this level of detail is not available or is not practical to perform, we recommend at least to follow the format of the aggregated balance sheet. While this work does not focus on the methodology of energy balances, it presents the structure of the balance from the information point of view.

For a more detailed study of the aggregated and detailed energy balance is recommended to consult the Methodology of Energy Balances and Energy Statistics Manual which can be found at the Documentation Center of OLADE.

ANNEX III-B: INDICATORS

1. Dimensions of sustainable development (OLADE, ECLAC, GTZ 1997, IAEA 2005).

Sustainable development implies an improvement in the quality of life in a way, economically, socially and environmentally, sustained over time and supported by the institutional structure of a country. For this reason, sustainable development is addressed in four different dimensions: economic, social, environmental and political-institutional. The indicators are currently categorized into only three dimensions: economic, social and environmental; at the moment the indicators within the political-institutional dimension are in development phase and can be incorporated into this set of indicators in a later phase.

Economic Dimension: Modern economies depend on adequate and reliable energy supplies, and developing countries need to secure this situation as a prerequisite for their industrialization. All sectors of the economy - residential, industry, commercial, transportation, services, and agriculture - demand modern energy services.

These services, in turn, foster economic and social development at the local level by increasing productivity and allowing the generation of local income. The energy supply affects work, productivity, and development. Electricity is the dominant form of energy for communications, information technology, manufacturing, and services.

Economic indicators have two sub-themes (IAEA 2005), (IEA 2008): Use and Production Standards, and Security. The first has the sub-themes of: General Use, General Productivity, Supply Efficiency, Production, End Use, Diversification, and Prices. The second has the sub-themes of Imports, and Reserves of strategic fuels.

The indicator of energy intensity (energy consumption per unit of Gross Domestic Product), or its inverse energy productivity, is an aggregate indicator. Much attention needs to be paid to aggregated and disaggregated energy efficiencies and intensities when defining sustainability and consumption trends. However, such caution is guaranteed when interpreting the indicators. A country whose economy is based on trade and services will use less energy per unit of GDP than another country whose economy is based on steelmaking and mineral processing.

There are indicators of energy intensity in individual sectors. Because these indicators are sector-specific, a good basis for comparison of energy efficiency, economic structure, and a distinctive of production and equipment plants can result. These indicators should be interpreted with great caution, because changes in commodity prices, currency fluctuations affecting trade-dependent sectors, etc., can dramatically change the value of indicators, but they have nothing to do with what actually happens with changes in energy efficiency.

Energy prices for the end-user by fuel and by sector have a visible economic importance. Adequate and fair efficient energy pricing is a key factor for the efficient delivery and use of energy, and a socially acceptable reduction in pollution levels. Energy prices, subsidies, and taxes can boost energy end-use efficiency, or improve access levels, or can also generate inefficiencies in the supply, distribution, and use of energy.

While high prices of commercial fuels can be seen as barriers, prices that cover energy supply are needed to attract investment for a safe and reliable supply.

Energy security is one of the main objectives of the criteria for sustainable development in many countries. Interruptions in the power supply can cause serious economic and financial losses. In order to support sustainable development goals, energy must be available at all times, in sufficient quantity and at the lowest possible cost. It is essential to have a secure energy supply in order to maintain economic activity in the country and to provide reliable energy services to the society. Monitoring of net energy import trends and the availability of sufficient reserves of critical fuels is important in assessing energy security.

Social Dimension: The energy availability has a direct impact on the quality of life, employment opportunities, education, demographic transition, pollution and health, and it also has gender and age implications. In industrialized countries, energy for lighting, heat, and cooking is readily available and is clean, safe, reliable, and affordable. In developing countries, it takes up to 6 hours a day to collect firewood and manure for cooking and heat, and this task is usually done by women, who might otherwise be involved in more productive activities. Commercial sources of energy can account for a large portion of household income. Inadequate equipment and ventilation means that these fuels, burned indoors, cause a high rate of illness and death from air pollution, and from fire. This example serves to illustrate two of the themes of the social dimension: Equity and Health. Social equity is one of the main values within sustainable development, involving a degree of justice and inclusiveness with which energy resources are distributed, energy systems are accessible, and price schemes are formulated to ensure them affordability. Energy should be available to all at a fair price. Equity indicators include the sub-themes of accessibility, affordability, and disparity. Due to the lack of access to modern energy systems (for example, a household is not connected to the electricity grid), low-income households not only spend a larger portion of their income than rich households but also pay more in absolute terms per unit of useful energy. The lack of electricity limits the opportunities for work and productivity because, without electricity, it is only possible to use basic equipment and tools. This usually means, among other limitations, inadequate lighting, limited telecommunications, and lack of refrigeration. Limited income (limited affordability) can force households to use traditional fuel and inefficient energy technologies, and the time needed to harvest fuel wood is a time they cannot use to grow or do other types of work.

There may be disparities in access or affordability between regions and among groups with a certain level of income within a region. Disparities within a country or between countries can be the result of very uneven income distributions, inadequate transport and distribution of energy, and large geographical differences between regions. In many countries, high inequality in household incomes and energy prices pose a major problem for low-income neighborhoods in urban and rural areas, even if there is an available energy service.

Indicators of accessibility and affordability are clear indicators of development progress. They also show an improvement in the situation of women, since they are usually the ones who carry the burden of collecting fuels sources in countries and regions with low economic development. If access to commercial energy were readily available, these women would have more time to improve their own situation and that of their children.

Environmental Dimension: The production, distribution, and use of energy creates pressures on the environment of the home, the workplace, and the city, at national, regional and global levels. Impacts to the environment can depend to a great extent on how energy is produced and used, the variety of fuels, the structure of energy systems, actions on energy regulation, and on the price structure. Gaseous emissions from the burning of fossil fuels are released into the atmosphere. Large reservoirs of hydroelectric plants cause sediment to accumulate. Coal and nuclear fuel emit some radiation and generate waste. Wind turbines can affect the field and its environment. The collection of fuel wood can lead to deforestation and desertification.

Environmental indicators are divided into three themes: Atmosphere, Water, and Soil. The subtopics of the Atmosphere category are Climate Change and Air Quality. Priority issues include acidification, the formation of ozone in the troposphere, and the emission of other pollutants that affect urban air quality. The emission of greenhouse gasses (GHG) is a core issue in the debate on whether humanity is exacerbating climatic conditions. Air pollutants of greatest concern are sulfur oxides, nitrogen oxides, and carbon monoxide and its particulates. These contaminants are capable of affecting the health of the human being, bringing respiratory problems, cancer, among others.

Water and soil quality are important sub-themes within the environmental dimension. The earth is more than just physical space and topographic surface. In itself, it is an important natural resource that consists of land and water, essential elements for the crops and for the habitat of diverse groups of animals and plants. Energy activities can result in degradation and acidification affecting water quality and productivity in agriculture. The use of fuel wood (non-commercial) results in deforestation, which in some countries leads to erosion and loss of soil quality. Some countries already have a long history of sustained deforestation. Although more rigid environmental legislation has been implemented in several countries to prevent soil degradation, the damage still affects large areas.

The soil is also affected by energy transformation processes, which often produce solid waste, including radioactive waste, which requires adequate storage. The water quality is affected by the discharge of pollutants from energy systems in water inflows, particularly in the exploitation of energy resources.

Finally, indicators of sustainable development do not yet include political-institutional indicators, which are at the stage of development by international energy organizations.

1.1. Methodological description of the set of indicators

A) Economic Indicators

i. *ECO1 - Energy Use Per Capita*

Description: This indicator shows the use of energy regarding Total Primary Energy Offer (TPEO), Total Final Energy Consumption (TFEC), and Total Electricity Consumption (TEC), per capita. The purpose is to measure the level of per capita energy use and to reflect the patterns of energy use and aggregate energy intensity of society.

The data for the calculation of the indicator can be perfectly obtained from the energy balance. The calculation of the indicator is the ratio between TPEO, TFEC, and / or TEC and the Total Population of the country to the mid of the Current Year (TPMY).

TPEO involves the production of primary energy, for example coal, crude oil, natural gas, nuclear, hydropower, and other renewable energy sources, plus imports minus exports of all energy products, minus international bunkers or barges, and finally corrected for net changes in energy reserves.

TFEC, TEC, refers to the sum of energy consumption (electric in the case of TEC), end use, of the different sectors, excluding energy consumed or associated losses, in the conversion, transformation, and distribution processes of the various energy products.

Periodicity: This indicator can be calculated every year.

Formulation:

ECO1 OTEP / PTMA;
ECO1 CTFE / PTMA;
ECO1 CTE / PTMA

Units: Energy: Tones of Equivalent Fuel (TEF) per capita. Electricity: kilowatt-hours (kWh) per capita.

