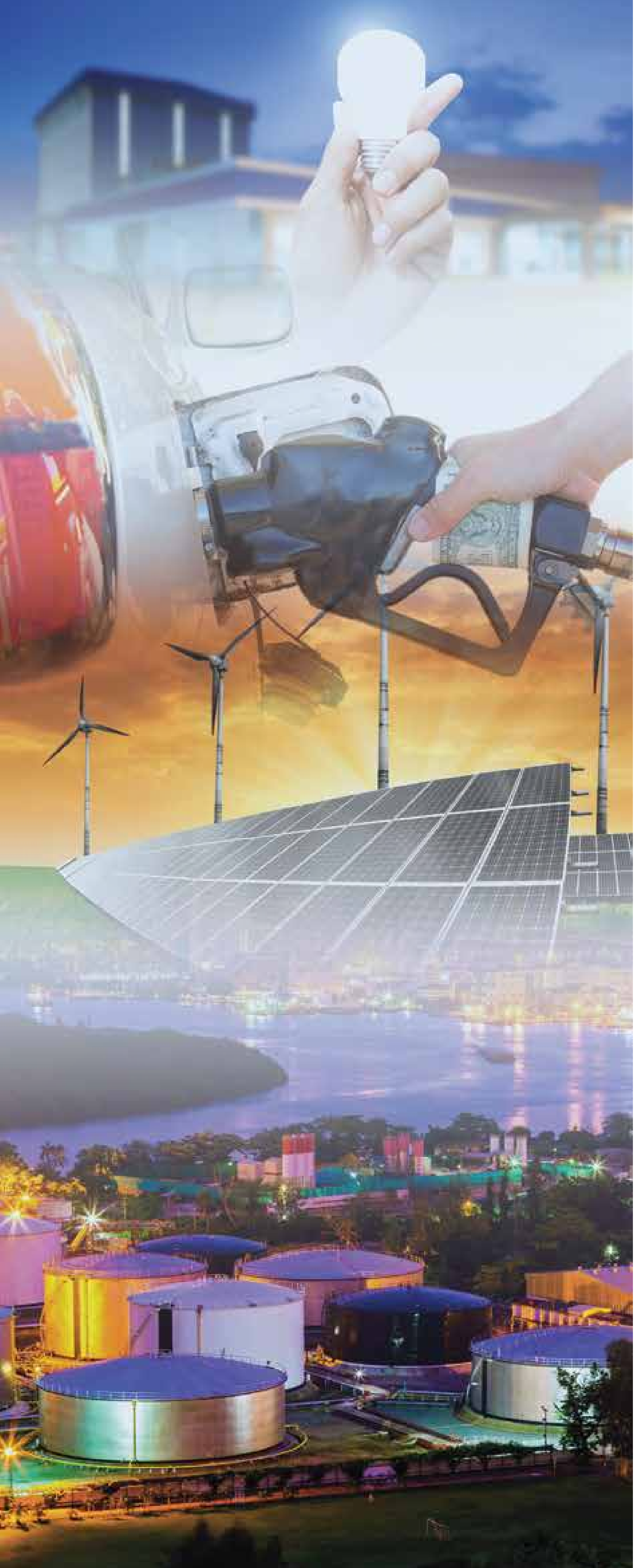

Balances of Useful Energy Manual

2017

Latin American Energy Organization

IDB

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This document was prepared under the direction of the
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FOREWORD

The Latin American Energy Organization-OLADE, makes available to its Member Countries and the public of the energy sector, this publication whose main objective is to become a reference guide for the preparation of the useful energy balances.

The organization has a deep understanding of the role of the energy balances as a key planning tool for the sector, and the ultimate objective of an energy system which is the provision of energy demand services such as: consumption in the production of goods and services, mobility, cooking, lighting, among others. On such grounds, it is necessary to go beyond final energy consumption with the aim of analyzing energy efficiency, substitution of sources, analysis and projection of demand, etc. All this requires the collection of information on consumption by subsectors, uses and technologies.

In this sense, the useful energy balance provides a deeper understanding of energy requirements and efficiency in each of the stages of the supply chain, including consumer equipment, allowing the analysis of the possibilities of substitution of sources and technologies, based on parameters such as efficiency in the availability of resources, yields, pollutant emission factors, etc.

This manual was based on OLADE's methodology and on the comparison with other applicable methodologies, in addition to the experiences of the Member Countries such as Brazil, Paraguay, Dominican Republic and Uruguay.
We would like to thank to the governmental authorities of our Member Countries, especially the information system advisors, and the team of consultants and officials who make up the Permanent Secretariat of OLADE, who have contributed to the preparation of this consultation document.

Alfonso Blanco Bonilla
Executive Secretary
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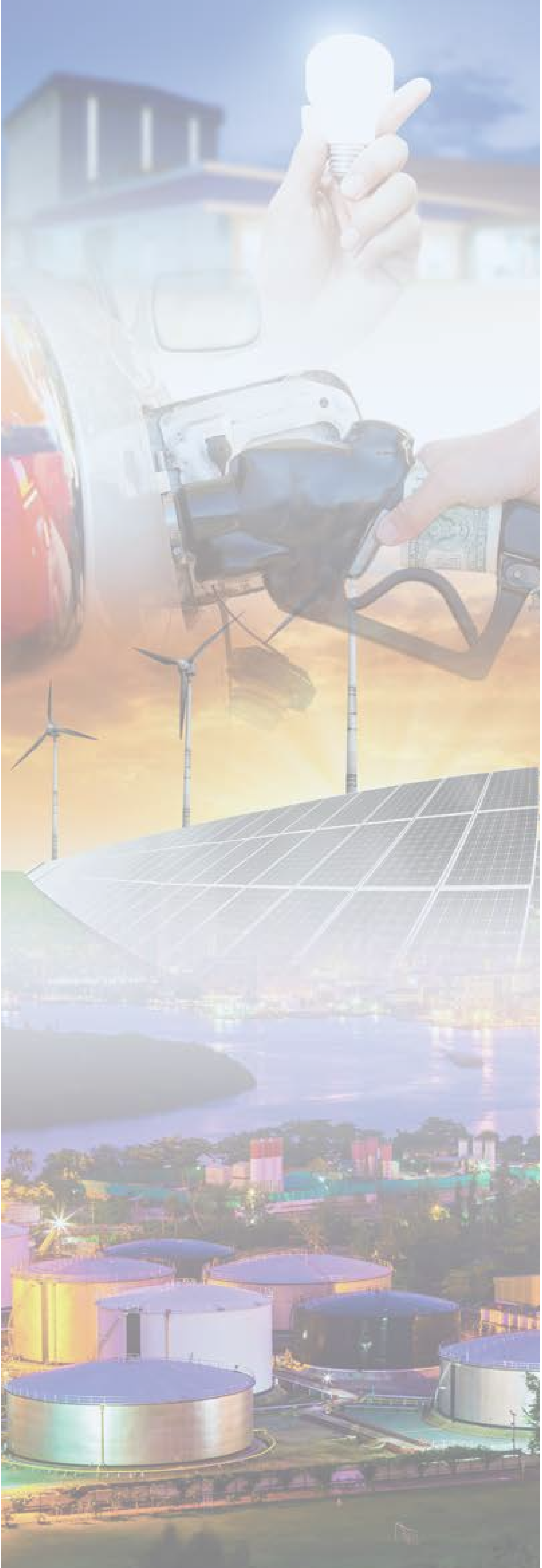
This document was prepared by the Latin American Energy Organization-OLADE with the financial support of the Inter-American Development Bank-IDB. The main objective of this work is to contribute to the strategies of the SEforALL Americas project led by the IDB.



Introduction

INTRODUCTION

The purpose for this document is to propose an update of the OLADE methodology for developing Utilizable Energy Balances. Following a review of the methodology developed by OLADE in 1986 and of methods available internationally (EUROSTAT, IEA, APEC, OECD, GEA, IIASA, IRES, DECC, Oslo Group, Bariloche Foundation), certain areas were identified for improvement such as definitions, especially in the transportation sector and other specific sectors, and in transformation centers. Past experiences with Utilizable Energy Balances in Latin America were also taken into account, including those in Uruguay, Brazil, Paraguay, the Dominican Republic, and the OLADE 2015 Energy Statistics Manual. The methodologies detailed below propose strategies for data collection and processing, the inclusion of efficiency factors in surveys and new proposals for managing them.

This is based on the OLADE document developed by a group of professionals from the member countries and from domestic/ international organizations, who developed methods for including utilizable energy in energy balances. It also reflects comments made during interviews with 15 of OLADE's member countries.

The updated methodology proposes a baseline document that analyzes the concepts of utilizable energy production and use. These concepts are related to the structure of OLADE's Final Energy Balance, along with a description of how to obtain Utilizable Energy Balances from current Energy Balances. It presents the new disaggregation of sectors into subsectors and the need to differentiate energy consumption by application with the specific technologies for each. It also describes data collection methods such as the following:

- Surveys and interviews with companies
- User surveys
    - Survey design
    - Surveying methods
- Secondary information
- Modeling
- On-site measurements

In comparison with the 1986 methodology, the main changes proposed are in the following areas:

1. **Transportation Sector**: It has a new structure in keeping with OLADE's demand forecasting methodology. A new proposal for data collection on the terrestrial mode and the vehicles fleet in circulation, along with specific consumption of fuel or energy sources, and determining efficiencies in terms of km/gal, m3/gal or similar and PKM (passenger kilometers) for public transport or TKM (ton kilometers) for cargo. All this is based on surveys at public and private service stations and companies providing cargo or passenger service and mass transit. We also propose using social networks and communication technologies to develop labs for determining the specific consumption indicators in actual operation.

2. **Residential Sector:** We propose combining the data collection methods as follows :

    a. Developing surveys to determine electric and gas household appliances owned for each application with characteristics such as age, technology, efficiency, etc.

    b. On-site measurement to determine usage patterns and specific energy consumption of each technology by application.

    c. Developing models to calculate energy consumption by use, reproducing the energy bill.

    d. Sample design by strata and clusters.

3. **Trade, Service and Public Sector**: We propose combining the data collection methods as follows :

    a. Developing surveys to determine electric and gas household appliances owned for each application with characteristics such as age, technology, efficiency, etc.

    b. On-site measurements to determine usage patterns and specific energy consumption of each technology by application.

    c. Developing models to calculate energy consumption by use, reproducing the energy bill.

    d. Sample design by strata and clusters.

4. **Industrial, Self-Consumption and Mining Sectors:** We propose technical visits or rapid audits to determine the following:

    a. Inventories of devices that consume power and fuel

    b. Use patterns per day, per week, or other period

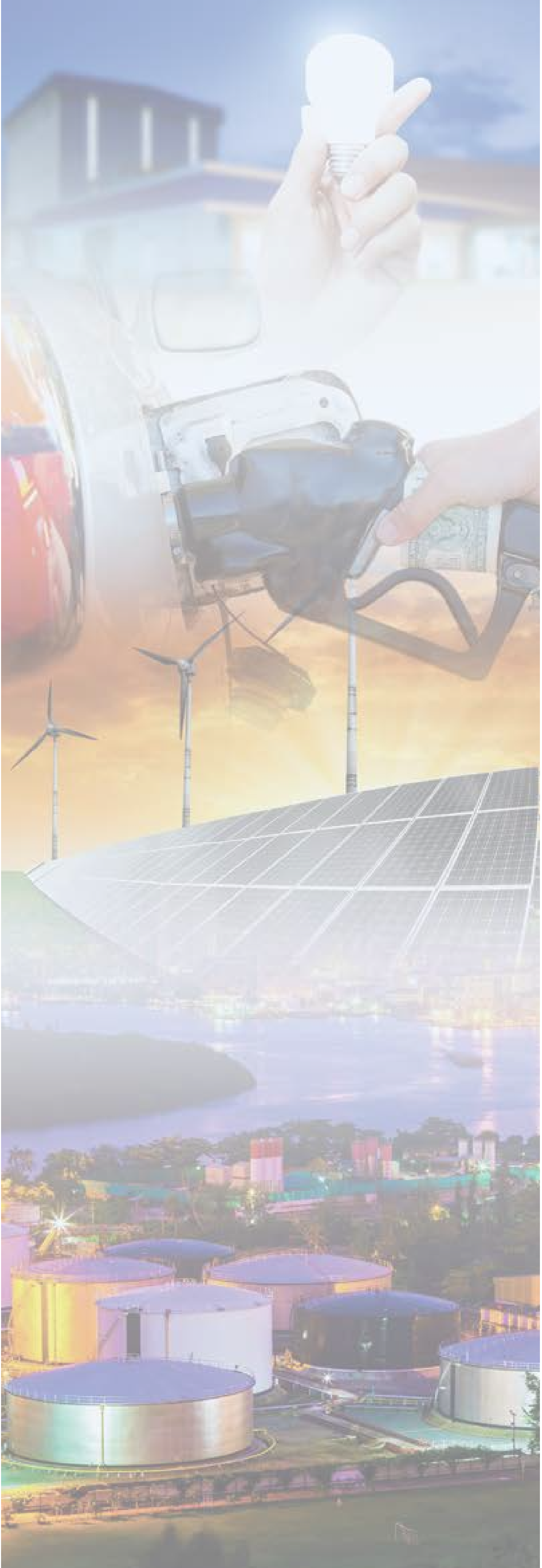
    c. Specific energy consumption and efficiency

    d. Consumption indicators

    e. Developing models to calculate energy consumption by use, reproducing the electricity and fuel bills.

    f. Sample design by strata and clusters.

It is necessary to indicate that those formats of data collection forms that are presented in the following document should be taken as reference or for orientation.



CHAPTER I

Rationale for the Methodology

1. RATIONALE FOR THE METHODOLOGY

For decades, long-term trends in the evolution of energy systems and their technological transitions have the subject of studies, invariably focused on the supply side of energy. Concerns over energy security and scarcity, and the environmental externalities of extracting and burning fuels, ranging from local issues to global pollution, explain this focus on primary energy supplies.

Data availability is another major factor. National statistics agencies started collecting and reporting data on primary energy extraction and trade in the late nineteenth century (often for tax purposes). The United Nations (or League of Nations prior to World War II) pioneered accounting and data collection methods for global primary energy during the first half of the 20th century.

However, in an energy system, primary energy consumption is a means to an end, not its ultimate aim. Rather, the most basic driver of an energy system is the demand for energy services such as transportation, production of material goods, thermal comfort and lighting. Therefore, the demand for services, coupled with constantly changing technologies that link the energy services provided, requires studies all the way upstream to primary energy needs. This complementary perspective is valuable for understanding the long-term evolution of energy systems and the opportunities for and limitations of energy processing to meet our sustainability goals.

Locally, most stakeholders are now aware that OLADE's energy balance matrix has been overwhelmed by requests for national and regional economic-energy analyses. The concepts of energy efficiency, energy source change outs and energy demand analysis and forecasting require that consumption be studied not merely by economic sectors (industrial, residential, etc.) and energy sources (electricity, oil products, etc.), as in the current balance, but also by economic subsectors (cement, iron, etc.), categories of use demand (heat, lighting, etc.) and information on end-use devices and their efficiency.

Accordingly, energy balances show the relationships between the supply, processing and final use of energy and are an important tool for organizing and presenting data for overall energy planning. They also keep track of consistent physical flows from primary energy to final consumption.

The Utilizable Energy Balance provides a clearer understanding of energy efficiency and lays the groundwork for studying potential energy source change outs, and the price/tariff competitiveness of diverse energy sources.

To achieve this, the Utilizable Energy Balance should show losses and inefficiencies on both the supply side and the final consumption side. It should follow the entire energy chain from extraction to useful consumption, thereby making it possible to monitor energy flows at each stage, from primary energy to transformation plants to transportation and distribution to the end user who turns it into utilizable energy to provide some service.

1.1 DEFINING UTILIZABLE ENERGY AND ENERGY BALANCES

Final energy (FE) is that which is available to consumers and is what current energy balances record. An energy source must be processed to obtain an energy form that is suited to the uses that consumers demand. The most common end uses include performing work, heat, certain physical/chemical processes, refrigeration, air conditioning, mechanical movement, and lighting.

One of the most common definitions of utilizable energy is that which is available to consumers following final conversion. This definition was used in the initial Utilizable Energy Balances by the EUROSTAT and the IEA.

OLADE considers that the useful energy (EU) is that which is available after the system of use for the production of a good or service, after deducting all the losses of transformation and transport associated with it.

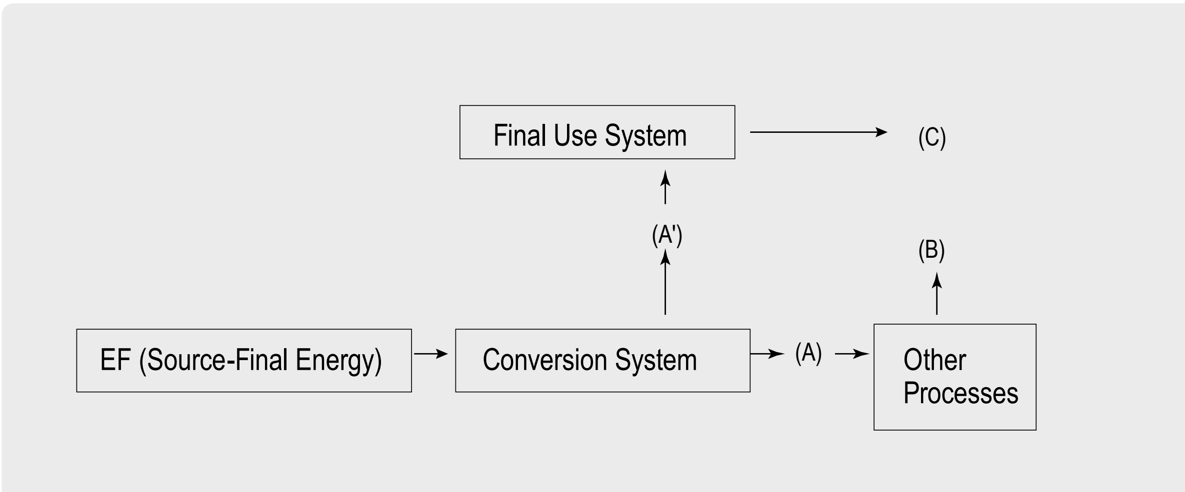
Utilizable Energy Balances are based on logging the various energy flows, considering their lower calorific power from primary supply to utilizable energy received by end consumers at their appliance outlets, which shows losses at the different stages of transformation and consumption. It is a balance that is derived from the final energy balance.