Precautions and Limitations: This indicator is influenced by the economic, social, environmental, technological and cultural context of the country under study.

ii. *ECO2 - Energy Use per unit of Gross Domestic Product*

Description: This indicator is associated with the relationship between TPEO, TFEC, and / or TEC and a country's Gross Domestic Product (GDP). The purpose is to reflect the trend of energy use about GDP, indicating a general relationship of energy use to economic development. The gross domestic product can be measured in dollars (US $) converted from the local currency using Purchasing Power Parity (PPP) for the base year in which the national currency was devalued.

The inverse of this indicator, called Energy Productivity (OLADE, ECLAC, GTZ 1997), which is calculated as the ratio of GDP to Final Energy Consumption, can be used as a global indicator of the energy productivity of a country.

Periodicity: This indicator can be calculated every year.

Formulation:

ECO2 OTEP / PTMA;
ECO2 CTFE / PTMA;
ECO2 CTE / PTMA

Units: Energy: Tones of Equivalent Fuel (TEF) per US dollar (US $). Electricity: kilowatt-hours (kWh) per US dollar (US $).

Precautions and Limitations: The ratio of aggregate energy use to GDP is not an ideal indicator of energy efficiency, sustainable use of energy, or technological development as it has been commonly used. This aggregate relationship depends not only on the energy intensities of different sectors or activities, but also on factors such as climate change, the country's geographic location, and the structure of the economy. As a consequence, changes in indicator time by factors that are not related to changes in energy efficiency. Therefore, it is necessary to complement this indicator using the energy intensities disaggregated by sector, because these disaggregated indicators represent better the advances in energy efficiency.

iii. *ECO3 - Industrial Energy Intensity*

Description: Energy use per unit of value-added in the industrial sector and selected energy-intensive industries.

Periodicity: This indicator can be calculated every month and every year.

Formulation:

$$IEI_i = (EFCIi / PIBi)$$

Where:

IEI_i = Industrial energy intensity for period i (toe / USD)
FECIi = Final energy consumed in the industrial sector in period i (toe)
GDPi = Gross domestic product in period i (USD)

Units: This indicator is given in Tons of Oil Equivalent (Toe) per US dollar (USD).

Application: The use of energy per unit of value added is a way of measuring energy needs about manufacturing output.

Industries that can be considered energy-intensive include iron and steel production, non-ferrous metals, chemicals, petroleum refining, non-metallic minerals, cement, and paper.

Changes in intensities are affected by factors other than energy efficiency, so intensity trend analysis provides important clues as to how energy efficiency and other factors influence energy consumption.

iv. *ECO4 - Energy intensity of the commercial sector*

Description: This indicator is a measure of global energy intensity in the commercial sector, which can be used for the analysis of trends in energy use.

Periodicity: This indicator can be calculated every month and every year.

Formulation:

$$IECC_i = (EFCi / PIBi)$$

Where:

$EICS_i$ = Energy intensity in the commercial sector for period i (toe / USD)
FECIi = Final energy consumed in the commercial sector in period i (toe)
GDPi = Gross domestic product in period i (USD)

Units: This indicator is given in Tons of Oil Equivalent (Toe) per US dollar (USD).

Precautions and limitations: It is very common that it is difficult to measure and interpret the energy intensity per unit of added value within the sub-sectors (private services, public services, etc.), because the different activities are frequently carried out in the same building. Therefore, the actual allocation of energy use between activities is uncertain. In such cases, intensities expressed per unit area disaggregated by type of building may be more easily related to actual energy efficiency. However, these have the similar problem that a variety of activities can have in a particular type of building. For example, a hospital will contain space for the preparation of food or laundry services, as well as for health care.

v. *ECO5 - Sector Specific Consumption Transport*

Description: This indicator shows the energy consumption per unit of freight-kilometer transported and per unit of passenger-km traveled. Transport indicators reflect the amount of energy used to transport goods and people. The separation of freight and passenger transport is essential for the analysis of energy consumption, both because they rely on the different modes and because of activities related to driving in the transport sector and energy consumption in this one, are different.

Periodicity: This indicator can be calculated every month and every year.

Formulation:

$$IETC_i = (EFTCi / Toneladas de Carga Transportada-km)$$

$$IETP_i = (EFTPi / Número de pasajeros-km)$$

Where:

$IETC_i$ = Specific consumption in the freight transport sector for period i (toe / Ton-km)
$IETP_i$ = Specific consumption in the passenger transport sector for period i (toe / Passenger-km)
FEFS = Final energy consumed in the freight sector in period i (toe)
EFTPi = Final energy consumed in the transport sector of people in period i (toe)

Units: Depending on what is going to be transported, in general terms, this indicator is given in:

Load: Tons of oil equivalent (Toe) per ton-km
Persons: Toe per passenger-km

Precautions and Limitations: The availability of data may limit the disaggregation of the indicator to the desired level. Considerable work is often required to disaggregate energy balances into different means of transport.

vi. *ECO6: Energy Autarchy*

Description: This indicator relates to the Energy Imports (EIMP) to the Total Energy Supply (OTE) of the country. A low value of this indicator indicates a greater autarky and vice versa. This indicator is related to security of external supply, a high degree of independence of energy imports and reduction of the risk of imbalances the payments balance.

Annually Periodicity:

Formulation:

$$ECO6 = EIMP / TES * 100$$

Units: Percentage.

Precautions and Limitations: Unavailability of data on imports and exports of some fuels.

vii. *ECO7: Robustness against external changes*

Description: This indicator relates to the Energy Exports (EEXP) to the Gross Domestic Product (GDP) of the country. A low value of this indicator indicates a greater robustness and vice versa. Robustness has to do with stable flows of export revenues and a reduction in the risk of imbalance in the balance of payments.

Periodicity: Annual

Formulation:

$$ECO7 = EEXP / GDP * 100$$

Units: Percentage.

Precautions and Limitations: not observed.

viii. *ECO8: Inventory of critical fuels to meet the corresponding consumption*

Description: The objective of this indicator is to measure the availability of National Critical Fuel Reserves (NCFR), such as oil, about the corresponding fuel consumption. The countries decide on the appropriate levels of stocks of critical fuels needed, as a forecast of possible supply disruptions. For some countries, critical fuel could be natural gas or other fuel. The indicator provides a relative measure of the amount of time the reserves would last if the supply is discontinued and the fuel use is maintained at current levels.

This indicator is calculated by dividing the stocks of critical fuels maintained by countries either by the Daily Critical Fuel Consumption (DCFC) or by the Monthly Critical Fuel Consumption (MCFC), or by the Annual Critical Fuel Consumption (ACFC).

Periodicity: Daily, Monthly or Yearly

Formulation:

ECO8 = RCC / DCFC
ECO8 = RCC / MCFC
ECO8 = RCC / ACFC

Units: Days, Months, Years

Precautions and Limitations: The rate of use of fuels, particular oil, depends on many factors including economic conditions, prices, and technological progress. Therefore, this indicator represents only a relative measure of the safety of the energy supply. Many countries cannot even maintain adequate levels of critical fuel inventories.

ix. *ECO9 - Relationship between reserves and energy production*

Description: This indicator shows the relationship between the remaining energy reserves in one year period and the energy production of that year. It also attempts to show the life cycle of the proven energy reserves and the production life cycle.

The purpose of this indicator is to measure the availability of Certified Energy Reserves (CERs) with respect to the Energy Production of a given energy material or resource (PE). Reserves are generally defined as identified (verified and estimated) resources that are economically recoverable at the date of the evaluation. Reserves are also defined as those quantities that indicate geologically and engineering information that may be retrieved in the future with reasonable certainty, from resources known or identified under existing technical and economic conditions. The indicator considers fuels such as oil, natural gas, coal, and uranium, and gives a relative measure of the time that the proved reserve would last if production continued at current levels.

The estimates of reserves are based on the results of geological exploratory information in a given area or on the evidence of duplication or parallelism of geological conditions occurring in known repositories. Unverified repositories should not be included. The duration of proven fuel reserves regarding the ratio between reserves and energy production is calculated by dividing the CERs of an energy resource at the end of one year for the total production of that resource (EP) at the end of the year.

Periodicity: **Annually**

Formulation:

ECO9 = CERs / PC

Units: Years

Precautions and Limitations: The rate of use of energy reserves depends on many factors such as: economic conditions, prices, technological advances, exploration efforts, etc. Therefore, this indicator only represents a relative measure of the availability of reserves. In many countries, this indicator has not undergone major changes over the years for oil and gas, for example, despite increasing exploitation. This is due to efforts in exploring these resources that identify reserves to replace the exploitation of existing reserves.

x. *ECO10-Efficiency in the conversion and distribution of energy*

Description: This indicator, which can be calculated for different subsectors, seeks to show efficiency in the conversion and distribution of energy, including efficiency in electricity generation using fossil fuels, efficiency in oil refinement, losses occurring in the transmission and distribution of electricity, and losses in the gas transmission and distribution. Overall, this indicator seeks to measure the efficiency that occurs in some parts of the energy supply chain, including losses that occur during energy transportation and distribution.

The indicator, for each relevant subsector, can be defined as:

√ Efficiency in the conversion of energy to electricity using fossil fuels: defined as the ratio of Gross Electricity Production - PBE (including the own use of electricity to power plants) to Fossil Fuel Energy (ECF) used. Significant improvements in the average efficiency of the thermal plants resulting from the fuel change can be obtained; of the entry into operation of plants with efficient technology, and the withdrawal of plants with inefficient technology. In particular, switching from coal to gas fuel using high efficiency combined cycle gas plants, it usually results in substantial gains in supply efficiency. This indicator can be calculated separately for generation based on fuels derived from oil, gas, coal, to isolate the effect of fuel change on the indicator's behavior.

√ Efficiency in the transmission and distribution of electricity: it is defined as the ratio between the Total Final Electricity Consumption (TEC) and the Total Electricity Supply (OTE). Losses in the transmission and distribution of electricity include losses during transportation of electricity from the source of production to the distribution points and from there to the distribution to the final consumer, and also includes energy theft.

√ Efficiency in gas distribution: defined as the relation between the Final Gas Consumption (FGC) and the Total Gas Supply (TGS). The transport and distribution of gas involves losses during transportation from the energy sources to the distribution and later final consumption of this resource.

√ Efficiency in oil refining: defined as the ratio in average percentage between the Output of Refined Products (ORP), to the products that enter the refining process, including raw materials.

The data for the calculation of the indicator can be obtained from the energy balance.

Periodicity: The calculation can be done monthly, quarterly, semiannually, or annually.

Formulation:

$$ECO10 = GEP / FFE * 100$$
$$ECO10 = TEC / TES * 100$$
$$ECO10 = CTG / OTG * 100$$

Units: Percentage (%)

Precautions and Limitations: The Data on energy efficiency conversion and distribution are not available in some countries.

b) Social Dimension

i. *SOC1 - Electrical Coverage*

Description: Percentage of households or population that do not have access to electricity in the public service network. This indicator attempts to measure the lack of access to modern energy services. One of the goals in sustainable development is to meet the goal of increasing the accessibility and affordability of energy services to low-income economic groups to alleviate poverty and promote social and economic development.

Periodicity: This indicator can be calculated every year.

Formulation:

$$PHSEi = (NHSEi / NTHi) * 100$$

Where:

PHSEi = Percentage of households without access to electricity for period i (%)
NHSEi = Number of households without electricity, for period i (GWh)
NTHi = Total number of households in period i (GWh)

Units: This indicator is given in percentage (%).

Precautions and Limitations: The availability of data on the number of households or proportion of the population without access to commercial energy or electricity may be a restriction.

ii. *SOC2 - Percentage share of family income that is invested in fuel and electricity*

Description: Percentage share of available household income spent on fuel and electricity (on average and for 20% of the lowest income population). The indicator gives a measure of affordability to energy services in an average household and in the lower income households. A country may have a high per capita GDP but the distribution of its income may be so unequal that a large percentage of the population is unable to meet their energy needs in their households at current energy prices with a very limited level of income.

Periodicity: This indicator can be calculated every year.

Formulation:

$$PIHi = (IGCEi / ITi) * 100$$

Where:
PIHi = Percentage of available household income spent on fuel and electricity for period i (%)
IGCEi = Average household income spent on fuels and electricity, for period i (USD)
ITi = Average total household income in period i (USD)

Units: This indicator is given in percentage (%).

Precautions and Limitations: The data availability may be a constraint in developing countries.

iii. *SOC3: Household energy consumption by income groups*

Description: This indicator provides a measure of the disparity in energy use and its affordability. The indicator allows evaluating the amount of electricity and fuels used by the population in relation to their level of income.

The energy consumption per household represents the final energy consumption, including traditional or non-commercial fuel. If only data on domestic energy fuel costs are available, then the corresponding fuel prices are necessary to calculate the amount of energy used. Household income, by income group in the quintiles, corresponds to the distribution of available income for most countries. Each distribution is based on percentiles of the population with households classified by income or expenditure per person. The values of available income per capita and consumer prices for commodities must be in national currency.

The energy price data must refer to a specific date. Global energy consumption can be calculated by converting energy fuel usage to an equivalent unit of energy (e.g., equivalent tons of oil, toe). Also, the energy use can be represented by fuel type using different *Units:* (E.g., fuels for heating and cooking, in toe and electricity in kWh).

Periodicity: Annually

Formulation:

SOC3 = Energy fuels / Households of the same income group
SOC3 = Electricity consumed / Households of the same income group

Units:

Energy: tons of oil equivalent (Toe) per household
Electricity: kilowatt-hours (kWh) per year per household.

Precautions and Limitations: The availability of data for a number of developing countries is a constraint, which is resolved through surveys.

i. *SOC4: Accident fatalities in the energy sector, by energy produced*

Description: This indicator shows the number of fatalities in activities related to the production chain and energy consumption, due to the energy produced. The indicator is used to assess the risk to human health derived from energy systems, and in particular the various energy fuel production chains.

To calculate the indicator, accidents related to energy and their distribution in specific fuel cycles must be identified and, subsequently, the energy produced must be quantified. For practical reasons, there is a discrepancy between the number of accidents actually occurring, and those that are published and analyzed in reports or newsletters. Therefore, relatively rare accidents are more likely to be recorded than more frequent and routine accidents.

The types of accidents for different fuel chains that can result in fatal accidents include the following:

- √ Coal: Explosions or fires in underground coal mines, collapsing of roofs or walls in underground or surface mines, transport/ vehicles accidents.
- √ Oil: offshore drilling accidents, fire or explosion due to leakage or failure of the process plant, transportation accidents resulting in fires, explosions or major spills, loss of contents in storage areas resulting in fires or explosions.
- √ Natural Gas (includes liquefied petroleum gas): The same as for oil, except in the case of spills.
- √ Nuclear: reactor failures, radioactive leaks, accidents during transport of radioactive waste, etc.
- √ Hydroelectricity: The rupture or overflow of the dam.
- √ Electricity Sector: Explosions or fires, equipment failures for electricity generation, transportation or distribution.

Periodicity: Annually

Formulation:

SOC4 = number of fatal victims / electricity produced

Units: Number of fatalities due to the amount of energy fuels or electricity produced annually.
Precautions and Limitations: The fatalities alone do not cover all kinds of consequences of the accidents. Despite the importance of monitoring all consequences, the lack of relevant information does not allow this issue to be fully addressed.

It is recognized that knowledge about the delayed health effects of accidents associated with different energy systems is limited.

ii. *SOC5: Coverage of basic energy needs*

Description: It is the ratio between the useful residential energy consumption (UREC) and the population (POP), particularly oriented to the low-income population

Periodicity: Annually

Formulation:

SOC5 = UREC / POP

Units: kilogram oil equivalent (kep) per person.

Precautions and Limitations: Ideally, there should be available information about the balance in terms of useful energy; and if it's not available, a survey should be prepared.

c) Environmental Dimension

i. *AMB1 - Relative purity of energy use*

Description: This indicator relates to CO_2 of the energy sector with the Total Final Energy Consumption (TFC). And it reflects the effects of the mode of production and consumption habits of society on the emission of greenhouse gasses

Periodicity: **This indicator can be calculated every year.**

Formulation:

$$AMB1 = CO_2 / TFC$$

Where:
AMB1 = Relative purity in the use of energy (ton / Toe)
CO2 = CO_2 emissions from the energy sector (ton)
TFC = Total final energy consumption (Toe)

Units: Tons of CO_2 by Toe.

Precautions and Limitations: No major limitations are observed.

ii. *AMB2 - Greenhouse gas emissions produced by the production and the use of energy, per capita and per unit of GDP*

Description: GHG emissions from the production and use of energy, per person and per unit of Gross Domestic Product, GDP, including Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). This indicator measures the total emissions of the three main GHGs from the production and use of energy, which has a direct impact on climate change.

Periodicity: **This indicator can be calculated every year.**

Formulation: CO emissions$_2$ from the combustion of fossil fuels are calculated by multiplying the energy used by each type of fuel by an emission coefficient associated with CO_2. Whenever possible, emissions should be measured directly at the source of energy. However, these measurements are mostly incomplete or unavailable. In the absence of measured data, emissions are calculated by multiplying a known data, such as the production of coal or natural gas by an associated emission factor derived from a small sample of a relevant emission source or through laboratory experiments.

$$AMB2 = GHG / POP$$

Where:

AMB2 = Per capita emissions of greenhouse gases (ton / inhabit.)
GHG = Emission of greenhouse gases (ton)
POP = Population (inhabit.)

Units: Annually GHG emissions in tons, per capita or per US dollar. CH4 emissions $_{\text{And N2}}$O must be converted to CO_2 Equivalents.