Developing a suitable methodology for calculating utilizable energy is based on considering four elements:

- Energy source
- Conversion system (final conversion devices)
- Other processes (such as steam or compressed air in the industry)
- End utilization system (the way final energy is utilized)

For Final Energy Consumption Balances, energy accounting can determine the amounts of each source that are consumed by each application, disaggregating the consumption of each economic or social sector by use. Alternative ways to express these quantities in terms of utilizable energy can be considered.

Figure 1. Methodology for assessing utilizable energy



Source: OLADE UEB Methodology, 1984.

The (A) and (A') alternatives, which take into account energy sources and their conversion, enable us to analyze an intermediate energy stage. However, according to some methods, this already represents utilizable energy. In the (A) ---> (B) section, losses originating from Other Processes (such as transporting steam or compressed air for industry) whose efficiency rates affect the PRODUCTION EFFICIENCY, will be added to the Conversion System losses. Only the path that goes through all four phases (FE) – (A) – (B) – (C) is suited to calculating the energy actually utilized in the final product or service. Utilizable energy can only be known by going through these four phases.

This concept, which OLADE believes to be exhaustive and complete, is not very practical according to the EUROSTAT methodology. The latter insists that while all those losses exist, the ability to measure the final energy that enters and the utilizable energy obtained should be considered.

The proposal is to divide the problem into two parts. The first part is to consider the (A) and (A') path, i.e., technologies and devices used in the final conversion for each energy source, where final energy is that which enters the conversion equipment and utilizable energy is that which is obtained following conversion.

The second part consists of considering how the resulting utilizable energy is consumed, i.e., the (A) to (B) path and then the final energy use systems. Less data is available on this second problem, and utilization systems can vary significantly from country to country depending on their particular weather conditions.

For example, for an industrial boiler, the first case would consider its efficiency to produce steam of a given quality from a given energy source, while the second case would include the steam transmission systems from the boiler to the point of consumption, its insulation, traps, recovery and return to the boiler, and steam exchanges to ensure the temperatures used in each process.

For an air conditioning or heating system in the residential or tertiary (trade and services) sector, the first case would consider the efficiency of the devices used to produce cold water, hot water or steam, while the second case would include not only the cold or heat distribution systems, but also the architecture, insulation, solar protection, visors, etc.

This second path, therefore, requires characterizing individual energy sources based on audits in each sector and subsector, on which to try to establish the main components that influence final energy consumption (energy waste following final conversion). An example in buildings (residential, commercial, public and services) would be as follows:

- Architectural elements cause increased energy consumption to achieve comfort.
- Non-rational, inefficient energy use (inefficient distribution of heat or cold, poorly insulated ducts, unnecessary recirculation, lighting in unoccupied areas, poor location of refrigeration devices, unnecessary operation of devices, etc.).

In the industrial sector, it would include:

- Steam distribution systems or ice water from the chiller without adequate insulation, energy-consuming equipment not integrated with the production process, optimization of production processes, etc.

In the transportation sector, it would include:

- Roads in poor conditions, incorrect road designs and insufficient routes, causing congestion and increased fuel consumption,
- Insufficient public transport, etc.

As can be seen, this path is complex and requires specific studies to quantify and standardize all components and processes. Therefore, the methodology recommends following the route proposed for this first path as an initial approach to the Utilizable Energy Balance. To calculate utilizable energy by this path, it is essential to know the following three consumption factors:

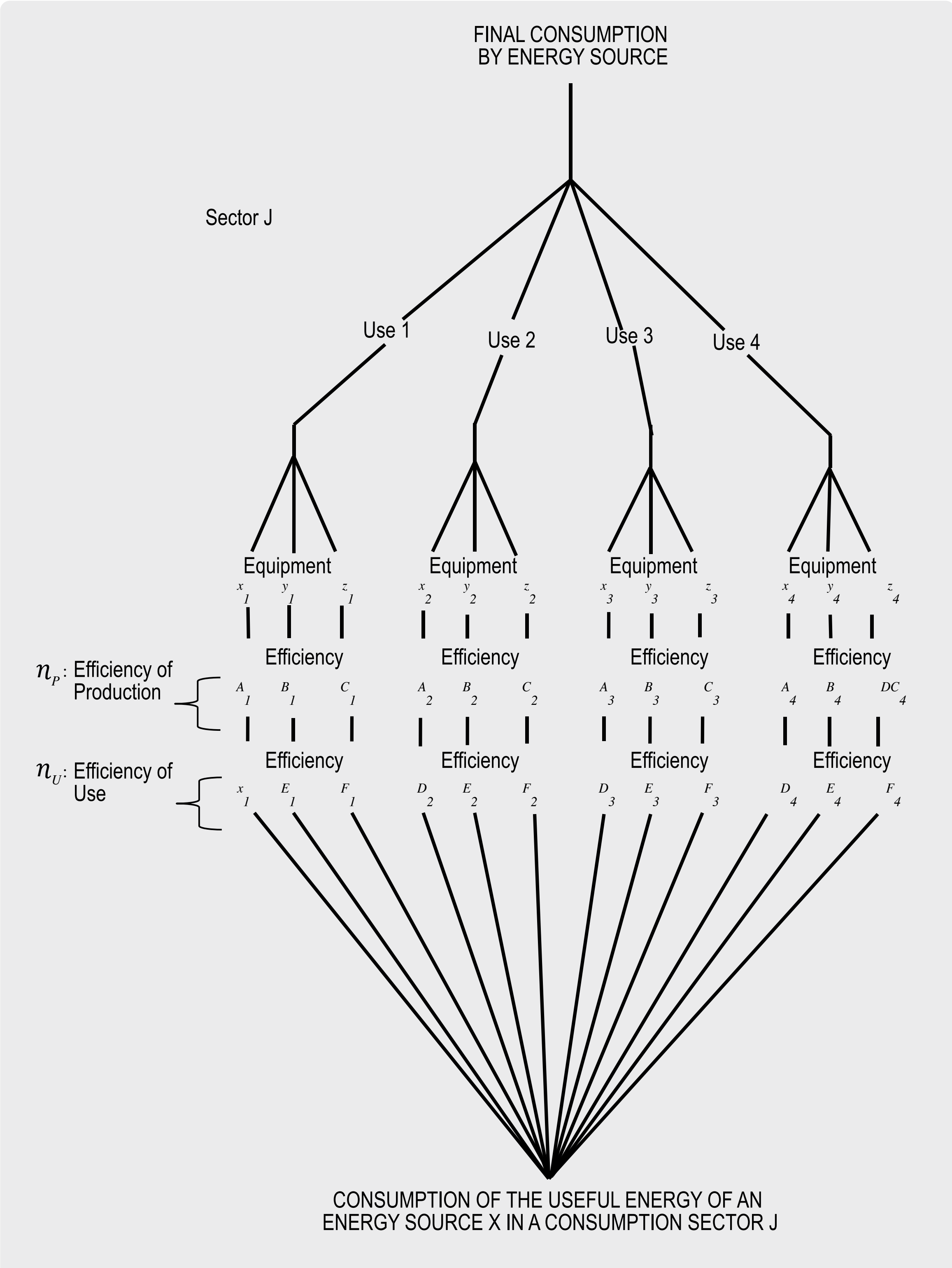
1. Energy consumption amounts by energy source and by application in the various sectors considered, i.e. the amount of energy entering the final conversion equipment.
2. The electric and gas household appliances used by consumers for various applications or services in different sectors.
3. The conversion efficiencies of the devices used.

Utilizable energy production, therefore, will be calculated by relating the final consumption of a source for a certain application in a given sector, subsector, activity, etc. to the performance of the equipment used. For the first factor, you start with the current final energy balance that differentiates the main sectors, and then you collect the data needed to disaggregate the energy consumption by subsector and by application. For the second factor, you collect the data needed to typify the devices used for each energy application or service (lighting, cooking, cooling, mechanical force, heating, direct heat, etc.) in each of the subsectors.

There are two alternatives for determining the efficiencies of typified equipment:

- Direct measurement using energy audits: This assesses the thermodynamic parameters of the processes measured. It is essential when seeking to emphasize energy SAVINGS and CONSERVATION alternatives, which require audits.
- Using efficiencies provided by producers or by competent authorities. Bear in mind that although appliance manufacturers provide efficiency values, they will depend on equipment age, as more modern devices are more efficient than older models. Remember too that a manufacturer's efficiencies are usually the optimal values under special conditions. Operating efficiencies below normal working conditions are lower and decrease with equipment maintenance and calibration, and these losses must be taken into account by using average efficiency values that cover all ranges.

Figure 2. Utilizable energy consumption of energy source X in a sector J



Source: OLADE UEB Methodology, 1984

1.2 DEVELOPING THE ENERGY BALANCE

Development of the Utilizable Energy Balance requires the following steps:

- Preparing the current Energy Balance to the final consumption level, but disaggregating it further by consumption sectors
- Disaggregating the final consumption by application
- Applying the diverse equipment efficiencies pertaining to each sector

It is essential to create a database that is compatible with the data needed in order to prepare the Utilizable Energy Balance.

1.2.1 Disaggregating Final Energy Consumption

An initial disaggregation of total final energy consumption consists of:

- **Final Energy Consumption**

This classification includes all primary and secondary products used by all consumption sectors to meet their energy needs.

- **Non-Energy Final Consumption**

This includes the volumes of products used for non-energy purposes in all consumption sectors.

1.2.2 Disaggregation by Consumption Sector

The OLADE methodology considers that in each sector, amounts consumed, energy sources and end-use devices differ by activity (in the case of productive areas) or housing/income characteristics (in the case of the residential sector) and involve various levels and forms of energy. Thus, the following main sectors are reviewed:

- **Transportation Sector**

Covers the energy consumption of all transport services, whether public or private, national or international, for different means and modes of passenger and cargo transport (by land, air or sea).

- **Industrial Sector**

Includes the energy consumption for all industrial activities and applications, except for the transport of goods, which is included in the transportation sector.

- **Residential Sector**

Includes all energy consumption to meet the residential needs (cooking, lighting, cooling, etc.) of urban and rural households.

- **Trade, Service and Public Sector**

Includes the energy consumption of all private trade and service activities, such as shops, hotels, restaurants, etc. It also includes energy consumption at all levels of government (national, provincial and municipal) and state or private utility institutions and companies. It includes hospitals, schools and the energy consumption of the military and/or police.

- **Farming, Fishing and Mining Sector**

Includes the energy consumed for all activities associated with obtaining raw materials, such as agricultural and livestock activities, fishing and ore extraction.

- **Self-consumption**

Covers energy self-consumption of energy during the production, transformation, distribution and pipeline transportation of primary and secondary energy sources.

- **Construction Sector**

Includes all energy consumption in the construction, building and civil works sector.

1.2.3 Disaggregation by Subsector

One of the main reasons for this disaggregation is to develop energy demand forecasting models, determined by the relationship between energy consumption and some characteristic magnitude of a product (industrial output, passenger-kilometers, etc.). Another reason is that consumption patterns, energy sources and devices used to meet production needs or provide energy services differ according to the activity, housing features or income level, which determine different consumption levels for both final energy and utilizable energy.

This gives way to a sufficiently broad sectorial disaggregation due to the diversity of energy sources and the various ways of using them in different sectors. Each Member Country can decide on its own disaggregation, depending on its needs, but the OLADE methodology recommends the following disaggregation for each sector:

Transportation Sector	Land	Load	Urban (public)
			Intercity (public)
		Passenger	Urban (public or private)
			Interurban (public or private)
	Rail	Load	Intercity public
		Passenger	Urban public
			Intercity public
	Air	Load	Public
		Passenger	Public
	River Waterways	Interurban	Passenger
			Load
	Maritime		Passenger Load
Industrial Sector	Food, beverages and tobacco		
	Textiles, clothing, footwear and leather		
	Wood and furniture		
	Paper, cellulose and graphic		
	Chemical (excluding oil refining)		
	Cement		
	Stone, glass and ceramics		
	Iron, steel and non-ferrous metals (excluding coking plants)		
	Machinery and equipment		
	Other industries		
Residential Sector	Urban	Strata	
		Low, medium, high	
	Rural	Strata: low and medium	

Trade, Service and Public Sector	Trade / Service	Wholesale and retail
		Restaurants and hotels
		Financial, insurance, real estate and corporate service establishments
		Other services
	Public	Public services
		Public administration
		Education
		Public health
Farming, Fishing and Mining Sector	Farming	
	Fishing	
	Mining	
Self-Consumption Sector	Transformation	
	Production	
	Distribution	
	Pipelines	
Construction Sector	Construction	
	Housing and buildings	
	Public works	

1.2.4 Disaggregation by Application

The disaggregation of final consumption by various applications is important in order to determine utilizable energy consumption. These basic categories are:

- Heat:
  Includes the full range of energy applications whose purpose is to raise the temperature of spaces or of certain products above the natural ambient temperature, for either production or comfort purposes.

- Mechanical force:
  Includes all energy applications where some kind of movement or work is produced, regardless of the type of device, equipment or energy source used to achieve this.

- Lighting:
  Considered independently from other heat applications because although all lighting fixtures radiate heat, their specific purpose is to provide electromagnetic radiation within the spectrum of visible wavelengths.

- Other applications (electronic, electrochemical, etc.):
  This separate category includes all cases in which energy has one of two aims: operating electronic devices or promoting electrochemical processes.

1.2.4.1 Applications in each Consumer Sector

The relationship between the disaggregation adopted for each sector and the basic applications is as follows:

Transportation Sector	Mechanical force	
Industrial Sector	Heat	Steam
		Direct heat
	Mechanical force	Mechanical force
		Refrigeration, air conditioning
		Transportation
	Lighting	Lighting
	Others	Raw material
		Electrolysis
		Other applications
Residential, Trade and Public Service Sector	Heat	Heating
		Cooking
		Water Heating
	Mechanical force	Air conditioning
		Ventilation
		Refrigeration
		Water pumping
		Mechanical force
	Lighting	Lighting
Farming, Fishing and Mining Sector	Heat	Direct heat
		Steam
	Mechanical force	Water pumping
		Irrigation
		Refrigeration
		Mechanical force
	Lighting	Lighting
	Others	Electrolysis
		Other applications
Self-Consumption Sector	Heat	Direct heat
		Steam
	Mechanical force	Transportation
		Refrigeration
		Mechanical force
	Lighting	Lighting
	Others	Electrolysis
		Other applications
Construction Sector	Mechanical force	
	Heat	
	Lighting	

1.2.5 Calculating Utilizable Energy

Shows the energy chain from primary energy production through transformation plants to delivery of final energy to users who turn it into utilizable energy by applying it to some service (lighting, cooking, movement, etc.).

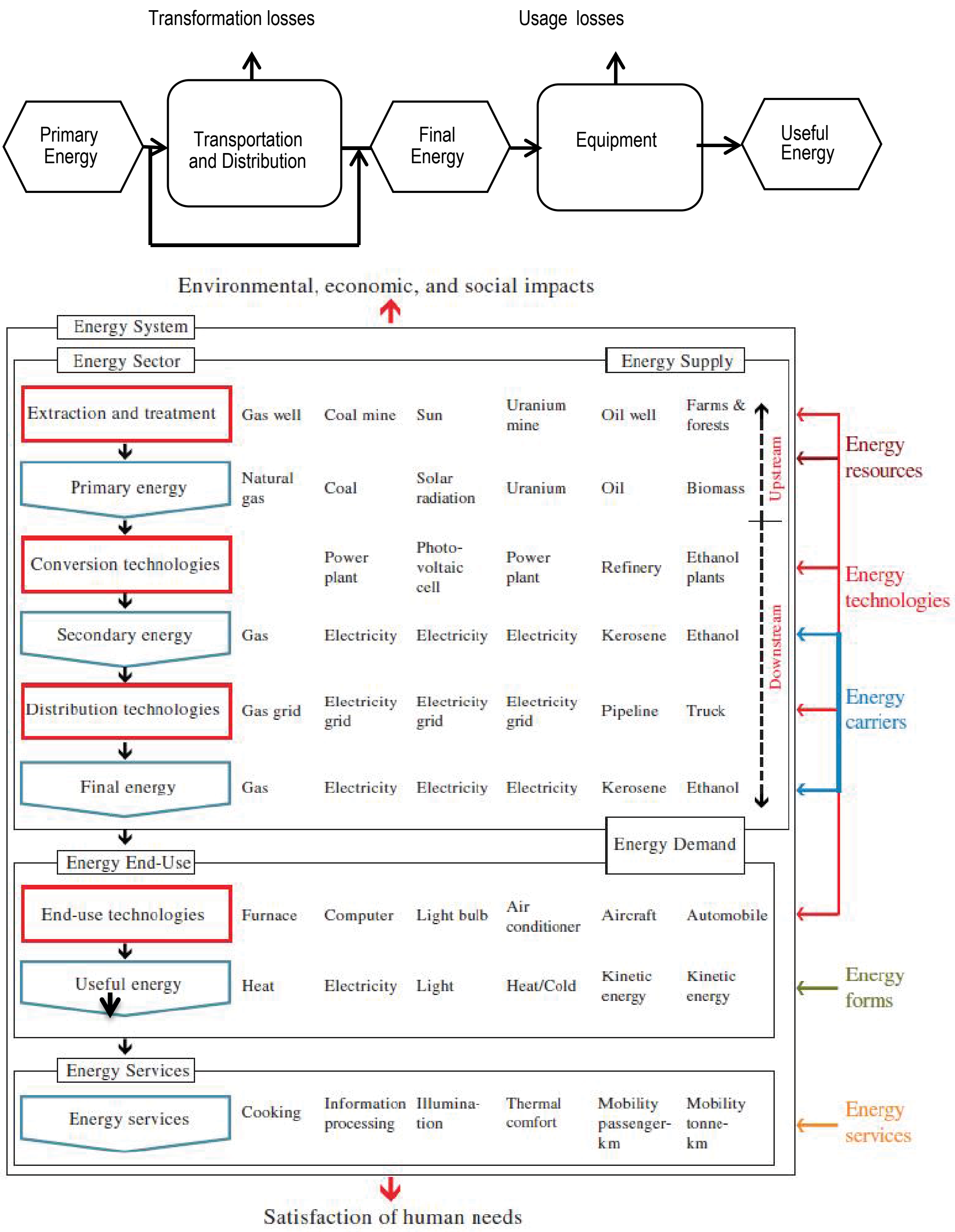
Final energy is that which is available to consumers and must undergo transformation to obtain an energy form suited for use. This transformation always takes place by way of end use equipment as mentioned under each subsector, albeit simple and subject to losses at that time.

Utilizable energy is the difference between that which is available to consumers and the total losses that occur at the final consumption stage.

Without including losses incurred due to use practices, an initial approximation to utilizable energy can be calculated by considering the efficiency of end-use equipment.

Utilizable energy = final energy x efficiency of the end-use equipment

Figure 3. The energy chain



Source: GEA (Global Energy Assessment) Energy Primer 2012

1.2.6 Transformation plants

Transformation plants are facilities where primary or secondary energy is subject to processes that transform their original properties or nature using physical, chemical and/or biochemical changes whose purpose is to turn it into another energy source that is better suited to final consumption.

Transformation plants are difficult to present in the current final energy balance because, by definition, the inputs of a process are different from its outputs. Process inputs and outputs appear in different columns of the balance and, since several products can be shown as inputs or outputs, it is hard to reconstruct the transformation process.

The simplest solution is to develop a separate but complementary energy balance for each transformation plant. These balance sheets should show all inputs and outputs for each plant, along with any losses in the operation. The amount of energy required for the transformation process should also be shown, as it represents a certain proportion of energy sector consumption. Processing balances are stated in specific units using a common measure of energy and should show the transport and distribution losses of the different energy sources.

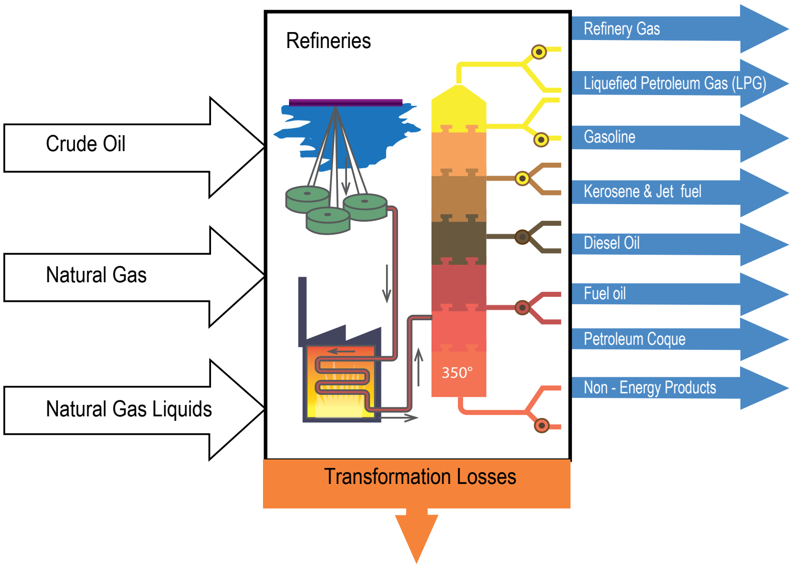
1.2.6.1 Main Transformation Plants

1.2.6.1.1 Oil Refineries

Oil refineries are transformation centers for the physical separation of crude oil into its various components and their chemical conversion into other components (see Figure 4). The most common conversion units are:

- Atmospheric distillation (the primary process of all refineries)
- Vacuum distillation
- Thermal cracking
- Catalytic cracking
- Coking
- Catalytic reforming
- Viscosity reduction
- Hydrocracking

Figure 4. Transformation centers – refineries



Source: OLADE Energy Statistics Manual, 2011

1.2.6.1.2 Power Stations

They are facilities that have equipment that converts different forms of energy into electricity, both direct energy obtained from nature, such as hydropower, geothermal energy, wind energy and solar energy, as well as the heat obtained from the combustion of other sources . Depending on the technology and type of source used to produce electricity, power plants are classified into:

Hydroelectric

Conventional Thermoelectric

Geothermic generation

Wind farms

Solar Photovoltaic

Nuclear

There are two different kinds of power generation stations:

Steam Turbo Power Stations

Turbo gas open cycle

Combined Cycle

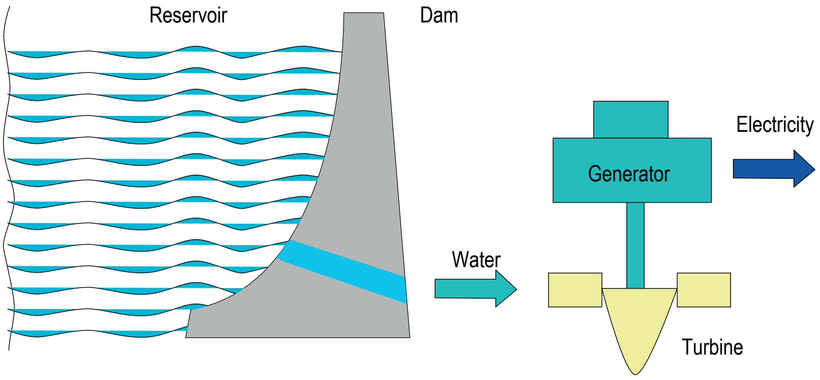
Internal combustion engines

- **Hydroelectric stations**

  They use the energy of a water flow to move a turbine coupled to an electricity generator (figure 5). They can be of two types: a) with reservoir and b) edge of water.

The first has an artificial reservoir of water, which allows to increase the height of fall and to regulate the flow into the turbines over time, whereas the second type lacks this reservoir and takes advantage of the natural fall of the river.
For hydroelectric power plants, the energy of the flow that enters the turbine is considered as input and the electricity generated as a product.

Figure 5. Transformation centers – power stations



Source: OLADE Energy Statistics Manual, 2011

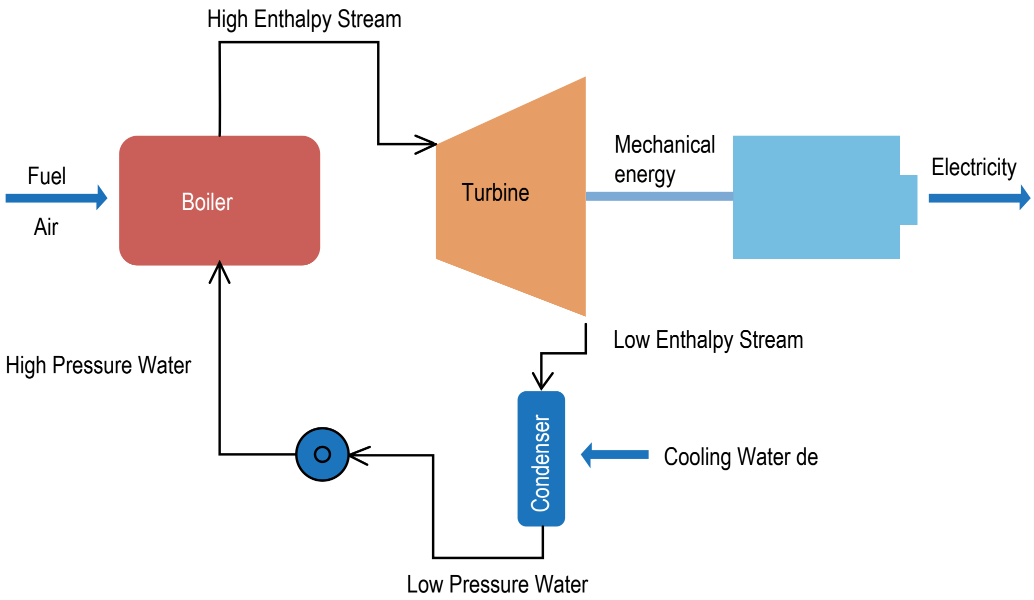
- **Conventional Thermoelectric stations**

They are the plants that convert the heat of combustion into electricity. They are classified into the following types:

- **Steam Turbo Power Stations**

The heat of combustion is previously absorbed by the water in a boiler that generates steam at high pressures, which moves a turbine coupled to an electricity generator (figure 6). The volumes of fuels used for the heating of the water in the boiler and as a product, the electricity generated, are counted as inputs to the turbo steam plant. The fuels used for this technology are generally diesel oil, fuel oil and coal, although in general any fuel having an acceptable calorific value can be used. Also included as fuel are biomass products such as firewood, bagasse, charcoal and some agro-industrial waste.

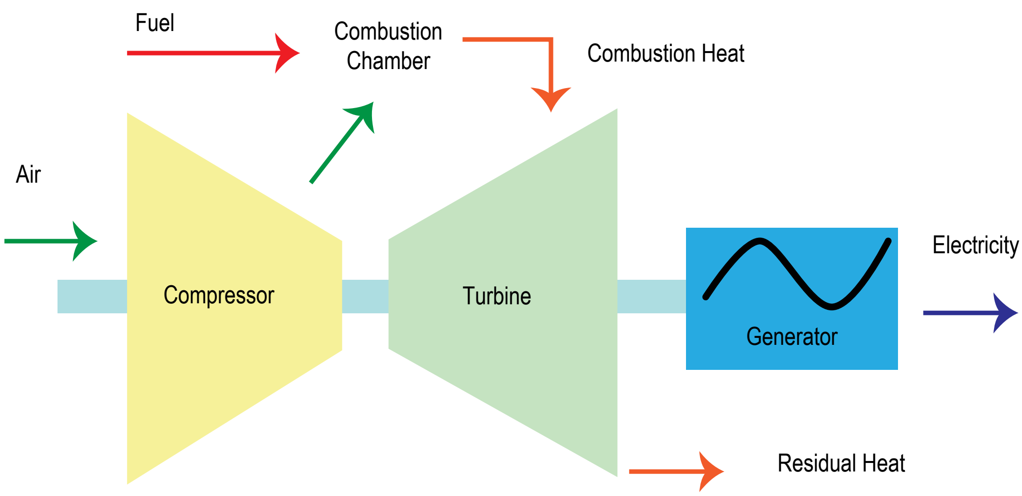
Figure 6. Steam Turbo Power Stations



- **Turbo gas open cycle stations**

It is the technology where the source combustion gases, when expanded, move the turbine-generator assembly, which also has a compressor that blows air to enrich the mixture (figure 7). The inputs are the fuels burned and the product, the electricity generated. The fuels generally used in this technology are diesel oil, natural gas and other gases.

Figure 7. Turbo gas open cycle stations



- **Combined Cycle**

This is a combination of gas turbo and steam turbo, in which surplus heat in the flue gases from the gas turbine is used to heat boiler water that feeds into a steam turbine. This combination achieves a higher overall efficiency than steam turbo and gas turbo separately.

- **Internal Combustion Engines**

These are engines that have cylinders and pistons with an Otto cycle and a diesel cycle, coupled to a generator. The most used are diesel cycle engines (ignition by compression), which consume primarily diesel and fuel oil. Otto cycle engines are used mostly as domestic generators and consume gasoline, ethanol, LPG, and other gases.

- **Plants with cogeneration**

These are thermoelectric plants, usually steam turbo and gas turbo, in which surplus heat from steam and flue gas, respectively, is used as process heat.

It is often said that the outputs of such plants are electricity and heat. However, the OLADE energy balances do not consider heat an energy stream. Rather, harnessing that heat directly for activities other than electricity generation is deemed a final consumption of fuel. Therefore, cogeneration plants require calculating the fraction of the total fuels used for electricity generation and the fraction used for residual heat, which should be recorded the final consumption for those fuels. Annex VI shows the approach for calculating the fuel fractions consumed for electricity generation and process heat.

- **Geothermal Plants**

These plants directly harness steam flowing from geothermal wells to drive steam turbines coupled to electric generators.

The input to geothermal power plants is the enthalpy of the steam arising from the well and entering the plant. Although geothermal plants are usually located at the wellhead, on its way to the turbines, geothermal steam suffers major heat losses, which means low efficiencies in the total conversion.

In the absence of parameters for calculating the enthalpy of geothermal steam, the energy balance uses the concept of direct energy, i.e., the primary production of geothermal energy estimated on the basis of the electricity generated, at an efficiency of 100%.

Thus:

EG=EE

Where:

EG=Geothermal Energy,

EE=Electricity generated

- **Wind Power Plants**

These facilities convert kinetic wind energy into electricity (see Annex). Due to the relatively low power developed by each generating unit, it takes a large number of wind turbines connected in parallel to achieve significant power values for a country. These complexes are also called wind farms. Although the input to this type of plant is wind power (which like any energy transformation process has losses through mechanical and electrical devices), the energy balance considers that the wind energy entering the plant has the same value as the electricity generated.
Thus:

EO = EE

Where:

EO = Wind Energy

EE = Electricity generated

- **Photovoltaic and Solar Thermal Plants**

These two types of power plants turn solar energy into electricity with the following specifications:

- **Photovoltaic power plants**

They have panels of photoelectric cells that receive solar radiation to generate an electrical current.

- **Solar thermal power plants**

In these plants, the sun's rays are concentrated by mirrors on a focal point where steam is produced at temperatures and pressures high enough to drive a turbine-generator combo. These are not very common in OLADE member countries.

For either of the above cases, the balance assumes that the primary solar energy used for generation is equal to the electricity generated by the plant.

Thus:

SOL = EE

Where:

SOL = Solar Energy

EE = Electricity generated

- **Power Production in Public Utility Plants**

This is the total amount of electricity produced by public utility plants in a country, i.e., the total electricity delivered to utilities by all plants, without discounting self-consumption.

The possible types of plant are:

a) Hydroelectric,

b) Geothermal,

c) Nuclear or Fission,

d) Steam Turbines,

e) Gas turbines (open cycle and combined cycle),

f) Diesel engines,

h) Wind power plants, and

g) Photovoltaic plants.

None of these should be omitted, whether connected to or isolated from the grid. It may be difficult to collect data on the latter, and surveys may be necessary to estimate production.

- **Electricity Production by Self-Producers**

Self-producers are private or public entities, such as:

- Industry (including the energy sector)

- Farming establishments,

- Commercial establishments, and

- Private homes

While not belonging to the electricity sector, they have facilities to self-produce the electricity they require, either due to the deficiency or absence of public utilities, or as an emergency service.

The types of such plants are:

- Small hydroelectric

- Steam turbines

- Gas turbines

- Internal combustion engines

In some cases, self-producers sell surplus electricity to the public utility grid, *and the total electricity produced by these plants should be considered*. In most countries, these data is not available, and the best way to obtain it is by:
1) Trying to identify self-producers that are also macro-consumers, which represent approximately 90% of all self-production.

2) As a second stage, it will necessary to conduct a comprehensive survey to capture the numerous small self-producers.

1.2.6.1.3 Natural Gas Treatment Plants

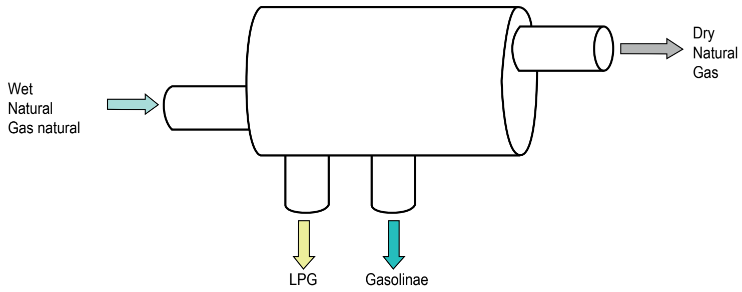
In these plants, natural gas is processed to recover liquid hydrocarbon compounds such as gasoline and naphthas, pure hydrocarbons (butane, propane, ethane or mixtures thereof), and non-energy products such as Carbon dioxide CO_2.

Gas (wet gas), with a significant content of high molecular weight compounds, is normally used to obtain (dry) gas, liquefied petroleum gas and gasoline.

Gas can be separated via absorption in mineral oil or gasoline at high temperatures, compressing and cooling, absorption by charcoal on fixed or continuous beds or, primarily, a combination of the above processes.

In order to operate, these plants need to consume fuel and small amounts of electricity (see Figure 8).