Precautions and Limitations: This indicator shows the amount of GHG emitted into the atmosphere from the use of energy alone. For some GHGs (N_2O), non-energy sources (agriculture) can produce significant levels of emissions. The availability of data may be a constraint in developing countries.

iii. *AMB3: Use of renewable energy*

Description: This indicator shows the relationship between the total sum of the renewable energy sources production (RSP) and total energy supply (TES). A High value indicates better air quality by reducing emissions of gasses and particulates with local and regional effects and GHG reduction.

Periodicity: **Annually**

Formulation:

AMB3 = RSP / TES * 100

Units: Percentage of share (%)

Precautions and Limitations: Lack of information regarding renewable energy sources

iv. *AMB4 - Concentrations of polluted air in urban areas*

Description: This indicator measures concentrations of polluting air such as ozone, carbon monoxide, particulates (PM10, PM2.5, total suspended particulates, black smoke), sulfur dioxide, nitrogen dioxide,
benzene and lead. The indicator provides a measure of the situation of the environment in terms of air quality, which may be of public health interest in urban areas.

Periodicity: **This indicator can be calculated every year.**

*Formulation***:** This indicator is measured directly in areas where contaminated air concentrations are desired.

Units: Micro or milligrams per cubic meter, as appropriate.

Precautions and Limitations: There are limitations in the measurements, related to limits of detection, interference, temporal resolution, operation, and costs.

v. *AMB5 - Emissions of air pollutants from energy systems*

Description: This indicator shows emissions of air pollutants from all energy-related activities, including electricity production and transportation. The main causes of the growing concern are emissions of acidifying substances, such as sulfur oxides (SOx) and nitrogen oxides (NOx), ozone precursors, such as volatile organic compounds (VOCs), NOx and Carbon monoxide (CO), and fine particles.

Periodicity: **This indicator can be calculated every year.**
Formulation: In some cases, emissions from industrial plants can be estimated on the basis of actual direct measurements in chimneys or by material balances. In general, however, emissions of pollutants are calculated with the help of an emission factor, which is a representative value that attempts to relate the amount of a released pollutant to the atmosphere with an activity associated with the release of that pollutant.

Units: Tons.

Precautions and Limitations: This indicator quantifies the air pollution derived from the use of energy, so it does not take account of pollutant emissions related to other activities, such as those of the industrial and agricultural sectors. In interpreting this indicator, this should be read in relation to the indicator of urban air quality.

vi. *AMB6 - Discharge of pollutants into liquid effluents from energy systems*

Description: Contaminant discharges present in liquid effluents from all energy-related activities, such as the discharge of cooling waters, which can raise the temperature of the water stream. The objective of this indicator is to control the discharge of harmful pollutants from energy companies, mining, and oil extraction, in particular, coal, in rivers, lakes and marine waters.

Periodicity: This indicator can be calculated every month or every year.

Formulation: When measuring water quality, measurements can be made directly on effluent discharges or downstream watercourse as a measure of the environmental impact of the discharge. The following list presents typical control requirements for energy companies:

- √ Flow: volume, measured in cubic meters per second, hours or days. The volumes can be multiplied by the concentration of the pollutant for the calculation of the mass emissions of the individual pollutants.
- √ pH: This is a measure of the acidity/alkalinity of discharge. The pH of a watercourse affects the solubility of different substances and alters the habitat of fish, animals, and plants.
- √ Total Organic Carbon (TOC): Measured in milligrams per liter (can be used as a substitute for chemical oxygen demand [COD] or biochemical oxygen demand [BOD]). TOC measures the organic content in a discharge, which can sometimes be elevated when the discharge is contaminated. Elevated levels of organic matter change the natural balance of plants and organisms in the water course.
- √ Hydrocarbons Petroleum: It is measured in milligrams per liter. Drainage of surface water that passes through industrial facilities and storage areas can be often contaminated with a hydrocarbon oil, which can contaminate streams and downstream plants and animals. Pollution of fresh water with very low levels of oils, makes the water unsafe.
- √ Solids in suspension: It is measured in milligrams per liter. These can often contaminate watercourses downstream from storage areas or mining/drilling operations. Suspended solids color the water, change the opacity of the water and can drown the plants and animals downstream.
- √ Ammonia and Total Nitrogen: measured in milligrams per liter. Nitrogen is a nutrient, which often causes nitrification of the watercourse, habitat change, and affects native species.
- √ Chloride and Sulphides: Measured in milligrams per liter. Wastewater from flue gas desulfurization plants, contain salts such as chlorides and sulfides, which can be especially damaging when released in freshwater environments.
- √ Fenoles and Sulphides: Measured in milligrams per liter. These are byproducts of the gasification and carbonization processes and may also be present in the coal drainage water etc.
- √ Metals: (typically cadmium [Cd], mercury [Hg], chromium [Cr], nickel [Ni], vanadium [V], zinc [Zn], copper [Cu], arsenic [As] and boron [B]) : Measured in milligrams per liter. Metals can leach out from fuel stocks and are often released from the various ashes and wastes that are derived from energy companies.

Units: Kilograms or milligrams per liter.

Precautions and Limitations: This indicator quantifies the air pollution derived from the use of energy, so it does not take account of pollutant emissions related to other activities, such as those of the industrial and agricultural sectors. In interpreting this indicator, this should be read in relation to the indicator of urban air quality.

vii. *AMB7: Deforestation rate attributed to energy uses*

Description: The forest area is defined by the lands that are covered by tree crowns, on at least 10% of the surface. Also, the forest areas that are the product of a plantation or sowing of those that correspond to natural forests are differentiated. The comparisons of Forest Areas (FA) over time, over the years, or with respect to a reference year, it allows the calculation of the percentage of Total Deforestation Rate (DTR) as the variation of the absolute values. The Deforestation Rate attributed to the Use of Wood as Fuel (DRUWF = ENV) is determined by the relationship between the Annually Average Firewood Production (AAFP) and the Total Annually Forest Logging (TAFL).

Periodicity: Annually

Formulation:

$$TDD=\left(1-\left(AF_N/AF_R\right)^{(1/(N-R))}\right)*100$$

Where *FA* is the forest area in the reference years *R* and in the present *N*; and

$$AMB7=TDUMC=TDD*(PMAL/TFAT)$$

Units: Percentage (%)

Precautions and Limitations: The indicator does not measure the total level of deforestation, since it focuses only on deforestation caused by the collection of firewood. The value of the forest area gives no indication about the quality of the forests. The indicator does not provide information on the degradation of a country's forest resources. The total area of forests in a country can remain unchanged. However, the forest may be degrading. The indicator equally qualifies a large variety of different forests.

viii. *ENV8: Relation between solid waste generation and energy produced*

Description: The main objective of this indicator is to provide information on the quantity and type of solid waste generated each year in the energy sector. Adequate storage facilities are generally required for these wastes.

Waste is defined as any substance or object from which the holder detaches or intends to discard because he considers that it no longer has any commercial value. This does not imply that it has value for another.

Solid waste from the energy sector is limited to that obtained from the normal operation of the energy sector. This includes waste from coal and lignite mining, coal improvement processes, oil and gas extraction residues and from refineries, combustion wastes from thermal power plants (slag, ash, etc.), waste from the incineration of industrial and municipal waste, when used as fuel in power plants, and waste from air pollution abatement technologies. Non-regular wastes, such as out-of-service oil, power stations, refineries and other machinery should be considered separately, as these occur in exceptional situations and require special disposal and disposal measures.

For the purposes of this indicator, radioactive waste, loss of vehicles on the road, railway wagons and sea-going vessels belonging to the energy industry are excluded (e.g. coal dust).

In order to quantify this indicator, it is possible to measure the residues through their weight when they leave the energy production facility. In the case of mining waste, which is normally stored on site, the amount can be estimated based on the amount of coal or lignite extracted.

The waste generated must be presented in absolute terms (tons), which gives an idea of the magnitude of the problem. They can also be reported in relation to the waste generated per unit of energy produced, which allows to evaluate reduction measures. In this case, it is important that the wastes are identified and classified for each process and are divided only by the resulting energy from that process.

The energy produced can be expressed in specific units of the fuel produced (i.e. tons of coal, lignite, and oil, cubic meters of gas, MWh of electricity), or in energy units (Tera-Joules (TJ), MWh or by the value of calorific value).

Periodicity: Annually

Formulation:

AMB8 = Qty of residue / energy produced in the process which generates the residue

Units: Tons/units of energy

Precautions and Limitations: The generation of solid waste in energy production, particularly waste from mining activity, is not always controlled at the source and may have to be estimated from coefficients. In this case, the waste generated per unit of energy produced will remain unchanged, unless the coefficients are changed. The indicator does not distinguish between toxic and hazardous wastes, and those that are more benign.

ix. *ENV9: Relation of adequately disposed solid waste to total solid waste generated*

Description: The main objective of this indicator is to assess the degree of adequate disposal of solid waste in the energy sector. The definition of solid waste in the energy sector corresponds to that expressed for the indicator ENV8.
On the other hand, solid waste from the energy sector is said to be adequately eliminated when:

√ Recycled or reused

√ They are the incineration in equipment with suitable filters to eliminate the harmful emissions;

√ They are solidified, in order to avoid landslides, or

√ They are disposed of in specialized landfills or in places where measures are taken to prevent runoff and uncontrolled combustion.