Figure 8. Gas Treatment Plants

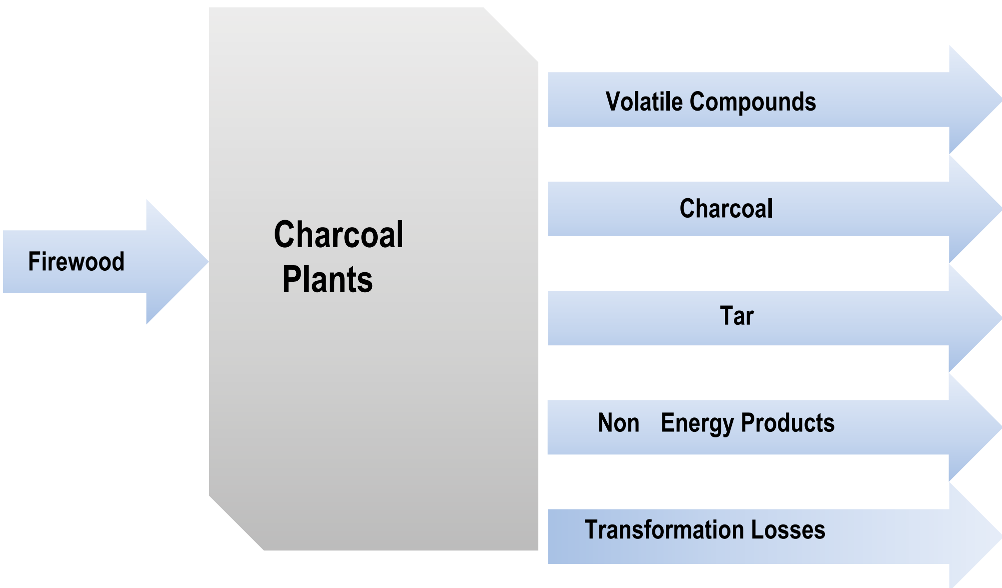


Source: OLADE Energy Statistics Manual, 2011

1.2.6.1.4 Charcoal plants

These biomass transformation centers consist of furnaces where incomplete combustion of firewood takes place to obtain charcoal, volatiles and non-energy products (see Figure 9). Charcoal plants are inefficient, due to incomplete combustion and high heat loss, with some of the charcoal left in ashes. Heat recovery ranges from 25% to 40% of the input into the unit.

Figure 9. Charcoal plants

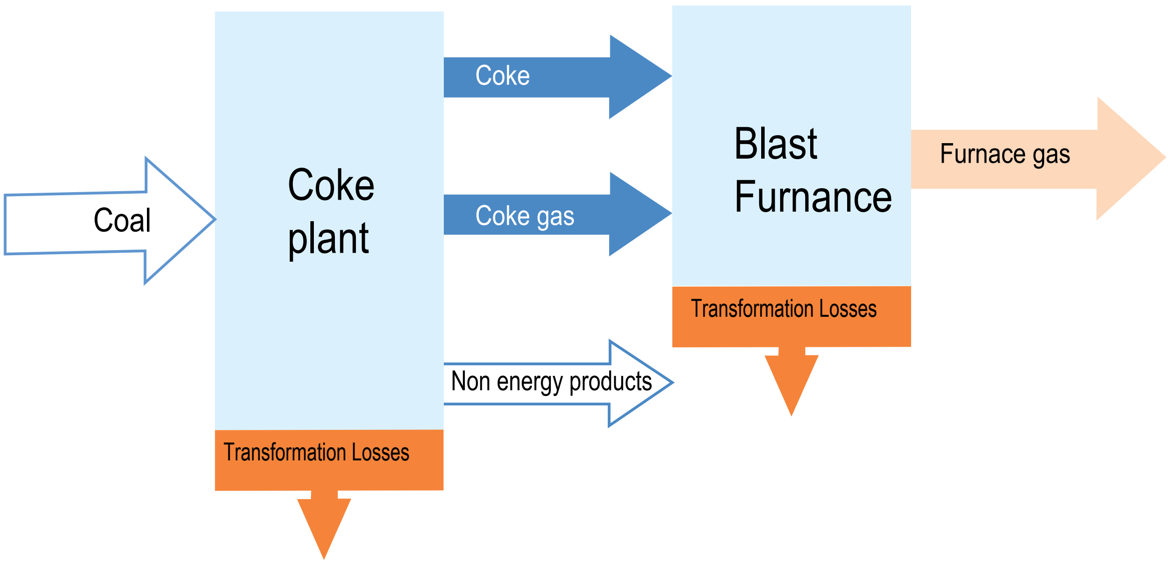


Source: OLADE Energy Statistics Manual, 2011

1.2.6.1.5 Coking plants

In these units, coal entering the transformation plant produces coke, coke oven gas, tar and non-energy products (benzenes, etc.). Much of the coke produced in this facility is carried to blast furnaces. A portion of the tar is consumed in the process itself, but its production is usually not recorded and its value is included as a loss or as a non-energy product (*see Figure 10*). This unit can also consume small amounts of electricity.

Figure 10. Coking plants



Source: OLADE Energy Statistics Manual, 2011

1 .2.6.1.6 Alcohol Distilleries

These units are transformation plants in most of which sugarcane products are transformed to obtain bagasse and alcohol (ethane). Some alcohol distilleries process other raw materials such as sugar beets, cassava and other crops high in starch or cellulose (see Figure **11**).

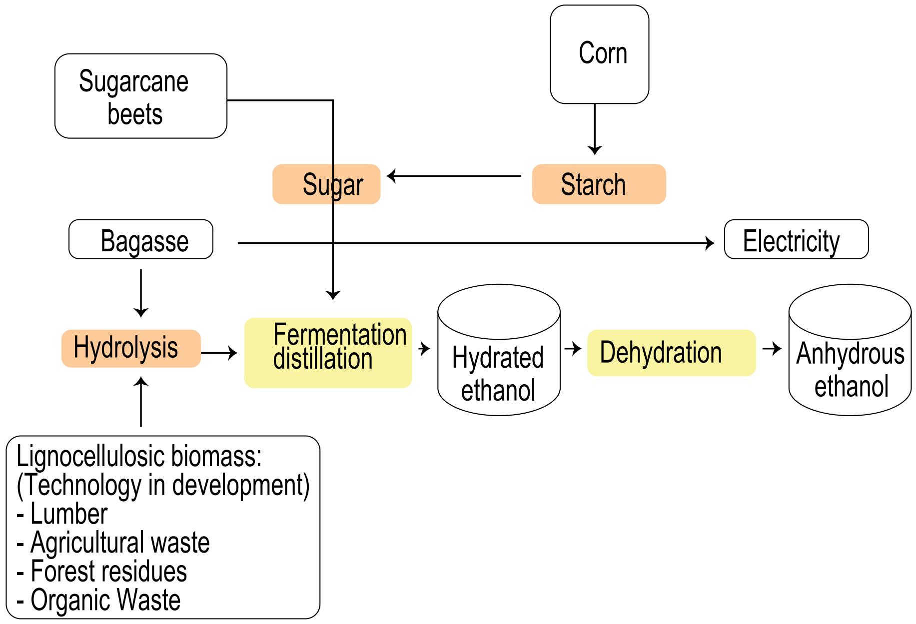
Alcohol production must go through 3 steps:

- Preparing the fermentable solution: In the case of inputs with high sugar content, a solution is prepared at a given concentration, which is then clarified via settling and/or centrifuging. If it is rich in starch, the raw material is peeled, washed and ground to extract the starch, which is then subjected to enzymatic hydrolysis to obtain soluble, fermentable sugars. In the case of cellulose-rich inputs, acid hydrolysis is required beforehand.

- Fermentation: This step involves microbiological conversion of hexoses into alcohol and carbon dioxide with heat release.

- Distilling and drying: This involves separating the alcohol from the fermented mass, purifying it and drying it. This stage consumes most of the energy needed for alcohol production.

Figure 11. Alcohol Distilleries



Source: OLADE Energy Statistics Manual, 2011

1.2.6.1.7 Other Transformation Plants

These facilities include processes that enable the production of a producer gas from wood and the production of biogas from materials of plant or animal origin.

1.2.6.2 Other Transformations

These include energy recycling of certain energy sources such as blast furnace gas, liquefied gas and petrochemical naphtha. The primary and secondary sources to be reported will be the same as are currently included in the final energy balance.

1.3 THE BALANCE STRUCTURE – CALCULATION METHODOLOGY

The final energy balance involves a double-entry matrix in which the columns represent energy sources and the rows indicate operations (activities) making up the energy system. The accounting unit is barrels of oil equivalent (Boe). The Final Energy Balance (FEB) comprises three parts:

- Supply
- Transformation plants
- Total final consumption

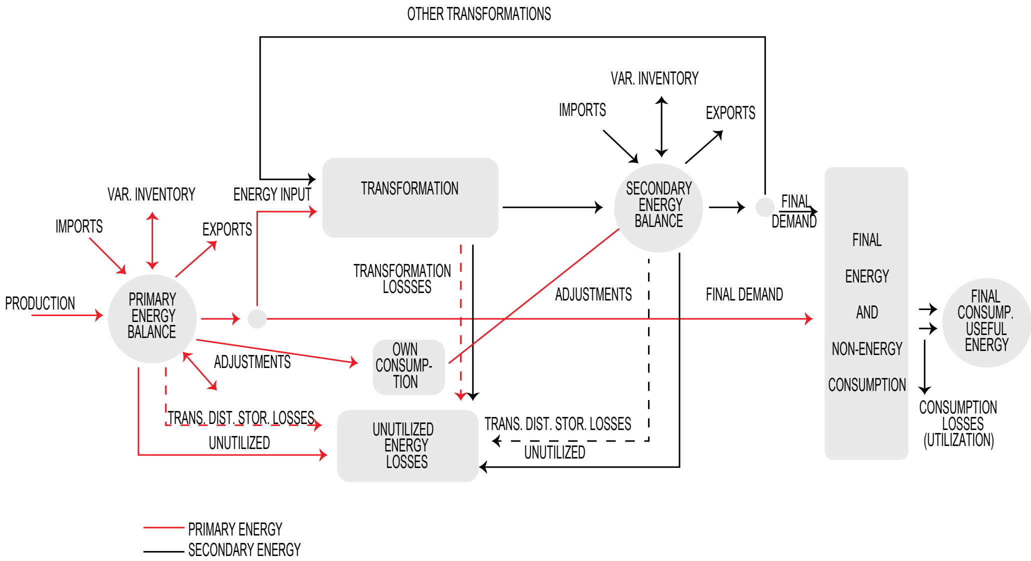
Achieving the Utilizable Energy Balance (UEB) requires extending the final consumption of the balance. Utilizable energy is calculated by disaggregating final consumption into applications, and then disaggregating these applications into energy sources and appliances used.

The new Utilizable Energy Balance matrix drawn up by OLADE details the relationships among all stages of the energy process.

"This is a double-entry matrix in which the columns represent energy sources and the rows indicate the operations (activities) making up the energy system."

		Primary Energy Sources													Secondary Energy Sources																	
		Primary Hydrocarbons			Mineral Sources		Direct energy				Biomass			Other primary		Oil and Natural Gas Products								Products from mineral sources			Biomass products					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Crude Oil	Natural Gas Liquids	Natural Gas	Coal	Nuclear	Hydro	Geothermal	Wind	Solar	Firewood	Sugarcane, bagasse	Other biomass		Electricity	GLP	Gasoline	Kerosene and Jet Fuel	Diesel oil	Fuel oil	Refinery Gas	Oil Coke		Coal Coke	Industrial gases	Other mineral products	Charcoal	Ethanol	Biodiesel	Biogas	Other secondary sources	Non-energy
1	Primary Production	PRIMARY ENERGY													SECONDARY ENERGY																	
2	Reinjection / GN recirculation																															
3	Imports																															
4	Exports																															
5	Stock Change																															
6	Unused																															
7	Transfers																															
8	Bunkering																															
9	TOTAL SUPPLY																															
10	Refinery	TRANSFORMATION CENTERS																														
11	Gas Treatment Plants																															
12	Power plants																															
13	Self-producers																															
14	Coke Plants																															
15	Blast furnace																															
16	Charcoal Plants																															
17	Ethanol Distilleries																															
18	Biodiesel Plants																															
19	Other transformations																															
20	TOTAL TRANSFORMATION																															
21	Transport	FINAL CONSUMPTION																														
22	Industry																															
23	Residential																															
24	Commercial, Public services																															
25	Farming, Fishing, Mining																															
26	Mining																															
27	Construction and others																															
28	ENERGY CONSUMPTION																															
29	Non Energy	USEFUL CONSUMPTION																														
30	Own Consumption																															
31	Losses																															
32	Adjustments																															
33	FINAL CONSUMPTION																															

Figure 12. Comprehensive energy flow



Source: OLADE UEB Methodology, 1984

The comprehensive energy flow (see Figure 10) differentiates four functions:

- Supply: obtaining energy by combining production, imports, exports, and inventory changes
- Transformation: physical, chemical and/or biochemical changes from one energy source to another in a transformation plant
- Final consumption: consumption of energy sources by users in different sectors before any chemical or physical conversion of the energy
- Utilization: final conversion to intermediate energy via applications and systems whose efficiencies give way to utilizable energy

When preparing the Utilizable Energy Balance or the main forms it contains (table 1 to Table 6), it is advisable to organize the data in those forms by energy sources and by sectors. The following principles should be taken into account:

1. Observe the first law of thermodynamics, which states that energy in a closed system is constant, i.e., input = output + losses. Since the balance is a closed system, consumers cannot receive more energy than is available.

2. Use similar criteria for all energy sources (uniform use of precise equivalents, conversion factors, and the balance system itself).

3. Use a common, general unit of measure that is applicable to all energy sources and all forms of energy use, whether barrels of oil equivalent (Boe) or any other calorific unit.

4. Consider energy flows from the time of production to end use.

5. Observe operations only at the national level on the supply side.

6. Obtain a set of statistics that can be processed on a computer.

For all general needs, including glossaries, definitions and others, refer to the current final energy balance and OLADE's Energy Statistics Manual.

This perspective on end use in energy systems is facilitated by the fact that this field of study has developed the concept of utilizable energy, which enables aggregated measurement and accounting in keeping with the diversity of energy services supplied. This concept and its statistics were introduced several decades ago, but disappeared from the attention of statistical agencies and, as a result, has been underrepresented in studies and models of energy systems and transitions.

		Primary Energy Sources													Secondary Energy Sources																	
		Primary Hydrocarbons			Mineral Sources		Direct energy				Biomass			Other primary		Oil and Natural Gas Products								Products from mineral sources			Biomass products					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Crude Oil	Natural Gas Liquids	Natural Gas	Coal	Nuclear	Hydro	Geothermal	Wind	Solar	Firewood	Sugarcane, bagasse	Other biomass		Electricity	GLP	Gasoline	Kerosene and Jet Fuel	Diesel oil	Fuel oil	Refinery Gas	Oil Coke		Coal Coke	Industrial gases	Other mineral products	Charcoal	Ethanol	Biodiesel	Biogas	Other secondary sources	Non-energy
1	Primary Production																															
2	Reinjection / GN recirculation																															
3	Imports																															
4	Exports	PRIMARY ENERGY													SECONDARY ENERGY																	
5	Stock Change																															
6	Unused																															
7	Transfers																															
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9	TOTAL SUPPLY																															
10	Refinery																															
11	Gas Treatment Plants																															
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13	Self-producers																															
14	Coke Plants																															
15	Blast furnace	TRANSFORMATION CENTERS																														
16	Charcoal Plants																															
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19	Other transformations																															
20	TOTAL TRANSFORMATION																															
21	Transport																															
22	Industry																															
23	Residential																															
24	Commercial, Public services	FINAL CONSUMPTION																														
25	Farming, Fishing, Mining																															
26	Mining																															
27	Construction and others																															
28	ENERGY CONSUMPTION																															
29	Non Energy																															
30	FINAL CONSUMPTION																															
31	Own Consumption																															
32	Losses																															
33	Adjustments																															
34	Transport																															
35	Industry	USEFUL CONSUMPTION																														
36	Residential																															
37	Commercial, Public services																															
38	Farming, Fishing, Mining																															
39	Mining																															
40	Construction and others																															
41	Useful Consumption																															

Table 1. Form for final and utilizable energy consumption by source

YEAR:
SECTOR: UNIT:

SOURCES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2) / (1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
SOURCE 1					
SOURCE 2					
SOURCE n					
TOTAL					

Source: OLADE UEB Methodology, 1984

Table 2. Form for final and utilizable energy consumption by application

YEAR:
SECTOR: UNIT:

USES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2) / (1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
USE 1					
USE 2					
USE n					
TOTAL		100		100	

Source: OLADE UEB Methodology, 1984

Table 3. Form for final and utilizable energy consumption by subsector

YEAR:
SECTOR: UNIT:

SUBSECTORS	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2) / (1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
SUBSECTOR 1					
SUBSECTOR 2					
SUBSECTOR n					
TOTAL		100		100	

Source: OLADE UEB Methodology, 1984

Table 4. Form for final and utilizable energy consumption by subsector and by application

YEAR:
SECTOR:
SOURCE: UNIT:

USES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2) / (1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
USE 1					
USE 2					
USE n					
TOTAL					

Source: OLADE UEB Methodology, 1984

Table 5. Form for final and utilizable energy consumption by subsector and by application

YEAR:
SECTOR:
SUBSECTOR:
SOURCE: UNIT:

USES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2) / (1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
USE 1					
USE2					
USE n					
TOTAL					

Source: OLADE UEB Methodology, 1984

Table 6. Form for consumption of non-energy products by sector

YEAR:

PRODUCT	PRODUCT 1	PRODUCT 2	PRODUCT 3	PRODUCT 4	PRODUCT 5	TOTAL
SECTOR						
1. TRANSPORTATION						
2. INDUSTRIAL						
3. RESIDENTIAL						
4. COMM / SERV / PUBLIC						
5. AGRO / FISHING / MINING						
6. SELF-CONSUMPTION						
7. OTHERS						
TOTAL						

Source: OLADE UEB Methodology, 1984

1.3.1 What data to collect

Building the Utilizable Energy Balance requires additional data to what is needed to develop the final energy balance. To obtain this data, most countries conduct energy characterization studies at the sectorial level.

If you hope to use the UEB as an energy assessment tool, it is essential to disaggregate the sectors into a set of relatively homogeneous activities in terms of both their energy requirements and the evolution of their activity levels. This is essential for explaining the changes in each sector's energy consumption.

Moreover, both UEBs and energy assessments provide starting points for demand forecast studies. Consequently, defining the subsectors must necessarily be related to organizing the macroeconomic data, because any energy demand forecast study must necessarily link energy consumption with the activity level of the branch under study.

Whether the proposed disaggregation will suffice for a good demand forecast study will depend on the degree of complexity of each sector in your country and the impact of each on the national energy consumption.

1.3.1.1 Transportation Sector

Characterizing this sector should enable you to discriminate data for each of the subsectors described in section 1.2.3.

The aim of this characterization is to understand the vehicle fleet, its energy and fuel consumption, the technologies used and their conversion efficiencies, the cargo or passengers carried, the kilometers traveled and, in general, an initial assessment of the issues and potential solutions to increase energy efficiency in the sector, including the road system and designing the urban and inter-urban traffic system.

All of this data is to be discriminated by:

- Mode: land, rail, air, river, maritime and pipeline
- Object of service: passengers or cargo
- Nature of service: urban or intercity
- Type of service: private, public or official

Consider all types of vehicles: trucks, tractor trailers, trains, buses, and articulated buses, motorcycles, cars, trucks, boats, barges, and others; and all technologies: internal combustion engines (gasoline, diesel, CNG, LPG, biodiesel, alcohol, Kerosene, Jet Fuel, Fuel Oil), electric motors, and hybrid systems.

13.1.2 Industrial Sector

Characterizing this sector should enable you to discriminate data for each of the subsectors described in section 1.2.3.

The purpose for the energy characterization in this sector is to know the consumption of energy and fuels (gaseous, liquid and solid), the technologies used for each energy application (service) in its subsectors, and their conversion efficiencies. Self-generation and cogeneration, the use of renewable energy and alternative fuels (biomass, waste, etc.), and, in general, an assessment of the issues and potential solutions for increasing the energy efficiency of the sector, including all production systems.

All of this data is to be discriminated by:

- Subsectors: Food, beverages and tobacco; Textiles, clothing, footwear and leather; Wood and furniture; Paper, cellulose and graphics; Chemicals (excluding oil refining); Cement, stone, glass and ceramics; Iron, steel and non-ferrous metals (except coke ovens); Machinery and equipment; and Other industries.

- Applications: Steam, Direct heat (high, medium and low temperatures), Mechanical force (fans, compressed air, pumps, conveyors, mills, fuel injection systems, etc.), and Other applications (cooling, lighting, raw material, electrolysis, internal transport, and others).
- Technologies: Boilers (coal, NG, LPG, diesel, biomass), Engines, Furnaces (high, medium and low temperatures), Cooling systems, Compressors, and Others. Production systems (for example: dry, wet or semi-dry cement, steel from sintering, smelting and other.)

1.3.1.3 Residential Sector

Characterizing this sector should enable you to discriminate data for each of the subsectors described in section 1.2.3.

The purpose for energy characterization in this sector is to know the consumption of energy and fuels (gaseous, liquid and solid), the technologies used for each energy application (service) in the subsectors, and the conversion efficiency from final to utilizable energy, self-generation, the penetration of renewable energy, the use of alternative fuels (biomass, waste, etc.) and, in general, an assessment of the issues and potential solutions for increasing energy efficiency.

All of this data is to be discriminated by:

- Subsectors: Urban and rural by socioeconomic strata, giving priority to those used by each country's statistics or household surveys.
- Applications: Heating, air conditioning, ventilation, cooking, cooling, water heating, lighting, driving force (water pumps, appliances and other motors), other electrical appliances (TV, PC, sound, communications, etc.)
- Technologies: Small boilers, stoves and water heaters (coal, NG, LPG, diesel, biomass); refrigerators, freezers, air conditioners, household appliances, lights, renewable energy (solar, wind, etc.); power generation using fuel.

1.3.1.4 Trade, Service and Public Sector

Characterizing this sector should enable you to discriminate data for each of the subsectors described in section 1.2.3.

The purpose for energy characterization in this sector is to know the consumption of energy and fuels (gaseous, liquid and solid), the technologies used for each energy application (service) in the subsectors and the conversion efficiency from final to utilizable energy, self-generation, the penetration of renewable energy, the use of alternative fuels (biomass, waste, etc.) and, in general, an assessment of the issues and potential solutions for increasing energy efficiency.

All of this data is to be discriminated by:

- Subsectors: Utilities (water, electricity); Wholesale and retail trade, transportation, storage and communications; Hotels and restaurants; Financial, insurance, real estate and corporate service establishments; Public administration, defense and government; Public health and other services (health, recreation, other personal and household services). In any case, it is advisable to define the subsectors based on an international classification that all countries respect in their information systems. The proposal is to base sector differentiation on the ISIC (International Standard Industrial Classification of All Economic Activities) Rev. 4, as in the industrial sector.
- Applications: Heating, air conditioning, ventilation, cooking, cooling, water heating, lighting, driving force (water pumps, appliances and other motors), other electrical appliances (TV, PC, sound, communications, etc.).
- Technologies: Small boilers, stoves and water heaters (coal, NG, LPG, diesel, biomass); Refrigerators, freezers, commercial cooling, air conditioners, household appliances, lights; Renewable energy (solar, wind, etc.); Power generation using fuel.

1.3.1.5 Farming, Fishing and Mining Sector

Characterizing this sector should enable you to discriminate data for each of the subsectors described in section 1.2.3.

The purpose for energy characterization in this sector is to know the consumption of energy and fuels (gaseous, liquid and solid), the technologies used for each energy application (service) in the subsectors and the conversion efficiency from final to utilizable energy, self-generation, the penetration of renewable energy, the use of alternative fuels (biomass, waste, etc.) and, in general, an assessment of the issues and potential solutions for increasing energy efficiency.

All of this data is to be discriminated by:

- Subsectors:
  - Farming: Farming and hunting; Forestry and logging
  - Fishing: Fishing
  - Mining: Extraction of metallic minerals; Extraction of non-metallic minerals
- Applications: Mechanical force, steam, direct heat, pumping and irrigation, pest control, and others (heat, lighting, refrigeration, electrolysis).
- Technologies: Boilers (coal, NG, LPG, diesel, biomass), driers, motors, farm machinery, tractors, crop dusters, transportation; Refrigerators, freezers, commercial cooling, lighting; Renewable energy (solar, wind, biomass, etc.); Power generation using fuel.

1.3.1.6 Self-Consumption Sector

Characterizing this sector should enable you to discriminate data for each of the subsectors described in section 1.2.3.

The purpose for energy characterization in this sector is to know the consumption of energy and fuels (gaseous, liquid and solid), the technologies used for each energy application (service) in the subsectors and their conversion efficiencies from final to utilizable energy, the penetration of renewable energy and use of alternative fuels (biomass, waste, etc.) and, in general, an assessment of the issues and potential solutions for increasing energy efficiency.

All of this data is to be discriminated by:

- Subsectors:
  - Processing: All transformation centers described in section 1.2.3
  - Production: Oil and gas, coal, nuclear fuels, and others (hydro, bagasse, firewood, solar, wind, etc.)
  - Transport and distribution. (Pipelines for gas and oil products, transmission and distribution grids).
- Applications: Steam, direct heat, mechanical force, and others (lighting, transportation, refrigeration, other)
- Technologies: Boilers and furnaces (coal, NG, LPG, diesel, biomass); Motors and pumps, transportation, refrigeration, lighting; Renewable energy (solar, wind, biomass, etc.)

1.3.2 How and When to Collect Data

Developing the Utilizable Energy Balance requires characterizing the energy of all the sectors described above at least once initially and then updating it with secondary information and smaller samples every two years, and only repeating the characterization when there are significant technological changes or when energy efficiency measures, labeling regulations or others are implemented that impact technological change and therefore energy consumption or, as currently proposed by OLADE, at least once every 10 years.

1.3.2.1 Data Collection Methods

The main methods used to collect the types of data required for energy characterization are:

1.3.2.1.1 Surveys and Interviews with Companies

Surveys and interviews with companies related to power supply can be a cost-effective method to obtain aggregate data on actual energy use and the factors affecting demand. This includes information on daily, hourly, monthly and yearly consumption by companies (large consumers) and the number of users per sector and subsector at the national and regional level.

The same applies to surveys and interviews with other energy suppliers such as fuels (solid, liquid and gas). Aggregate and per-company (large customer) data is also available from the monthly and yearly consumption information. In the case of the transportation sector, data on major distributors (usually few companies) can also be obtained. Usually for each country, sector, subsector and company there are ways to collect aggregate data on energy sales and consumption (electricity, LPG, NG, diesel, coal and others).

This approach has the advantage that once contacts are established and the survey type established, these companies can continue to provide information on a regular basis (monthly, quarterly or yearly). Some countries' laws require companies to supply the ministries with annual reports with some detail on sectoral consumption.

Obviously, the data thus collected cannot detail some subsectors, but it can always be used as control data for information from detailed sectorial surveys. Inconsistencies may arise if some companies have local coverage and handle different levels of information, which could hinder relating data among them. Data must be validated with information from other sources, or it will lose quality.

1.3.2.1.2 User Surveys

This is the approach that most countries (EUROSTAT) use to collect this type of information. Consumer surveys are the traditional statistical tool for collecting energy consumption data. Its main advantage is that it can be designed to capture the needed data, in this case energy consumed, fuels (solid, liquid and gas) burned, and electricity used.

Data should also be collected on the inventory of energy-consuming equipment and use patterns in all sectors, as described above. This inventory should contain all the technical details to infer equipment efficiency, such as boilerplate data, age, consumed energy and allocated use according to the classification established for each sector and subsector, etc.

In addition, collect data on self-generation (using fuels or renewable energy), cogeneration and energy storage where applicable, production data in the industrial sector and cargo/passengers carried in the transportation sector, and service production. However, it may be difficult for users to answer all the questions about their energy consumption, so bear in mind that all reported data should be thoroughly reviewed and validated.

Although there are more inexpensive and/or quicker ways to collect such information, face-to-face consumer surveys (visiting users' facilities) remain the most common for official statistics to characterize energy sectors (EUROSTAT and others in Latin America). Compared to supplier surveys—mostly censuses—consumer surveys normally use sampling.

1.3.2.1.3 Survey design

First of all, in order to design and implement a good energy characterization study, its aim should be clear and leave no room for ambiguity or doubt. The first step is to define the survey objectives and the questions it should answer, e.g., what it seeks to cover, how the data will improve policy-making, what goals will be assessed, its geographical coverage, the level of accuracy required of the findings, any legal requirements, etc.

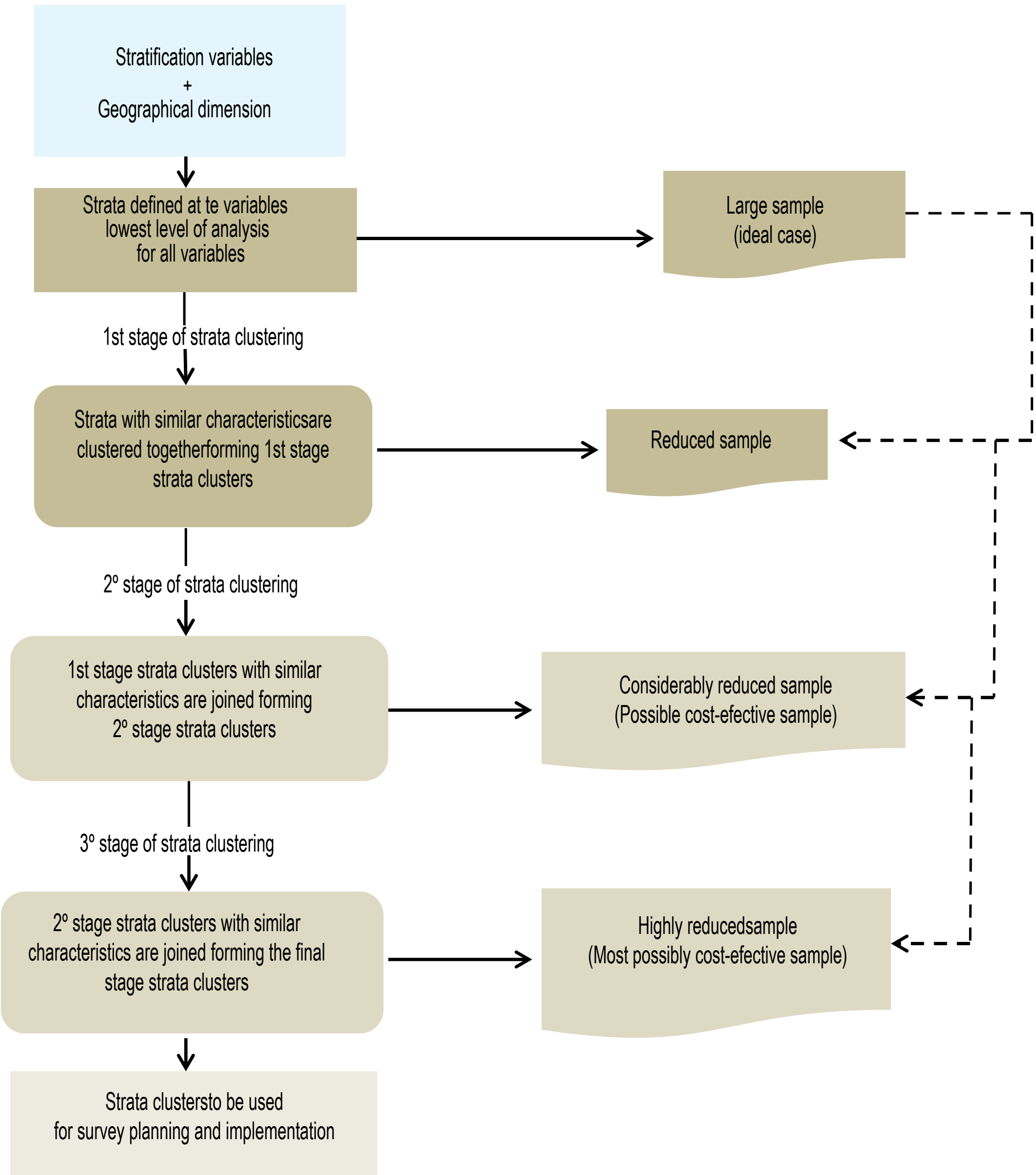
Strategies should be designed to collect data on in each sector. For example, the residential sector has numerous users, and surveys should be conducted by sampling. Surveys are limited in scope, so do not expect to collect data directly from the survey on the internal consumption of a home, as this would be impractical, expensive and very time-consuming. In this case, obtainable data includes appliances owned and their age, technologies and usage patterns, which will enable you to deduce energy consumption by application. Although other sectors have fewer users, their facilities are more complex (industries, hospitals, hotels, restaurants, etc.), son in addition to simple surveys, they require technical visits by persons familiar with the matter, who can take inventories of equipment and deduce their use patterns.

User selection for samples should follow a structured process to ensure that its design factors produce a representative sample of users in the country. Factors to consider in sample selection include user type, sector, subsector, climate zones (temperature), location (rural or urban), or other factors that explain energy consumption differences among households on a national scale. For example, regional disaggregation is more important in countries spanning several climate zones than in others.

Various sampling methods are able to provide representative samples of large populations, such as random, stratified, cluster, systematic, or multistage sampling. While sampling helps to reduce costs and the number of respondents, the key is to avoid sampling bias when selecting the sample. The sampling method should be chosen with departments specializing in statistics and other experts, in order to meet the requirements for statistical error and sample representativeness.

The final sample size is determined not only by statistical parameters, but also by the available budget, and alternatives should be sought to reduce costs, taking into account homogeneous groups in each sector with similar equipment and little variance in consumption. Figure 13 outlines an example of this.

Figure 13. Survey design



Source: Manual for Statistics on Energy Consumption in Households, 2013

1.3.2.1.4 Surveying Methods

There are several methods for managing questionnaire-based surveys, such as face-to-face or telephone interviews and mail or Web based surveys, each of which has its pros and cons. You can also use a combination of these methods, such as sending a questionnaire by mail prior to a telephone interview to promote participation or enhance responses. This is especially useful in the case of long or complex questionnaires.

Face-to-face interviews are the most common for collecting data via large-scale sample surveys, and usually result in higher response rates. This approach consists of interviewers visiting selected respondents on site to collect information by asking questions. The main advantage of this approach is that interviewers can persuade (motivate) respondents to answer questions and can better explain the purpose of the survey. It also offers greater potential for collecting statistics on conceptually difficult issues. However, the main limitations of face-to-face interviews are that different interviewers may interpret questions differently; interviewers may skew the findings by suggesting answers to respondents; and the interviewers' personal characteristics, such as age, sex and sometimes even race may influence respondents' attitudes.

In any case, successful surveys with high response rates require designing a respondent loyalty plan, which consists of establishing some type of incentive for users to answer the survey. In the residential sector, this can be simple energy saving manual, a small gift, etc. For users in the industrial, service or transportation sectors, it may be possible to establish that users must answer the survey with a given regularity in order to receive State benefits. In Colombia, voting in public elections is encouraged by providing a voting certificate as an incentive, with advantages when applying for a passport, seeking discounts at some public universities, or other State benefits.

1.3.2.1.5 Using Secondary Data

This means using administrative data and secondary sources of energy statistics, and other information relating to the characteristics of companies and general users in all sectors. In practice, administrative data are typically used to manage State policy or for keeping records on individuals or their properties, and are therefore a source of management information.

Administrative data are often summarized in a record or database that is continually updated for either administrative or statistical purposes. An example of an administrative record is the billing records of power companies, which contain data on the energy consumption of all their customers (which when combined would include virtually all users). The obvious advantage of the full coverage of such records is that they can enable you to produce more detailed statistics and eliminate sampling errors.