In order to obtain a reasonable estimate of the appropriate disposal of waste, it is important to have an inventory of the treatment of energy waste and storage facilities, either on the spot or in separate facilities enabled even for disposal of other types of waste. The weight of properly discarded waste energy can be more easily measured when collected, to be sent to treatment facilities or when entering thereof. For this indicator, it is important that different types of waste be recorded separately to identify those for which adequate storage facilities are needed.

Periodicity: Annually

Formulation:

AMB9 = Total residues adequately disposed / Total energy residues

Units: Percentage (%)

Precautions and Limitations: The term "adequately eliminated" may have different meanings in different countries, so the indicator does not necessarily mean the same thing everywhere. However, as the use of this indicator is mainly internal, this does not pose a major problem. The indicator does not distinguish between toxic and hazardous wastes and those that are more benign. For this reason, it may be important to divide the total indicator into sub-indicators for different types of waste.

x. *ENV10: Ratio of solid radioactive waste to produced energy units*

Description: The purpose of this indicator is to account for the quantities of the various radioactive waste streams deriving from the nuclear fuel cycle in particular and from other fuel cycles per unit of energy produced.

For nuclear fuel cycles it is possible to classify radioactive wastes, in solid form, into three different categories:

√ High Activity Radioactive Waste (HARW)

√ Low and Medium Activity Radioactive Waste (LMAR), and

√ Used or spent nuclear fuel.

The vast majority of radioactive waste is of low activity, and for many years there have been sites of safe disposal. There are viable means for waste management. There are two options in the case of medium and low activity. On the one hand, the surface confinement or its storage in underground facilities of low depth.

On the other hand, high activity waste requires management systems that guarantee its isolation and confinement over long periods of time. The two options for storage are long term storage and deep storage or deep geological storage. Prolonged temporary storage allows the storage of fuel between 100 and 300 years and can be carried out with the technology currently available through centralized temporary storage. With regard to the second option, deep geological storage has yet to be demonstrated to be effective for extremely long periods or at least similar to those of prolonged temporary storage. Although there is no specific international regulation in this regard, there is consensus on deep geological storage on the best option once the technology offers total guarantees. Prolonged temporary storage, however, does not offer a definitive solution to the problem, but remains pending for future generations. It is, therefore, a temporary management option, and not a final option.

In addition, radioactive waste includes spent nuclear fuel, although in some countries it is not considered as waste and is routinely transformed (or stored for future use) in order to recycle uranium and plutonium. The ENV10 indicator described represents a set of indicators since each type of radioactive waste should be assessed separately.

For nuclear radioactive waste packed in packages, the volume must be the actual volume in m^3 as recorded in the register, and for spent nuclear fuel the volume should be expressed in tones of heavy metal (tHM). For radioactive waste not yet packaged, the volumes used must be those based on the conditioning method with which the waste is to be disposed of.

The indicator is defined, for each type of waste and for each industry or activity, as the ratio of solid radioactive waste to energy produced. The waste is normalized with respect to the amount of energy produced for a selected period (several years or during the life of the facility).

Periodicity: Annually

Formulation:

AMB10 = Qty of radioactive residues / produced energy

Units: Volume / Energy; m^3/ TWh; TMP / TWh; m^3/ Tep; TMP / toe; m^3/ EJ; TMP / EJ; where EJ are exajoules (10^{18} Joules).

Precautions and Limitations: Differences may arise in the classification system used to carry out national inventories due to differences in definitions of waste between countries. The definition of the global indicator of the fuel cycle requires an elaborate methodology that is not yet fully defined.

xi. *ENV11: List of solid radioactive waste pending disposal with total solid generated radioactive waste*

Description: This indicator shows the percentage of radioactive waste still awaiting disposal with respect to radioactive waste existing at any given time for any energy fuel cycle. The increase over time in the quantities of radioactive waste awaiting disposal indicates the increasing need in the long term to expand appropriate disposal options such as deep geological storage.

The indicator relates to the amounts of all radioactive waste from the energy combustion cycles, including mining, milling, power generation and other related processes. Radioactive wastes in solid form are classified according to the ENV9 indicator. This indicator represents a set of indicators given each for each type of radioactive waste.

Periodicity: Annually

Formulation:

AMB11 = Qty of radioactive residues awaiting disposal / total radioactive residues

Units: Percentage based on cubic meters (m^3) of solid radioactive waste (or tones of heavy metal [tHM] for spent fuel) pending disposal on total generated radioactive waste.

Precautions and Limitations: There is an inevitable time lag between the time the waste is produced and the time of disposal. In the case of spent nuclear fuel and HARWs, this time span may be in the order of several decades, and therefore the trends should be carefully interpreted.

Differences may arise in the classification system used to carry out national inventories due to differences in definitions of waste between countries.

xii. *ENV12 - Emissions of greenhouse gasses per unit of generated electricity*

Description: It is the division of the total volume of emissions of greenhouse gasses produced by the electric sector, for the total electricity generation. The indicator allows the environmental impact of each generated GWh to be measured.

This indicator can be mitigated by the greater use of renewable or clean energy sources in electricity generation.

Formulation:

ENV12 = GEIEE / PREE

Where:

ENV12 - Emissions of greenhouse gasses per unit of generated electricity (ton/GWh)

GEIEE = Emission of greenhouse gasses due to electricity generation (ton)

PREE = Total Electric Production (GWh)

ANNEX IV-A: Multi-criteria evaluation of Options[117]

In essence, it is a question of expressing in a quantitative order the appreciations and preferences of a group of people on the set of scenarios previously constructed.

The four steps on which the method of this evaluation technique is developed are detailed below:

Step 1: Establishment of the Evaluation Group or Groups

The members of the Group have to meet two conditions: solvency and representativeness. It is very important for them to be properly informed people about the energy issue, and in turn they must be able to express the views of all potential stakeholders. This does not necessarily require that they be formally invested in representation by some institutional mechanism, but that all possible opinions can be gathered in the debate.

Of course, all the participants have to share the main objective. It would not make sense, for instance, to call people who, even with the highest qualifications, are convinced of the futility of planning, or who think that this task should be carried out in another area.

In addition, when the members become part of the Evaluation Group, they must be willing to have their opinions and convictions on the issue that calls them up, to be questioned or reformulated by other members. And they must also be properly informed about the method to be followed and the rules of the game that have been previously set for this.

If circumstances allow it, it is advisable to set up two Assessment Groups: one predominantly technical, responsible for awarding the scores, and the other with a predominance of policy makers, responsible for the weightings. We will explain later about the specific meaning within the method, of these two concepts. By all means, the project's team will participate in the group of technical predominance, except the chief of staff, and some specialists, who will later be in charge of the specific planning tasks. The group of policy makers may be integrated by those called upon to approve the planning at the immediate top level and the project manager. Again, the possible participation of the members of the political level in this instance has the purpose of enriching the process with their contributions of ideas and appreciations. He will be part of a working group and will not merely execute a decision-making function. Each of the Groups must have a Coordinator, who must be entitled to call for the technical, computer and logistical support required by the Group.

The criteria definition or selection may require time and many discussions. In any case, it will be time well spent. The method advises that the selection task should not be considered finished until all the members of the Group accept they opinions as duly reflected

Step 2: Selection of Evaluation Criteria

The first task of the Group is to determine or select the Evaluation Criteria. Based on the experiences of application of the method, the group has access to certain sets or families of criteria of which we give examples below. However, it is not advisable for the Group to begin its work on the basis of a closed list.

The evaluation process will be well developed if the criteria selection reflects the full range of opinions expressed by the members of the Group. There is no restriction on the number of criteria, but they will be required to form a coherent set and not contain overlaps or redundancies.

117 It can also be called the Delphi Method.

Ideally, the criteria should be selected at this stage in a definitive manner, and the chosen list should not be modified.

In a planning scenarios evaluation there are at least six sets or families of criteria, of which we show the following examples:

- √ **Economic criteria**: Influence of the expected rate of economic growth of industrial and emerging countries; Impact of OPEC oil price; Situation of financial markets and the interest rate.
- √ **Environmental criteria:** admitted ranges in terms of emissions, ecosystem affectation, possible participation in the "carbon market".
- √ **Technological criteria**: Trends in the share of renewable energy sources in the world energy supply; Changes of technological origin in the costs per unit of product according to sources; Changes of technological origin in the demand of the transport sector.
- √ **Political criteria**: Influence of international conflict on the local or regional energy market; Definition (or lack of definition) of the participation of public or private capital in the energy sector; Governmental definitions of efficient use, on greenhouse effect, on nonconventional repositories.
- √ **Social criteria**: Energy cost and energy accessibility; Social acceptance of nuclear, hydroelectric, wind, and high voltage transmission facilities.
- √ **Legal criteria**: There is the need to amend the standards at the legislative or regulatory level, as well as constitutional restrictions,

Step 3: Weighting

Once the Criteria list has been selected, it must be accepted that when they all are relevant as to be considered by the Group, not all of them have *the same importance*. The next task is to assign a relative weight to each of them, as an indicator of the importance attributed by the members of the Group to each one of them.