A record is usually based on data collected by other organizations (secondary data). Such secondary sources can collect and store data as a private company or entity or, more commonly, a government agency (public source). Secondary sources that may be useful for energy statistics include records of power and gas consumption from energy utilities, building or property registries, sales records from distributors or manufacturers of appliances or other energy-consuming equipment (cooling, heating, motors, etc.). It is also possible to obtain the technical specifications of equipment used in the different sectors for various services such as lighting, heating, driving force, cooling, and others.

In practice, however, the population covered in an administrative record may not coincide exactly with the target population. For more complete coverage when using commercial records, it is usually advisable to combine several sources. Some useful records that are available in most countries include:

1. Business registration or the equivalent in chambers of commerce or similar databases, classified by ISIC with the company data, number of employees, assets, sales or production, number of branches, and others
2. The tax registration of the company or establishment, from national tax offices
3. Vehicle registration for cars, trucks, buses, tractors trucks, motorcycles, and all types of vehicles, in the administrative offices of transit and transport
4. National accounts
5. Registry of imports and exports
6. Annual manufacturing survey
7. Annual household and quality-of-life survey
8. Population censuses
9. Directories of private and official companies
10. Other sectorial studies and reports (such as gas and power utilities)

1.3.2.1.6 Modeling

Energy consumption for each application (service) cannot be obtained directly through surveys, as users do not have this data or it is not available, being a very complex issue that respondents cannot answer. This fact is the perfect starting point for thinking about using models, whose most important feature is making unavailable information available, among others. Using models helps to reduce survey frequencies and, in some cases, sample sizes and respondent numbers, which saves resources.

Given the complexity of energy consumption, all survey responses should be carefully validated, usually based on preset (default) values, to check the reliability of the answers given. Therefore, one could say that applying the survey is just the first step, and that model-based data validation is the second step, which is vital to obtaining the actual consumption figures.

However, model outcomes are highly dependent on realistic assumptions. This means that the modeling assumptions and steps must be known in detail and be the result of other surveys, especially laboratory measurements by experts in the field.

Models can be used in two different ways.

1. Approximations based primarily on the model:

   In this case, there are no specific energy consumption surveys, or questions related to energy consumption in other surveys. The input for the model can be administrative or secondary data collected for various purposes, for example. In these cases, modeling is used, at least partially, instead of surveys. One possible case would be residential energy consumption models based on measurement records for other homes.

2. Models applied to survey findings:

   In this case, either energy surveys were conducted or survey findings were available, including questions on energy consumption, such as quality-of-life surveys in the residential sector, and models are used to collect information that cannot be asked directly. Some typical cases of this include:

   - Disaggregating consumption by application (service) if an energy source is used for more than one purpose (e.g., electricity for cooling, lighting, cooking, etc.)
   - Percentage of shared energy, when more than one energy source is used for the same service (e.g., space heating or air conditioning)
   - Converting the season measured (winter or summer) to the rest of the year
   - Estimating unmeasured consumption of non-purchased energy sources, such as heat from the sun
   - Estimating the consumption of non-standardized biofuels, mainly firewood
   - Calculating utilizable heat
   - Validating data

1.3.2.1.7 On-site Measurements

On-site measurement (defined as a process by which highly detailed measurements are taken of users’ energy consumption) is a key tool for improving existing knowledge of final energy use in all sectors. These on-site measurements are often used to assess the detailed power consumption of different end uses, one appliance at a time. They are also used to assess indoor and outdoor building temperatures. Using thermal imagers, temperatures can be measured on rooftops, in electrical panels, on building facades, and in furnaces, boilers and other thermal devices for industry and the tertiary sector. These detailed measurements can then be used for modeling or as input for statisticians, model developers, manufacturers and policy makers who focus on different sectors.

In the EU, numerous efforts have been made in this field since the early nineties, often promoted by energy efficiency programs and policies for household appliances. The experience accumulated to date has enabled knowledge transfer to third-world countries. In the EU, the 2006-2008 REMODECE project (Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe) was designed to raise awareness and understanding of energy consumption in EU households for different types of appliances, behavioral modes and consumer comfort levels, and to identify demand trends. Large-scale measurement programs were carried out in 12 countries, covering some 1,300 homes.

To the extent that this type of measurement makes it possible to track consumption by end use, not only is it the only way to assess the efficiency of conversion from final to utilizable energy (intermediate energy per OLADE), but it also includes losses in utilization systems (good or bad use practices), such as energy consumption for heating or air conditioning in dwellings with different types of construction or insulation, and consumption of refrigerators under different operating conditions (e.g., with or without ventilation or high ambient temperatures). In sum, this method is used to measure final energy in both production and consumption.

Monitoring is central to this approach, but due to budgetary constraints associated with this type of process, sample sizes and measurement-taking periods are often restricted, which may limit the scope of data collection, the representativeness of findings, and subsequent analysis. As a result, it may be sensible to combine follow-up with a survey on a larger sample, including a monitoring sample. This integrated process enhances the consistency of results and links the knowledge of end-use power consumption patterns to behavioral factors.

In Colombia, for example, the residential, tertiary (trade, service and public) and industrial sectors were characterized from 2005 to 2012. More than 200 homes were measured and 4000 were surveyed, more than 250 business establishments were measured, surveyed and visited, and more than 150 industries were measured and more than 200 surveyed and visited. These measurements provided the specific consumption of most electrical appliances in all sectors, including refrigerators, motors, air conditioners, chillers, and others. It was also possible to characterize many types of boilers and furnaces that use different fuels. In the residential sector, the efficiencies of NG and LPG stoves were measured.

This approach makes it possible to develop models for detailed assessment of final energy consumption based on other variables that can be surveyed more frequently without taking new measurements. However, final energy is determined by a broad range of factors, such as quantifiable behavior and others, which are not easily measured through surveys.

On-site measurement seeks to log actual (on-site) consumption of the main electrical devices and their usage patterns. To ensure the reliability of on-site measurement results, it is advisable to supplement them with a survey, either on the same sample or on a larger one. The two have different aims and restrictions. While on-site measurements focus on energy use patterns and power consumption by end uses, surveys center more on behavioral factors and inventories.

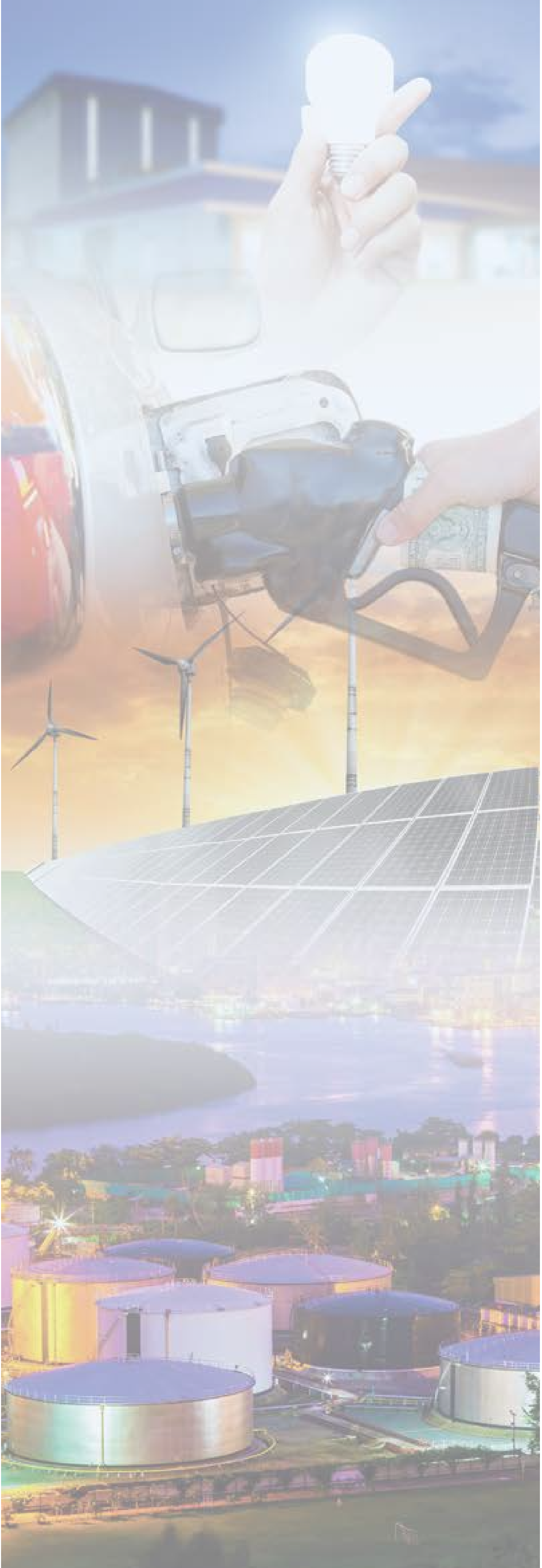
Measurements correct the subjectivity of a survey, because respondents are not necessarily aware of the inefficiencies in the energy consumption process, so cannot answer such questions. Measurements *determine* actual energy consumption by application, while surveys *estimate* it based on the *ideal* consumption of the equipment for a given use, ignoring its state of repair, consumption practices, operating conditions, etc.

It was easy to access homes, business establishments and company headquarters, because past experience in Colombia had shown that users were happy to receive a report of the measurements, cost-effective energy saving opportunities and other recommendations to optimize energy consumption.

The process of sample selection is key to ensuring the success of the operation. Measurements are made for a sample of users, which is usually smaller than in the case of surveys due to the higher cost involved. The privacy and confidentiality of all information supplied must be guaranteed, as in the case of study programs.

As in the case of survey sampling, a statistically representative sample is required to ensure the reliability of the findings. However, the representativeness of monitoring samples should be approached differently. In either case, some consistency and representativeness must be assured in the sampling criteria, but often sample selection will be determined more by practical considerations than by the need for high levels of representativeness. In neither case can small samples be considered representative, as they limit statistical inference unless a supplementary survey is used, but they should be valid enough to identify use and consumption patterns for each type of appliance.

In the case of medium to large industries and large establishments in general, great strides have been made towards automation and control due to the ample supply of technologies that facilitate the measurement and monitoring of variables that represent critical inputs for production, including power, fuel consumption and other physical factors such as pressure, temperature, lighting, and others. This, along with the growing adoption of efficient energy management systems (ISO 50001) by numerous industries, will aid in understanding much more deeply the utilizable energy production of equipment and its consumption for these processes, taking into account use practices.



CHAPTER II

The Transportation Sector

2. THE TRANSPORTATION SECTOR

To build Utilizable Energy Balances (UEB) that are general enough to cover all countries of Latin America, we propose a practical disaggregation that avoids both unnecessary duplications and the inclusion of subsectors whose order of magnitude makes them negligible.

Important considerations include the relative weight of groups in a disaggregated balance and the usefulness of such disaggregation to propose meaningful conservation and substitution policies.

We propose the following disaggregation into 14 groups:

Table 7. Disaggregating Transportation

Sector	Subsector	Travel	Type of service	Final Usage	Technology	Energy sources
Transportation	Land	Urban	Private	Passengers	Motorcycles, automotives, SUVs, pickups	Gasoline, diesel, electricity, biofuels, CNG, LPG
			Public	Passengers	Taxi cabs, busses, vans, trolleybus	Gasoline, diesel, electricity, biofuels
			Public	Payload	Pickups, trucks	Gasoline, diesel, biofuels
		Inter-cities	Public	Passengers	Busses, vans	Gasoline, diesel, biofuels
			Public	Payload	Pickups, trucks, trailers	Gasoline, diesel, biofuels
	Railroad	Urban	Public	Passengers	Metro, tram, funicular, cable car	Diesel, Electricity
		Inter-cities	Public	Passengers	Train	Diesel, Fuel Oil, Electricity
			Public	Payload	Train	Diesel, Fuel Oil
	Air	Inter-cities	Public	Passengers	Helicopters, big and small airplanes	AvGas, Jet fuel
			Public	Payload	Helicopters, big and small airplanes	AvGas, Jet fuel
	River	Inter-cities	Public	Passengers	Yachts, boats, ferries	Gasoline, Diesel, Fuel Oil
			Public	Payload	Boats	Gasoline, Diesel, Fuel Oil
	Maritime		Public	Passengers	Boats	Gasoline, Diesel, Fuel Oil
			Public	Payload	Ships	Diesel, Fuel Oil

This classification may be excessive for many countries, so it should be seen as a maximum disaggregation. It could be regrouped into two categories: passenger and cargo, each subdivided by modes of transport, for a total of 10 groups.

2.1 DISAGGREGATION BY TECHNOLOGY AND SOURCE

From a physical viewpoint, utilizable energy for the transportation sector is mechanical force. Accordingly, its sole use would be to transport persons and goods by producing mechanical work and kinetic energy. This sole use can be subdivided into several categories according to the technology that engines use to produce that kinetic energy.

- Internal combustion engines (diesel, gasoline, LPG, VNG)
- Jet engines (turbo jet, turbo propeller, water-fueled engines, etc.)
- Electric motors
- Hybrid systems

Although these machines produce mechanical force, they do so with different levels of efficiency, which must be taken into account when examining fuel substitutions.

It is worth noting that in the case of the transportation sector, determining utilizable energy based on efficiency allocation is less meaningful than disaggregating final energy sources and subsectors, because once you reach this stage, you already have most of the data required for demand analysis and forecasting.

In this case, utilizable energy and energy efficiency are expressed in terms of final energy as a specific consumption (**c**) in liters, gallons or square meters per kilometer. Manufacturer reference values refer to ideal conditions (flat, paved road with no obstacles, no traffic lights, etc.), but they also be measured under real traffic conditions by specific labs with a suitable sample design. These amounts will also depend on vehicle age, maintenance and tuning (timing). Assessing the averages of these values by vehicle type could enable you to determine how far actual values fall from those given by manufacturers, and thereby quantify losses due to use practices.

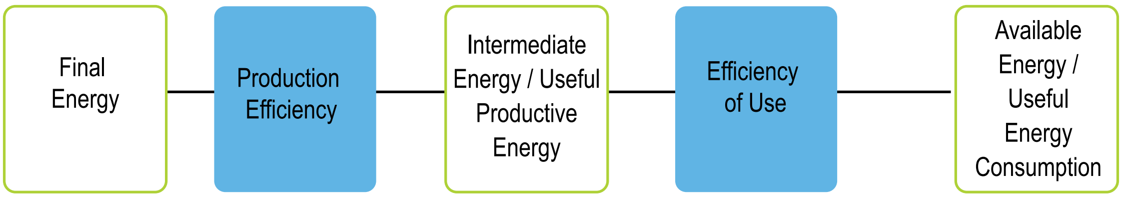
Transported magnitudes are commonly expressed in tons-kilometer (TKM) or passengers-kilometer (PKM), which obviously represent the sector's productiveness. Therefore, energy consumption can be obtained by TKM or PKM, or added value, to compare means of transport or technologies.

Sometimes reference is made to the thermal conversion efficiency of each technology: 40% for diesel engines, 28% for gasoline engines, 30% for turbo jet engines, etc. In this way, these conversion losses plus any losses due to utilization practices are counted in the actual fuel efficiency factor in terms of liters, gallons or square meters per kilometer.

2.2 OUTLINE OF THE UTILIZABLE ENERGY BALANCE (UEB) IN THE TRANSPORTATION SECTOR

Based on the concepts described above, it is possible to determine the UEB structure for the transportation sector and define the flows and the equations that link them together. Below we will address the specific data collection and data processing procedures proposed for calculating such flows.

First of all, applying the UEB to an automotive unit follows a two-stage pattern in which final energy is transformed into kinetic energy by combining the thermal efficiency of motors with the efficiency of the transmission and bearing mechanisms designed by manufacturers (gear box, type of tires, axles, etc.), and takes into account factors such as capacity and weight. This combined efficiency is reported in gallons, liters or square meters per kilometer traveled under ideal conditions. In the second stage, the energy produced in the first stage is used under actual field and traffic conditions (slopes, traffic lights, unpaved terrain, etc.) to provide the utilizable energy with use practices. The final efficiency factors can be obtained from field measurements and especially designed and implemented labs.



Depending on the depth of the characterization in each country, utilizable energy can be established at the first or second stage, with the understanding that the second stage requires taking measurements in all subsectors.

Clearly, data collection procedures must be designed in order to disaggregate consumption in the subsectors described above. Furthermore, if this consumption structure is to aid in planning and demand forecasting, it is advisable to express the passengers-kilometer (PKM) and tons-kilometer (TKM) with the same levels of disaggregation. The latter magnitudes, while not part of the UEB, are an indispensable complement thereof, among other things to ascertain the specific consumption elasticities by PKM or TKM.

The baseline used is road transport, being the most complex, and its results can be easily applied to other modes of transport. The referential universe for road vehicle subsectors is the number of vehicles (N) making up the automobile fleet, along with its main features, namely:

- Vehicle type: N should be known for each category, such as motorcycles, private cars, taxis, vans, campers, trucks, vans, buses, tractor-trailers, etc.
- The transport capacity offered, measured by number of passengers or tons of cargo
- The model or age of each unit within each category
- The type of fuel used (gasoline, diesel, LPG, VNG, biodiesel, alcohol), or electricity
- The type of road, whether urban or interurban
- The type of service, whether private, official or public

2.2.1 THE UEB APPLIED TO A MODE OF TRANSPORT

Here you apply the FLOWCHART technique—the same used to design a national or regional energy balance—to the mode of transport chosen following the energy conservation principle.

Generally speaking, a mode of transport purchases energy and converts it into mechanical force in order to transport passengers and cargo using the existing vehicle fleet and the technologies mentioned above. The PURCHASED ENERGY is disaggregated by energy source, according to those in the energy balance matrix.

In this case, the energy input matches the purchased energy. Some countries may have generators that run on renewable—hydro, solar, geothermal, wind or biomass— energy, allocated solely to transportation. Although these energy sources are not purchased, they should be included as inputs to avoid an imbalance.

This consumption by source can now be compared to the FINAL CONSUMPTION BY TECHNOLOGY. Final consumption by source and the sum of final consumption by application (technology) must be balanced and consistent, although not equal due to inventory variations or statistical error. An overview of these ideas is summarized in a single form (Table 19).

Table 8. Summary Form

Transport Sector									
Technologies	Internal Combustion Engines		Reaction Engines		Electric Engines		Hybrid Systems		Total consumption per source and average efficiency
Sources	Unit	n%	Unit	n%	Unit	n%	Unit	n%	
Crude Oil									
Natural Gas Liquids									
Natural Gas									
Coal									
Nuclear									
Hydro									
Geothermic									
Wind									
Solar									
Firewood									
Sugarcane products									
Other biomass									
Electricity									
GLP									
Gasoline									
Kerosene and Jet Fuel									
Diesel Oil									
Fuel Oil									
Refinery gas									
Oil coke									
Other oil and gas products									
Coal coke									
Industrial gasses									
Other products from mineral sources									
Charcoal									
Ethanol									
Biodiesel									
Biogas									
Other Secondary Sources									
Non-energy									
TOTAL									
AVERAGE EFFICIENCY / TECHNOLOGY									
USEFUL ENERGY CONSUMPTION									
LOSSES									

We start with the net energy input, which matches final consumption. This is disaggregated by technologies, and the production efficiency is also indicated. At the bottom, we calculate the intermediate utilizable energy consumption by adding up the useful consumptions weighted by their respective production efficiencies. Next, the application efficiencies are added up (if they are known or can be estimated) and the useful consumption is calculated by multiplying the intermediate useful consumption by these efficiencies. Finally, losses are calculated as the difference between final consumption and useful consumption.

2.2.2 THE UEB APPLIED TO THE TRANSPORTATION SECTOR

As seen above, virtually all the data making up the UEB for a mode of transport can be placed in the form of a double-entry table. In this sub-section, we will see how to present the UEB for the entire transportation sector of a country or region. First of all, in order to view all the data making it up, the proposed disaggregation imposes a 4-entry table:

- By mode of transport
- By technology
- By source
- By consumption type: final, useful, efficiency and losses

Following the OLADE balance format, i.e., listing energy sources in columns, the UEB for the transportation sector can be presented in the main form (Table 202), which records final consumption and a summary of the useful consumption data in maximum detail. There will be as many forms as there are modes of transport considered in each country. They will be included in their own BUEs but should not necessarily be part of the OLADE balance matrix, although they should be attached for the OLADE database.

2.3 DATA COLLECTION AND PROCESSING

2.3.1 Secondary data

2.3.1.1 Automobile fleet

An attempt should be made to build the automobile fleet based on data from the secretaries or ministries of transport in each country. There are other secondary sources, such as insurance agencies, vehicle registries, inspection records in some countries, or other certifications, and road tax offices also have valuable data on the vehicle fleet. In any case, a disadvantage is that many of the vehicles registered in the fleet are no longer in circulation, since the procedure to de-register them is complex and therefore avoided.

2.3.1.2 Fuel Consumption

It is very important to collect data from national oil refineries and biodiesel/alcohol producers, and from national and regional fuel importers and wholesale distributors. Distribution companies as Texaco, Mobil, Esso, Petrobras, and others have data that is vital to characterization, which can be obtained by different means such as interviews, high-level contacts, etc. There are also large fuel consumers that are reported differently, including power generators and certain industries, and this data is important to closing the national fuel consumption balance.

2.3.1.3 Mass Transport Systems

Wherever there are integrated or mass transport systems (metros or articulated buses on exclusive or preferential lanes) at the urban or interurban level (trains), they have organized historical data. It is also relatively easy to survey air transport systems in terms of fuel consumption, passengers and cargo carried, because they use unique fuels.

2.3.2 Surveying users, service stations and transportation companies

We start with the assumption that data collected at service stations is sufficient to characterize the transportation sector, since the entire active fleet refuels at service stations (EDS from the Spanish: *Estaciones de Servicio*).

2.3.2.1 CHARACTERIZING SERVICE STATIONS

The main source of data for the study to characterize the road transportation sector is surveying vehicle drivers across the country. To ensure representativeness, these surveys should be conducted at a sampling of public service stations on different days of the week and at different times of the day, as vehicles arrive to refuel. Since the survey is conducted at service stations, it is advisable to collect certain data (operational, technical and commercial) on these stations prior to surveying the drivers, in order to validate the findings. Specifically, data of operative, technical and commercial nature was gathered.

2.3.2.2 DEFINING THE UNIVERSE

The first step, then, is to define the universe for the study, i.e., the census of public and private service stations. Each country has different data systems for national and regional fuel distribution, but most have geo-referenced systems on the location of such service stations.

The next step is to classify all service stations by region, size, location on the main route, or others. A form is designed to collect operational, technical and commercial data on the average time that public service stations have been in operation, how many days per week and hours per day they work, what fuels they sell, how many islands, hoses and pumps they have, the number and capacity of their tanks, the average volume they purchase and how often and, as noted above, commercial data related to sales volumes by fuel type.

2.3.2.3 ENERGY CHARACTERIZATION OF THE ROAD TRANSPORTATION SECTOR

Shown below are the main objectives pursued when characterizing energy for the road transportation sector.

A. To determine the fuel consumption (regular gasoline, premium gasoline, diesel, LPG, and VNG) distributed through the country's service stations by geographical area, economic sector and segment of the automobile fleet

B. To validate the service station census with secondary data on fuel sales, specifying the relevant data to characterize road transport

C. To update the country's large consumer census using data available from private and public entities that deal with this matter

D. To determine fuel consumption distributed through service stations, design and implement samples, conduct surveys at each of the selected service stations for at least 16 hours during two days in a week, with one on the weekend

E. To determine the vehicle fleet, specific consumption and level of vehicle use (kilometers driven, number of passengers and amount of cargo carried) for regions and segments of particular interest in each country

F. Based on secondary data, to develop a census of cargo and passenger companies, design the sample and implement the survey to determine the demand of their vehicles and characterize them

G. You can also develop a private service station census based on secondary data and apply a survey to a sample of them to quantify the number of vehicles they refuel, with a 5% margin of error and a 95% confidence level.

2.3.2.4 SAMPLE DESIGN

We suggest using a probabilistic, stratified, multistage sample, i.e., a sample designed to show the probability of selecting each of the observations made, separated by fuel types (gasoline, diesel, LPG, VNG) and by region, grouped by service stations, defining their size, and selecting in order by region, station, island, and pump.

To select service stations, you will also use the average fuel volume sold per station (if available) as a stratification variable. Until you have all this data on each station, they will all have the same likelihood of being selected.

The sample should provide error levels 1.0% to 5% nationwide with a reliability of 95%, and be balanced by region, seeking to achieve similar error levels in each one.

2.3.2.5 *Sample Type*

The recommended sample design is of the probability, clustered, multi-stage type.

Probability sampling: You know the probability of each fuel customer being selected, which is greater than zero.

Cluster sampling: The universe under study (fuel buyers) is grouped by fuel type and by region. If the data is available, you can also order stations by volume sold and make the selection based on this criterion, thereby increasing the reliability of your estimates.

Multistage sampling: We propose selecting the sample in five stages for each region and each fuel type:

- Random selection in each region of the stations where that fuel type is sold, with the probability of selection being based on the sales volume of the fuel at the station if that data is available (liquid fuels), or an equal probability if not.
- At each selected station, for the fuel type to be studied, choose a pump at which to count vehicles and apply the survey to fuel buyers;
- At each station, choose a second pump, which should be the closest one to the first with the same fuel, except that in the case of regular gasoline you will choose the nearest premium gasoline pump.
- Choose any day of the week for the field work at the station, ensuring that all the days of the week are covered for each fuel and region. Doing one day of field work per station, and covering its entire working day, you will be able to survey a large number of stations, which will increase the accuracy of the conclusions derived from the data supplied directly by the stations.
- All fuel buyers at the selected pumps will be surveyed to calculate the indicators for characterizing road transport, and at each selected station a form for collecting data that could be relevant to the characterization.

The selection process, then, has the following steps:

- It starts with an inventory of service stations at the regional level as required.
- For each region, randomly select the stations by size, as follows: (i) sort by fuel volumes demanded; (ii) calculate a 'skip' equal to the number of service stations divided by the number to be selected; (iii) choose a 'seed' as a random number between 1 and the skip; and (iv) select all stations in order that coincide with the seed, i.e., with the result of adding the skip as many times as necessary to cover all stations.
- For regions such as border areas and the rest of the country, we recommend prior clustering at the municipal level, and the municipalities to be visited will be selected according to the total volume of fuel sales in each one.
- At each selected service station, randomly choose a pump where the selected fuel is expended, plus the closest one with the same fuel, except for selecting the nearest premium pump in the case of regular gasoline.
- For one previously-defined day, track each pump for 24 hours or as long as the service station is open, counting the number of fuel buyers and taking note of the vehicle data and sale volume. This applies to all nozzles of each pump.

2.3.2.6 *Estimates to be made*

Four main estimates have to be made in this survey:

i. Yearly fuel consumption (Q_{year}), obtained as the product of the average volume of each sale (v_{sale}), the average number of sales per pump during an eight-hour day (n_{pump}), the average number of suppliers per service station ($S_{station}$), the number of service stations (E), and the number of work hours per year for each station ($h_{station}$) divided by eight, which is the duration of each working day. This is done for each of the fuel types under study.

$$Q_{year} = v_{sale}\, n_{pump}\, S_{station}\, E\, \frac{h_{station}}{8}$$

ii. The size of the active vehicle fleet purchasing fuel at service stations, estimated as the number of sales (N_{year}) and the average number of refuelings per year per vehicle. The latter is 365 days divided by the average refueling period ($P_{refueling}$).

$$N_{year} = n_{pump}\ S_{station}\ E\ \frac{h_{station}}{8}$$

$$Fleet = \frac{N_{year}}{365/\ P_{refueling}}$$

iii. The vehicle use level (U_{year}), measured in kilometers per year or in cargo/passengers carried, is obtained as the product of the average per vehicle (U_{year}) derived from the responses of drivers at service stations and the active vehicle fleet.

$$U_{year} = u_{year}\ Fleet$$

iv. The performance R in km per gallon, which is the ratio of vehicle fuel consumption (Q_{year}) to total km traveled.

$$R = \frac{Q_{year}}{U_{year}}$$

The aim of this approach is to achieve a reliability of no less than 95% and a margin of error not exceeding 5% for domestic demand and 12.5% on the regional level. Thus, sample design should aim for the above when estimating the five parameters for determining the demand:

- Average volume per sale (v_{sale})
- Average number of sales per pump (n_{pump}) and working day
- Average number of pumps per station ($S_{station}$)
- Average working hours per year per station ($H_{station}$)
- Number of stations N that distribute each fuel type

2.3.2.7 Calculating the Sample Size

The above shows that estimates based on the data collected from the sample of service station users are mean (average) population calculations, and the formula for calculating sample size is a simple random sampling of items, adjusted for cluster sampling due to having applied a design of this type.

Yearly consumption (Q_{year}) can also be calculated as the product of the number of sales per year (N_{year}) and the average sale (v_{sale}), which reduces the consumption estimate from five to two parameters.

$$Q_{year} = N_{year}\ v_{sale}$$

However, the number of fuel sales at a country's public service stations can be described as very large for the purpose of calculating sample size. This, along with the sample size having a diminishing marginal growth over the size of the study universe, led to proposing that the sample size be calculated assuming an infinite universe, which simplifies size calculations to the characteristics of a single parameter—the average sale—and the formula for calculating sample sizes to:

$$n = \frac{z^2 CV^2 Deff}{e_{rel}^2}$$

Where:

n	Required sample size
Z	Quantile of normal distribution for the desired reliability
CV	Coefficient of variation for the measured variable (standard deviation / mean)
Deff	Effect of sample clustering, i.e. the ratio of the variance with clusters to the variance of a simple random sampling of items
E_{rel}	Relative error of the estimate, i.e. the absolute error over the mean of the parameter

This simplifies sample size calculations to the characteristics of a single variable.

Thus:

- The parameter z for calculating the sample size takes the value of 1.96.
- The relative error, at a 95% confidence interval, is 0.05 for national estimates and 0.125 for regional estimates.

2.3.2.8 *Coefficient of Variation (CV) and Cluster Effect (Deff):*

Based on prior studies in Colombia, the CV and Deff values as benchmarks were:

Table 9. Coefficient of Variation and Deff for Fuel Type

Parameter Weekly purchases (gal) of:	CV	Deff
Regular Gasoline	2.50	1.22
Premium Gasoline	1.74	1.28
ACPM	1.57	1.25

2.4 TOOLS FOR DATA COLLECTION AT SERVICE STATIONS

The annexed Excel file contains the tools recommended for data collection at service stations, taken from the station manager survey, the fuel sale count and observation, the driver survey, and the survey of bulk fuel purchasers.

- STATION MANAGER SURVEY (see annex)
- VEHICLE COUNT AND DRIVER SURVEY (see annex)
- BULK PURCHASER SURVEY (see annex)
- TRANSPORTATION COMPANY SURVEY (see annex)

2.5 EFFICIENCY, UTILIZABLE ENERGY

As stated in section 1.2, once a country's active automobile fleet is known, it is necessary to conduct a study (research) of vehicle efficiency (for all categories and fuels). It starts with nominal performance values in km/gal or t-km/gal, which defines phase 1 of efficiency or production efficiency. Next are the field and lab measurements, such as those suggested in the on-site measuring approach to determine the urban and interurban operating performance for each category.

2.6 APPLICATIONS

Below is a description of how this approach was applied to the Colombian case.

2.6.1 The Colombian Case

We started with the national directory of service stations, with a universe of 4,098, of which 3,784 distributed liquid fuels within the country, located in the ten regions defined by the *Unidad de Planeación Minero Energética* (UPME). We then stratified the sample and divided the stations in the metropolitan areas of Bogotá, Bucaramanga, Medellin, Barranquilla, Cali, and Villavicencio into four groups:

- Group 1: those on a main avenue of the city for which the metropolitan area was named
- Group 2: those on another type of street in that city
- Group 3: those in the municipal seat of another town within the metropolitan area
- Group 4: those in rural areas or roads linking the towns of the metropolitan area amongst themselves or with others

The universe of public service stations selling liquid fuels was distributed as follows:

Table 10. Distribution of the Universe of Service Stations selling Liquid Fuels

Region	Group 1	Group 2	Group 3	Group 4
1. BOGOTA M.A.	165	179	50	59
2. BUCARAMANGA M.A.	13	25	16	22
3. MEDELLIN M.A.	22	89	80	18
4. BARRANQUILLA M.A.	34	55	26	6
5. CALI M.A.	80	72	58	15
6. THE COFFEE BELT	70	–	45	27
7. TOURISM DISTRICTS	37	17	10	19
8. VILLAVICENCIO M.A.	10	17	10	14
9. REST OF THE COUNTRY	1,634	–	–	–
10. BORDER AREAS	790	–	–	–
TOTAL STATIONS:	**2,855**	**454**	**295**	**180**

Source: ***Cálculos Econometría S.A.*** **Does not include the San Andres Archipelago**

2.6.1.1 *Selecting the Stations*

The proposed sample design established that to meet the survey targets needed to reach the statistical significance requested by the UPME, in each region we would need to apply surveys in 20 stations selling regular gasoline, 10 selling premium gas, 8 selling diesel and 12 selling VNG. Thus, the numbers of stations where we worked, by fuel type and region, were the following:

Table 11. Station Selection

Region	Regular Gasoline	Premium Gasoline	Diesel	VNG
1. BOGOTA M.A.	24	18	10	13
2. BUCARAMANGA M.A.	23	21	8	13
3. MEDELLIN M.A.	21	30	10	12
4. BARRANQUILLA M.A.	20	23	8	12
5. CALI M.A.	22	21	9	16
6. THE COFFEE BELT	21	24	9	13
7. TOURISM DISTRICTS	21	19	9	12
8. VILLAVICENCIO M.A.	22	20	9	13

Region	Regular Gasoline	Premium Gasoline	Diesel	VNG
9. REST OF THE COUNTRY	22	9	17	2
10. BORDER AREAS	11	9	6	5
TOTAL STATIONS:	**207**	**194**	**95**	**111**

Source: ***Cálculos Econometría S.A.*** **Does not include the San Andres Archipelago**

Note the number of stations surveyed for VNG in the border areas and the rest of the country, due to the low coverage in these areas. In total, 80,000 sales were recorded and 60,000 drivers interviewed.

2.6.1.2 *Findings*

- Fuel consumption:

Table 5 shows that public service stations market a total of 153.4 KBPD in liquid fuels, 5.6% of which are sold in bulk for purposes other than road transport, primarily for farm use.

Table 12. Fuels distributed through public service stations, balance by use

Sector	Regular (KBPD)	Premium (KBPD)	Diesel (KBPD)	VNG (MPCD)
Road transport	**67.5**	**1.7**	**75.8**	**77.9**
Refueling	65.8	1.7	74.8	77.9
Bulk	1.6	0.0	1.0	0.0
Other sectors (bulk)	**5.7**	**0.0**	**2.9**	**0.0**
Electricity Generation	0.1	–	0.6	–
Industrial	0.5	–	1.4	–
Farming	2.3	–	0.6	–
Trade	1.6	–	0.0	–
Others	1.1	–	0.2	–
TOTAL PUBLIC SERVICE STATIONS	**73.1**	**1.7**	**78.7**	**77.9**

Source: ***Cálculos Econometría S.A.*** **Does not include the San Andres Archipelago**

- Active automobile fleet:

The estimate of the country's active road transport fleet is based on the number of fuel sales combined with the average time between vehicle refueling, as follows:

$$\text{Fleet}_{\text{universe}} = \text{Number}_{\text{sales}} * \text{Period}_{\text{sales}}$$

The above can be interpreted as meaning that the number of vehicles in any group of interest is equal to the ratio of daily fuel sales for those vehicles to the average days between sales.