In some simple cases of application of the multi-criteria analysis, it will be found that the weighting is previously fixed, by consensus or by regulation, and it is not a subject of discussion among the evaluators. Of course, the scenarios selection for energy planning is not a simple case. There is no prior consensus, each member of the Evaluation Group may assign a different relative weight to each criterion, and as in the previous Step, and there may be discrepancies and discussions.

> All criteria are of relevant enough to be considered by the Group. Not all of them have the same relevance

Weighting using coefficients

We assume that each of the members of the Group can give each criterion a numerical value that reflects their preference.

Table IV-A.1: Weighting table of criteria using coefficients

CRITERION	a STAKEHOLDER X	b STAKEHOLDER Y	c STAKEHOLDER Z	d=(a+b+c)/3 AVERAGE	PRELATION	d/Total WEIGHING
CRITERION 1	5	5	8	6	1°	0,25
CRITERION 2	3	2	2	2,33	5°	0,10
CRITERION 3	3	5	1	3	4°	0,13
CRITERION 4	3	1	1	1,67	6°/7°	0,07
CRITERION 5	5	4	2	3,67	3°	0,15
CRITERION 6	1	1	3	1,67	6°/7°	0,07
CRITERION 7	4	6	7	5,67	2°	0,24
Total	**24**	**24**	**24**	**24**		**1,00**

Source: self-made

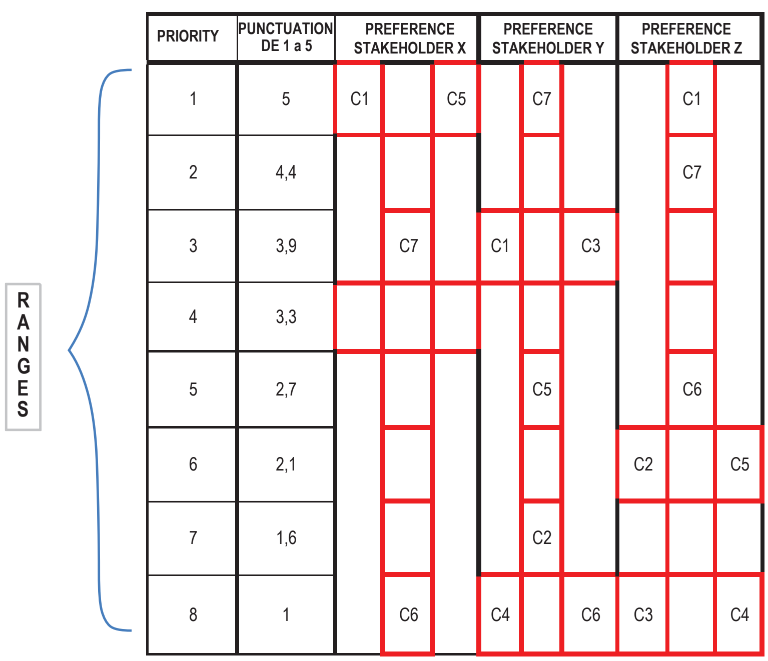
One possible way is to prepare a Weighting Table, bringing together in a double entry table the list of criteria and that of the members of the Group. To give each criterion a numerical value, a scale from 1 to 10, or from 1 to 5 can be used, or to assign to each member a total of points to be distributed among the different criteria.

As an example, we present below a case in which the Evaluator Group would consist of three members ("stakeholders") and seven criteria have been selected. In this example, each member has a total of 24 points, and has to distribute them to reflect the relative importance of each of the seven criteria.

Weighting by the 'cards game' method

It is a method that "on the one hand, is simple enough so that all interested parties can understand it and, on the other hand, it insufficiently elaborated to consider notions such as equivalence, preference and clear preference.

Figure IV-A.1: Weighting of the criteria through the "cards game."



Source: self-made

As if it were a game of cards, it works as follows:

- √ All criteria are noted in a series of cards, and some can also be left blank (without written criteria).
- √ Each member of the group receives a series of cards with the criteria, and as many white cards as you wish.
- √ It is a question of classifying the criteria by order (usually in decreasing order of importance). This method has two interesting possibilities: different criteria can be placed at the same level (equivalence), and white letters can be inserted between two criteria to mark the intensity of the preference.
- √ Two simple rules should be set at the beginning: the number of levels of cards accepted (e.g., no more than 8 levels of classification of the criteria) and the scoring mode (e.g., the distance between the best and the worst score cannot exceed a ratio of 5). The following example uses the values mentioned.

In this example, the score of the different possible levels reflects the decided distances: the 8 levels receive linearly between 5 and 1. For the stakeholder x, the criteria C1 and C5 are the most important, but does not express any preference among them.

Figure IV-A.2: Weighting of the criteria through the "cards game" (I)

CRITERION	a STAKEHOLDER X	b STAKEHOLDER Y	c STAKEHOLDER Z	d=(a+b+c)/3 AVERAGE	PRELATION	d/Total WEIGHING
CRITERION 1	5	3,9	5	4,63	1°	0,22
CRITERION 2	3,3	1,6	2,1	2,33	5°	0,11
CRITERION 3	3,3	3,9	1	2,73	4°	0,13
CRITERION 4	3.3	1	1	1,77	7°	0,09
CRITERION 5	5	2,7	2,1	3,27	3°	0,16
CRITERION 6	1	1	2,7	1,57	6°	0,08
CRITERION 7	3,5	5	4,4	4,30	2°	0,21
Total				**20.6**		**1,00**

Source: self-made

Criterion C7 obtains a good position in the classification, but the stakeholder has wanted to point out the difference of importance that for him separates this criterion of the first two, by inserting a white card. And so on until reaching criterion C6, which is not only the least important for this person, however he stresses the degree of this opinion is separating it from the others by three white cards[118].

If in the same example we opted to remove the restriction on the distance between the best and the worst score, and we simply adopted the score 8 to 1, we find the values of the *Fig. IV-A-2*.

Comparing the data obtained by the three paths shown by the example, it is observed that the results do not have important differences. The priority order to which we have concluded is always the same, and there are only small differences in the resulting weighting coefficients.

118 European Commission "Evaluation".

Sensitivity Test

As its name implies, it is a test designed to know what impact would have some changes in the values introduced on the results, either on the score given to each of the criteria or in the preferences that determine the weighting. It can even be examined the influence of a suppression of a criterion on the results. If small variations in the values introduced produce substantial changes in the results, a review of the actions would be suggested, although it will not be mandatory to modify 1.

Step 4: Application of the Criteria

Once the criteria and their respective weighting have been defined, each of the members of the Evaluation Group ("stakeholders") must give its judgment. That is, it must express an assessment of each of the scenarios about each of the criteria.

The objective of this phase is to grant each scenario a criterion score and a total score. This allows one to compare the scenarios on one side and the other the opinions between the different stakeholders regarding the same scenario.

Table IV-A.3: Weighting table of the criteria by the "game of cards" (II*)*

CRITERION	a STAKEHOLDER X	b STAKEHOLDER Y	c STAKEHOLDER Z	d=(a+b+c)/3 AVERAGE	PRELATION	d/Total WEIGHING
CRITERION 1	8	6	8	7,33	1°	0,25
CRITERION 2	4	2	3	3	5°	0,10
CRITERION 3	4	6	1	3,67	4°	0,13
CRITERION 4	4	1	1	2	6°/7°	0,07
CRITERION 5	8	4	3	5	3°	0,17
CRITERION 6	1	1	4	2	6°/7°	0,07
CRITERION 7	3	8	7	6	2°	0,21
Total				**29**		**1,00**

Source: self-made

Continuing with our example, we prepared a Valuation Table assuming that the Evaluation Group has three members ("stakeholders" X, Y, Z), and that it is a question of choosing between **N** Scenarios (I, II, III, IV, ...) applying seven criteria (*Fig. IV.7*)

Each one of the members must complete a Table in which he / she records his / her evaluation of each one of the scenarios, with respect to the selected criteria, in a previously agreed numerical scale. For example, between 1 and 10, understanding that the 10 represents the highest rating with respect to that criterion, and 1 the lowest. The application of the weights and the final sum allows us to know the final pronouncement of that stakeholder on the relative positions he attributes to each scenario.

Subsequently, the aggregation by sum of the values expressed by each stakeholder allows to arrive at the Group Valuation Table, whose result will indicate the order of priority of the scenarios.

The mathematical treatment presented in the previous cases is undoubtedly the simplest, both for the determination of the relative importance of the Criteria (weighting) and for the qualification given by each member of the Evaluation Group, and the subsequent aggregation of those values until the final result.

It is not the only methodological choice. The literature on "multi-criteria evaluation" also presents other methods, which add complexity - especially depending on the available computer tools - although not necessarily these are more precise.

It should be borne in mind that, in any case, it is an effort to summarize and express in measurable values a weighted set of opinions and intuitions issued by different people (an evaluation group constituted “ex profeso” and made up of experts according to the nature of what will be evaluated), which will reflect a preference on possible solutions, before the set of economic, environmental, technological, political, social, legal criteria and those that are part of the exercise that is carried out.

Table IV-A.4: Valuation table per stakeholder

STAKEHOLDER	SCORING OF EACH SCENARIO								
X	Criterion 1	Criterion 2	Criterion 3	Criterio 4	Criterion 5	Criterion 6	Criterion 7	Total by Scenario	Rank
Weighing	P1	P2	P3	P4	P5	P6	P7	1	
Scenario I	X11	X12	X13	X14	X15	X16	X17		
Scenario II	X21	X22	X23	X24	X25	X26	X27		
Scenario III	X31	X32	X33	X34	X35	X36	X37		
Scenario IV	X41	X42	X43	X44	X45	X46	X47		
Scenario n	Xn1	Xn2	Xn3	Xn4	Xn5	Xn6	Xn7		

Source: self-made

Table IV-A.5: Valuation table of the Group

GRUPO	SCORING OF EACH SCENARIO								
	Criterion 1	Criterion 2	Criterion 3	Criterio 4	Criterion 5	Criterion 6	Criterion 7	Total by Scenario	Rank
Weighing	P1	P2	P3	P4	P5	P6	P7	1	
Scenario I	SUM(X11+Y11+…)								
Scenario II									
Scenario III									
Scenario IV									
Scenario n									

Source: self-made

ANNEX IV-B: Scenarios in the Planning of LAC and others

Scenarios in LAC

Country	Entity - Horizon	Scenarios	Relevant variables considered
Argentina	AGEERA[119] - 20 years	Two: BAU (business as usual) and ERU (rational energy use).	Energy efficient policies. Incorporation of renewable generation (wind energy)
Argentina	Secretary of Energy[120] - 2008 - 2025	Two: Tendency and Structural (this, with policies of UEE - use of energy efficiency - and restrictions to the penetration of natural gas in motor vehicles).	Energy efficient policies. Incorporation of renewable (wind - solar) and nuclear energy. Restriction to compressed natural gas in motor vehicles.
Mexico	Secretary of Energy[121] - 2009-2024 - Natural Gas	Three for demand: planning, low and high demand. Only for supply: official projections (PEMEX). Each new "Foresight" modifies the planning scenario and hence periodic changes in planning.	Official macroeconomic projections: GDP, prices, demography. Trends and plans of demand sectors (oil, electricity, industry, residential and services). Low and high scenarios based on GDP.
Mexico	Secretary of Energy[122] - 2009-2024 - Electricity	Three for demand: planning, low and high demand. Unique to supply: SEN expansion program. Each new "Foresight" modifies the planning scenario and hence periodic changes in planning.	Evolution of GDP: high, medium and low, correlated with electrical demand. Trends and plans by sector of demand (residential, commercial, industry, services, agricultural pumping, and export). Supply (public service and self-supply)
Mexico	Secretary of Energy[123] - 2009-2024 - Natural Gas	Unique: trend projections of demand with structural adjustment for each case. Projections of PEMEX supply.	Residential demand, services, industry, self-transport, agriculture, oil. Variables: inhabitants/housing, industrial product, alternative fuel prices.
Ecuador	CONELEC[124] - Electricity - 2007 - 2016	Three to project GDP, demand and coverage: higher - medium - lower[125].	Evolution of GDP; Demand Growth; And the extension of the electrical coverage.
Colombia	UPME[126] - 2006 - 2020	Three for electrical demand (power and energy): high - medium - low.	Demand growth, variables: GDP, population and energy losses.
Central America	ECLAC[127] 2020	Six: 1) Electric Plan I, hydro up to 75MW; 2) Electrical Plan II, hydro up to 150MW; 3) Electric Plan III, free hydro; 4) Electrical Plan I + URE (9,000GWh), 5) Electric Plan I + biofuels + cogeneration; 6) Electric Plan III + ERU + biofuels + cogeneration + improved kitchens + transport measures (10%).	Technological alternatives in the expansion of supply; Penetration of ERUs, biofuels, and cogeneration; Demand Management (kitchens and transportation).
Central America	GTPIR-CEAC [128] 2012-2027.	Two Scenarios for Demand Growth: Average Growth (historical) and High. It takes 6 determinant factors that form 12 cases of study that derive in a Scenario of Reference, with analysis of sensitivities. From this, costs are calculated for 12 scenarios[129].	Alternatives analyzed: 1. Existence of favorable conditions for Hydro and renewable energies (extreme case: plus thermal without Hydro energy); 2. Price of fossil fuels; 3. Growth of the Demand; 4. Panama-Colombia Connection; 5. SIEPAC line input; 6. Detailed representation sist. Colombian.

119 Association of Electric Power Generators of Argentina.

120 Argentina, Secretary of Energy. Strategic Planning Group (2008).

121 Mexico, Federal Government (2009) Natural gas.

122 Mexico, Federal Government (2009) Electricity..

123 Mexico, Federal Government. (2009) LPG.

124 Ecuador, CONELEC.

125 Compulsory planning is proposed, as opposed to an indicative one.

126 Colombia, UPME.

127 ECLAC, (2007), p. 84

128 Central America, GTPIR - CEAC (2012).

129 Resulting Scenarios: Base; without SIEPAC and without Colombia; without Colombia; without SIEPAC (2) and without Colombia (2); without SIEPAC (2); without Colombia (2); without restriction Hydro; with Generic Renewables; Fuels High Prices; without restriction Hydro and Fuels High Prices; High Demand; and Colombia detailed.

Country	Entity - Horizon	Scenarios	Relevant variables considered
Brazil	EPE[130]- PDE 2021.	A reference scenario and a mitigation scenario (<emissions,> efficiency). The reference scenario emerges as the most likely trajectory of a "cone of scenarios" of longer-term studies[131]. It is incorporating sensitivity analysis by subsectors of energy consumption. Each new annual PDE analyzes and modifies the baseline scenario and hence periodic changes in planning.	Relevant variables: 1) Macroeconomics. A) Level of Activity. GDP worldwide; World trade and national GDP (agriculture, industry and services); B) Development. Savings Rate and TFP; Investment (public and private) / GDP; C) Public Sector. Primary surplus; Nominal deficit and net debt / GDP; D) External Sector. Trade Balance; Foreign Direct Investment and Balance of Payments. Oil price - Brent; 2) Demography. Population, housing.
Brazil	EPE[132]- PDE 2021.	A reference scenario and a mitigation scenario (<emissions,> efficiency). The reference scenario emerges as the most likely trajectory of a "cone of scenarios" of longer-term studies[133]. It is incorporating sensitivity analysis by subsectors of energy consumption. Each new annual PDE analyzes and modifies the baseline scenario and hence periodic changes in planning.	Relevant variables: 1) Macroeconomics. A) Level of Activity. GDP worldwide; World trade and national GDP (agriculture, industry and services); B) Development. Savings Rate and TFP; Investment (public and private) / GDP; C) Public Sector. Primary surplus; Nominal deficit and net debt / GDP; D) External Sector. Trade Balance; Foreign Direct Investment and Balance of Payments. Oil price - Brent; 2) Demography. Population, housing.
Chile	CNE[134]. 2008-2030.	Baseline scenario with sensitivities: optimistic and pessimistic scenario.	GDP and production by sectors.
Guatemala	CNEE[135].2012 – 2026.	7 Scenarios: Biomass-carbon; Natural gas; Without Geothermal; All resources; Exports; Energy efficiency; Trends and high demand.	Variables: Demand, Price of Fuels and technologies of supply (penetration of renewable energies)
Costa Rica	ICE. Electrical Generation 2012-2024[136].	42 scenarios were studied iteratively. Demand: medium, high and low. One, two or three combined cycles and work delays. Alternative dates, hydro and thermal reduction. Derive in a Reference Plan and a Recommended Expansion Plan.	Impact of four variables: demand (projections), combined cycle, large hydro and policy to reduce thermal plants.
PERU	OSINERGMIN[137]. 2008-2015.	Projections growth in average demand (8%), 7% and 10%. Two cases: With and without new generation.	Significant variables: GDP growth; Greater penetration of natural gas into electricity generation (CAMISEA).

Source: self-made

130 Brazil, Ten Year Plan.
131 Brazil, Ten Year Plan.
132 Brazil, Ten Year Plan.
133 Brazil, Ten Year Plan.
134 Chile, CNE (2008).
135 Chile, National Electric Energy Commission (2012).
136 Costa Rica. ICE (2012).
137 Peru.

Other "Scenarios"

Country	Entity - Horizon	Scenarios	Relevant variables considered
USA	USEIA[138]. - 2025 and 2040	Three referred to renewable energy and reduction of CO^2 emissions: a) Reference (with existing regulation); b) Temporary extension of incentives to renewables; And (c) Extension of incentives to renewables. Three related to the interaction between economy and energy[139]: a) case of high growth; b) case of reference; and c) case of low growth.	Insertion of renewables in energy matrix; Reduction of greenhouse gas emissions. Variables for growth: real GDP; Non-rural employment; and productivity.
USA.	Inter-laboratory Working Group[140]. 20 years	Three scenarios: BAU (business as usual), moderate and advanced to 2020. It frames them in four global long-term energy scenarios (2050): A1 high economic growth and low population projection; A2 under economic growth and high population projection; B1 average economic growth and low population projection; B2 similar but lower economic growth and greater population increase.	Commitment of public policies to clean energies (reduce energy intensity, use of coal and promote the capture of emissions). Economic and demographic growth.
Netherlands / World	Shel141 2050	Two scenarios: Inertia (scramble) and Planning (blue prints)	Decisions or political indifference regarding the rational use of resources and their global environmental effect.
USA / World	ExxonMobil[142] - 2010 - 2040	A global scenario, based on analysis by consumption subsectors: residential / commercial, transportation, industry and electricity.	Demography, economic growth, new technologies, greater energy efficiency, more renewable, less emissions, public policies.
Great Britain	National Grid Co.[143] - 2020-2030 and 2050.	Three referred to renewable energy and GHG: a) Slow progression; B) Green advance; And c) Accelerated advance.	Penetration of renewable energies in the energy matrix and GHG reduction.
Spain	MITC – SGE[144] – 2008 - 2016	An initial "basic scenario" with sensitivity analysis to different changes in basic assumptions or policies demand. For electricity and gas the demand is projected based on a "technical scenario" of the operator of the respective systems and another "efficiency scenario". Typical specific scenarios for the modeling of transport networks.	Economic growth, protection of the environment, fiscal policies, transport and new technologies.

Source: self-made

138 US EIA / DOE (2013).
139 Macroeconomic activity module, EIA / DOE (2013).
140 United States, DOE (November 2000).
141 Shell International BV, (2008).
142 ExxonMobil. (2013).
143 National Grid. (2011).
144 Spain, Ministry of Industry, Tourism and Trade (2008).

ANNEX V-A: Modifiers

1. The case of Greenhouse Gases

Throughout the temporary journey begun in the early 1970s at the Stockholm Climate Conference and continuing today, the international discussion has largely transcended the initial outline of a scientific society. Networks of experts and environmental NGOs, together with international cooperation organizations, have extended the debate to mass media such as television, newspapers and popular magazines, the discussion on Climate Change and its link with GHG emissions is an example of Public dissemination through information and media of various kinds.

Both nature and human activities are sources of emission of pollutants. In the case of emissions of gases originating from natural elements such as oceans, volcanoes, and plants, the same nature was commissioned, through a process of millions of years, to absorb part of them, finally achieving a natural balance that allowed the development of life on our planet.

As it was mentioned in the borders section, this balance has been somewhat disturbed by the appearance of man and mainly after the Industrial Revolution. As a consequence, a series of new environmental phenomena have manifested, and they have constituted in one of the main concerns humanity has so far.

With regards to natural emissions, these include animal and plant biological processes, volcanic emissions, marine emissions and spontaneous forest fires. In contrast, anthropogenic emissions - caused by man's actions - include those derived from the combustion of fossil fuels, industrial processes, chemical industry, land use for crops, deforestation, the use of biomass, and also the use of pesticides and fertilizers, among other activities.

The main gasses of natural and anthropogenic origin are detailed below:

Table V-A.1: Gases Emitted from Natural and Anthropogenic Sources

NATURAL and ANTHROPOGENIC SOURCES	
Name	**Symbol**
Water vapor	
Carbon dioxide	CO_2
Methane	CH_4
Nitrous oxide	N_2O
Ozone	O_3
Carbon monoxide	CO
Nitrogen Oxides (NO_X)	NO, NO_2
Organic Components Different Volatiles of Methane	NMVOC
Sulfur Oxides (SO_X)	SO_2, SO_3
Particles	PART
ANTHROPOGENIC SOURCES	
Chlorine-Fluor-Carbon	CFC
Hydro-Chloro-Fluor-Carbon	HCFC
Hydro-Fluor-Carbonates	HFC
Perfluor-Carbonos	PFC
Sulfur Hexafluride	SF_6
Lead Rust	PbOx

Source: Di Sbroiavacca Nicolas (2001).

Some of the gasses detailed above, but not all simultaneously, are involved in the three major environmental damages, as a consequence of their emissions to the environment: **Greenhouse effect Decrease of the ozone layer** and the **atmospheric pollution**. Each of these effects must be analyzed regarding its consequences and the gasses that cause it.

GHGs that are present in the atmosphere have the peculiarity of absorbing long-wave infrared radiation, which causes the atmosphere to warm up. Thanks to this phenomenon of natural origin, it has been possible to develop life on our planet, since the balance between incoming solar radiation and energy radiated by the earth made it possible to generate a climate system, suitable for the development of living beings.

In short, CO_2 is primarily responsible for anthropogenic GHG emissions, followed by CH_4, then the CFCs and finally the N_2O. Hence, the different emission levels often form the backbone of future scenarios.

It should be emphasized that it is not possible right now, to accurately predict future levels of GHG emissions, nor the expected concentration of greenhouse gasses in the atmosphere, and even less future climate changes due to a new atmospheric composition.

However, several studies conclude that if global temperature rise continues, the process of sea level growth could be accelerated by 20 cm by 2030 and by 65 cm by the end of the next century. Both processes would produce major problems for humanity as 50% of the world's population is located in cities off the coast and several biological and climatic processes will be affected.

We should not forget to mention that the strategies that should be implemented to address this problem are essential of two types: adaptation - changes that should be implemented to reduce the consequences of climate change - and mitigation - tend to control and slow the growth of emissions of GHG and therefore to reduce climate change. The main efforts have been linked to the second set of measures.

However, as the fourth IPCC report concludes, given existing mitigation policies and sustainable development practices, GHG emissions will increase between 25% and 90% between 2000 and 2030.

The descriptive table is now completed with the ozone first and finally the atmospheric pollution. The O_3 is produced in the stratosphere in a natural way, and its main role is to absorb ultraviolet radiation, a vital function for the normal development of human, plant and animal life. The concentration of O_3 at stratospheric level is also known as the ozone layer.

The main responsible for the decrease in O_3 are chlorine and bromine. Both products are produced by nature, mainly from the volcanic eruptions. There was at planet level a balance that allowed to maintain the concentration levels of O_3, but from the massive use by man of CFCs (chlorine products), this balance was affected. CFCs after being used mainly in (a) the refrigeration industry, (b) as a spray and (c) as a solvent, they rise from the earth's surface without any modification, and once in the stratosphere, they become chlorine (derived from chlorine), which attacks the O_3 and destroys it[145].

The **Urban and Regional Atmospheric Pollution** is the last of the three environmental problems analyzed that affect the atmosphere from gaseous emissions. Air pollution is part of a phenomenon that occurs at an urban and regional level, the main precursors of which are the following pollutants: Particles; Ozone (O_3); Sulfur Dioxide (SO_2); Carbon Monoxide (CO); Nitrogen Oxides (NO_X) and VOCs (Volatile Organic Compounds).

The analysis thus far could continue to examine the evolution and state of international negotiations in the diplomatic sphere; the technical aspects and details of the agreed texts and the timely implementation of market mechanisms (emission permits). The reader is referred to the original records of the United Nations Framework Convention on Climate Change (http://unfccc.int/portal_espanol/informacion_basica/la_convencion/items/6196.php) Or Hanssen, Jy Percebois, J. (2010).

145 As described above man also produces O_3, but at tropospheric level (known as tropospheric ozone), which contributes to the greenhouse effect. Therefore it is observed that human activities on the one hand produce O_3, which is unstable, of short-life period and it is produced at tropospheric level, and it fails to supply the O_3 which, on the other hand, also due to human activity destroys at the stratosphere.

OLADE's MEMBER COUNTRIES:

Argentina
Barbados
Belize
Bolivia
Brazil
Chile
Colombia
Costa Rica
Cuba
Dominican Republic
Ecuador
El Salvador
Grenada
Guatemala
Guyana
Haiti
Honduras
Jamaica
Mexico
Nicaragua
Panama
Paraguay
Peru
Suriname
Trinidad & Tobago
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Energy unites us

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