Thus, since daily fuel sales in the country is 2.1 million and the average refueling period is estimated at 2.97 days, the country's active automobile fleet would be 6.1 million vehicles.

$$\text{FLEET}_{\text{universe}} = 2051 \text{ thousand} * 2.93 = 6003 \text{ thousand}$$

In this regard, we should mention that this is lower than the figure of just under seven million vehicles reported by the Ministry of Transport as registered nationally in December 2009,[1] even when including the 93,000 cargo and passenger vehicles that do not refuel directly at public service stations, but rather at private stations, being vehicles that work for companies that purchase fuel directly.

As discussed below, this difference can be explained by inactive vehicles that may not have been deregistered in the Ministry's statistics. However, the automobile fleet can be estimated by classification level, fuel type, region of the country, and vehicle type.

Table 13. Vehicle fleet by region

Region	Sales (thousands)	Period (days)	Fleet (thousands)	%
REGION 1 - BOGOTA M.A.	381	3.21	1,220	20%
REGION 2 - BUCARAMANGA M.A.	53	2.70	143	2%
REGION 3 - MEDELLIN M.A.	146	2.61	379	6%
REGION 4 - BARRANQUILLA M.A.	80	1.99	159	3%
REGION 5 - CALI M.A.	141	2.76	387	6%
REGION 6 - THE COFFEE BELT	70	3.27	230	4%
REGION 7 - TOURISM DISTRICTS	54	1.54	84	1%
REGION 8 - VILLAVICENCIO M.A.	43	3.11	133	2%
REGION 9 - BORDER AREAS	133	3.32	442	7%
REGION 10 - REST OF THE COUNTRY	951	2.97	2,826	47%
TOTAL COUNTRY:	**2,051**	**3.06**	**6,003**	**100%**

Source: ***Cálculos Econometría S.A.*** **Does not include the San Andres Archipelago**

Table 14. Fleet Distribution by Category (thousands of units)

Item	Gasolines	Diesel	VNG	Total
Automobiles	1,469.5	8.2	146.6	1,624.3
Utility Vehicles (SUV)	388.9	67.7	45.6	502.2
Motorcycles	2,668.6	0.1	0.2	2,668.9
Pickups	206.2	129.4	40.2	375.8
Trucks	137.9	307.7	39.0	484.6
Tractor-trailers	0.5	49.2	0.2	49.9
Passenger capacity <21	38.1	132.0	22.0	192.1
21 to 35 passengers	1.0	56.4	0.6	58.0
Over 35 passengers	1.4	42.7	2.7	46.9
TOTAL FLEET:	**4,912**	**794**	**297**	**6,003**

Source: ***Cálculos Econometría S.A.*** **Does not include the San Andres Archipelago**

1 While figure of 7,000,000 refers to all vehicles registered by the Ministry of Transport, some publications only refer to models of the past 40 years, in which case the figure drops to 5.9 million.

• Vehicle performance and utilization:

The transport company survey also provides valuable data regarding the average automobile performance, especially for cargo and passenger vehicles. The findings are presented below:

Table 15. Average performance of company-affiliated vehicles (km/gal. or m^3)

Type	Regular Gasoline	Premium Gasoline	Diesel	VNG
Automobiles	35	52	40	36
Vans	24	-	32	26
Minibuses	29	-	20	12
Large buses	-	-	12	14
Pickups	35	-	39	40
2-axle trucks	35	-	16	11

Source: ***Cálculos Econometría S.A.***

There is no official technical source against which to compare the above data, but we checked it with various sources seeking to obtain the expected performance of different types of vehicles. The following table shows these findings and compares them to the above figures and those collected from the service station surveys.

Table 16. Average vehicle performance in Colombia (km/gal)

Type	Transport companies	Driver Survey	Users (Internet)	Experts
Automobiles	35	51	32 – 57	37 – 43
Utility vehicles (SUV)	–	42	29 – 37	–
Motorcycles	–	65	115 – 150	–
Pickups, vans	35	37	32 – 44	25 – 30
Trucks	16	29	33	16 – 18
Tractor trailers	–	19	–	7 – 13
<21 passengers (vans)	24	44	37 – 41	30 – 35
21–35 passengers (minibuses)	20	38	12 – 15	13 – 18
> 35 passengers (large buses)	12	34	9	9 – 13

Source: *Cálculos Econometría S.A.*, based on driver surveys at service stations, transport company surveys, blogs on the Web, and experts representing the business areas of the Automotive Committee member companies.

The above table shows great variability among sources with regard to expected vehicle performance. This could be due to the multiple models found in Colombia for each vehicle type,[2] different levels of repair, and diverse operating conditions. Based on the above, we suggest that the UPME use the following reference values:[3]

• Automobiles – 40 km/gal.

2 As a reference, suffice it to say that the country markets more than a thousand different vehicle lines with more than fifty different brands.

3 The proposed references for vehicles normally used by families (sedans, utility vehicles and motorcycles) were calculated from various sources and from the shares of different segments in the various vehicle categories. For commercial vehicles, they are based primarily on data from transport companies and experts consulted.

- Utility vehicles (SUV) – 34 km/gal.
- Motorcycles – 124 km/gal.
- Pickups – 25 Km/gal.
- Trucks – 16 Km/gal.

- Tractor-trailers – 8 Km/gal.
- <21 passengers – 24 km/gal.
- 21-35 passengers – 20 km/gal.
- >35 passengers – 12 km/gal.

Another interesting finding of this research is the level of vehicle use per type measured, both in kilometers per week and in number passengers or amount of cargo over the same time period.

Table 17. Use of company-affiliated vehicles

Type	Km per year	Passengers per week	Tons per week
Automobiles	64,100	200	-
Vans	66,900	220	-
Minibuses	70,500	780	-
Large buses	95,700	650	-
Pickups	37,000	-	90
2-axle trucks	61,400	-	353

Source: ***Cálculos Econometría S.A.***

2.6.1.3 *Modes other than Land Transport*

- River transport:

This mode will only be of interest in countries with large rivers, and is treated similarly to land transport. The fuel consumption survey should be conducted at harbor stations and vessel registries collected from port authorities or pertinent government agencies. The census should provide at least the number of vessels by fuel type, service type, passengers or cargo, and capacity. The ideal is to collect the following data on as many vessels as possible:

- Number of routes covering port of origin and destination
- Capacity
- Number of trips per year on each route
- Fuel consumption per trip
- Cargo and passengers carried

- Rail and Air Transport

These two modes are treated similarly. In this case, no surveys are conducted, because data on consumption, passengers/cargo carried, and distances are known. The number of units traveling (trains, planes, etc.), their capacity (in passengers or tons) and their occupancy (amount transported on each route) are also known.

The fuels used in aviation—aviation gasoline and jet fuel (JP1 to JP8)—are specific, so knowing the sales of both products will give you the total consumption for air travel. All jet fuel is used by commercial aviation, although a small portion is allocated to the armed forces. Aviation gasoline is divided into:

- Commercial aviation
- Spraying
- Private aviation (private light aircraft, air taxis)
- Armed forces

Commercial aviation consumption is known from company records, and the rest is distributed among the others. Spraying pertains to the farm sector, and data can be collected from company surveys and interviews, as in the case of air taxi companies using light aircraft.

- Maritime Transport

The first thing to be done is a good initial assessment of the status of the information available in each country. A differentiation should be made between cabotage, measured in ton-km, and international transport, measured in tons. Whether surveys will be taken will depend on the findings of the initial assessment.

Then it is necessary to identify the existence of "captive fleets" that transport fuel, cement, iron, etc., are registered and have all the data, on the one hand, and "general fleets" for which surveys are required, on the other. A special case is fishing fleets, some of which may be complete water-borne processing and transporting industries. In general, the maritime mode has good data on fleet capacity, trips, occupancy, and fuel consumption.

2.6.1.4 *Efficiencies*

The nominal efficiencies of the technologies used are either known or sufficiently referenced on the Web. However, as in the case of land transport, field and lab measurements should be taken to assess the operating efficiencies of equipment. There are two ways to do this: using on-site measurement, or through voluntary users who report on fuel used, trips made, and cargo/passengers transported.

In the case of land transport, modern means of communication—mobile phones, WhatsApp, Waze, etc.—can be used to develop an app where users register all their vehicle data (private, passenger, cargo, etc.), license plate, age, engine, fuel, etc. An incentive can be offered, whether economic, in fuel or others, for reporting at least five times on refuelings, odometer readings, and any other data such as type of route (urban, rural, interurban, etc.) to collect data on vehicle operating efficiencies.

2.7 ANNEX – SURVEY FORMS

NATIONAL SURVEY TO FINAL ENERGY CONSUMPTION SECTORS

RECKONING OF USERS BUYERS AT LIQUID FUEL SERVICE STATIONS

A. OPER ATING CONTROL

A1. Name of the distribution company

A2. Address:

A3. Province

A4. Municipality

A5. Name of the manager A6. Phone Number:

A7. Day of visit	Mon	M	Wed	Thu	Fri	Sat	

A8. Day of visit Day Month

A9. Activity start time H H M M

A10. Activity End Time H H M M

B. DESCRIPTION OF THE STATION

B1. Types of fuel marketed	Regular Gasoline		Premium Gasoline (Plus)	
	Regular Diesel		Premium Diesel (Best)	
	LPG		Natural gas	

B2. Number of Islands B3. Number of Suppliers B4. Number of Total Hoses

B5. Type of hoses

How Many Regular Gasoline Options are?	
How Many Premium Gasoline Options are?	
How many regular diesel options are?	
How many premium diesel options are?	

B6. Storage tank capacity:

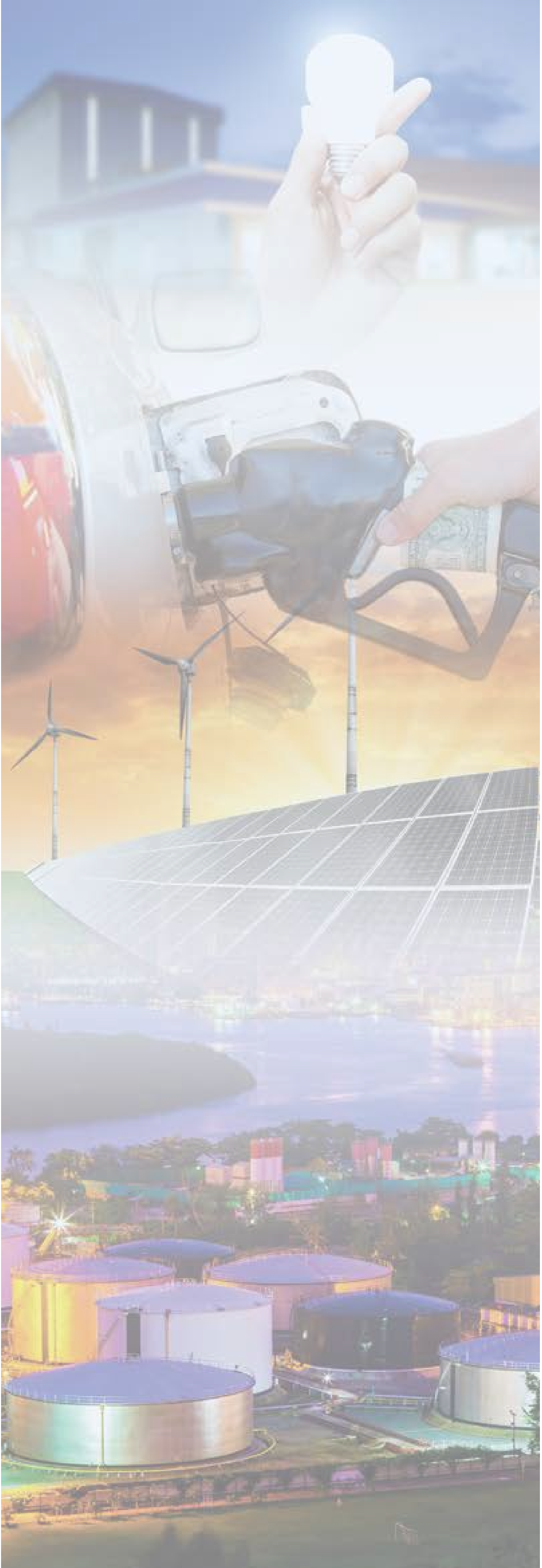
Regular Gasoline Capacity		Gallons	Premium Gasoline Capacity		Gallons
Regular Diesel Capacity		Gallons	Premium Diesel Capacity		Gallons
GLP Capacity		Gallons	Natural Gas Capacity		Gallons

B7. Request to know the reckonings of the odometers at the exit of the main tank during the day of the survey

Start of day log	
Final day record	

<table>
<tr><td></td><td colspan="9">C. REGISTRATION OF FUEL SELLING IN THE SELECTED SUPPLIER - VEHICLES</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="5">QUESTIONS TO THE DRIVER</td></tr>
<tr><td rowspan="7"></td><td>C1. Vehicle use class</td><td>C2. Type of Vehicle</td><td>C3. Fuel type</td><td>C4. How often do you buy</td><td>C5. Do you buy another fuel?</td><td rowspan="7">C6. What year is your car?</td><td rowspan="5">C7. How much did you buy?</td><td rowspan="5">Time of purchase</td><td rowspan="5">How many kms/gal does your vehicle run on?</td></tr>
<tr><td>A. Public</td><td>A. Automobiles</td><td></td><td>A. Daily</td><td>A. Regular Gasoline</td></tr>
<tr><td>B. Private</td><td>B. Buses</td><td>B. Premium Gasoline</td><td>B. Weekly</td><td>B. Premium Gasoline</td></tr>
<tr><td>C. Official</td><td>C. Pickup truck</td><td>C. Regular Diesel</td><td>C. Monthly</td><td>C. Regular Diesel</td></tr>
<tr><td>D. Business</td><td>D. Motorcycles</td><td>D. Premium Diesel</td><td rowspan="3">D. Every __ days</td><td>D. Premium Diesel</td></tr>
<tr><td rowspan="2">E. Taxi</td><td rowspan="2">E. Load</td><td>E. LPG
F. Natural gas</td><td>E. LPG
F. Natural gas</td><td rowspan="2">Gal (m^3)</td><td rowspan="2">$</td><td rowspan="2"></td></tr>
<tr><td>G. Biofuels</td><td>G. Biofuels</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

C. FUEL SELLING REGISTRATION ON THE PICKED STATION - BULK						
		QUESTIONS TO THE BUYER			C7. How much did you buy?	
	C3. Fuel type	C4. How often do you buy it ?	C3. Main use of fuel			
	A. Regular Gasoline	A. Daily	A. Residential	F. Ground		
	B. Premium Gasoline	B. Weekly	B. Industry	G. Non-energy source		
	C. Regular Diesel	C. Monthly	C. Agricultural		Gallon	$
	D. Premium Diesel	D. Every __ days	D. Commercial	H. Other specify		
	E. LPG		E. Resale			
	F. Biofuels		E. Resale			
1						



CHAPTER III

The Industrial Sector

3. THE INDUSTRIAL SECTOR

3.1 DISAGGREGATION BY SUBSECTOR

Realizing the need to disaggregate final consumption in the industrial sector was a logical step in the evolution of Utilizable Energy Balances (UEB). The development of demand forecasting models has always been determined by the relationship between energy consumption and some variable to characterize industrial output, value added, or contribution to the GDP. This gave way to the concept of consumption elasticity per added value or of energy content per economic unit produced. Consequently, disaggregating consumption is linked to the national accounts, based on the ISIC classification, which will also be used as a methodological basis for discriminating consumption types.

However, the 4-digit ISIC classification is very extensive. While some countries may already have this data, most Latin American countries do not, and collecting it requires a very large, costly sample. Therefore, in order to include most OLADE countries, we suggest using the following two-digit classification instead:

Table 18. Subsectors and ISIC Rev. 4 classification for the industrial sector

Table	Sub-sector	CIIUU Activities
1	Food, drinks and tobacco	10,11,12
2	Textile, leather, shoes	13,14,15
3	Paper and printing	17,18
4	Wood and furniture	16,31
5	Chemistry, rubber and plastic (except oil refinery)	20,21,22
6	Concrete	23
7	Rocks, glass, pottery, other non- metallic	23
8	Iron, steel, non-ferrous metals (except coke plants in sale, including high furnace)	24,25,26
9	Machinery and equipment	27,28,29,30
10		32

Source: Prepared by author

3.2 DISAGGREGATING BY APPLICATION

Energy end uses for industry are highly varied, to the point that arguably each manufacturing technology has certain processes linked to a given energy use pattern. However, to present the minimum applications for UEB development, we propose the following:

- Steam or process heat
- Direct heat
- Mechanical force
- Other applications (cooling, lighting, inputs, electrolysis, etc.)

Industrial users express their utilizable energy demand in terms of these applications or services. All industry needs electricity or fuel to drive its engines or heat its ovens, and will therefore have a demand for process heat or steam, direct heat, mechanical force, raw materials, or lighting. This demand depends on two factors:

- The manufacturing technology
- The higher or lower efficiency with which this technology is used in practice

For example, steam for sterilization in the food industry can be used more or less efficiently depending on pipe insulation and loss levels in the distribution network. Steam is therefore an intermediary required by that sterilization technology, and the fuel used to produce it can be changed for another or used more efficiently, but its demand is inherent in the technology itself. The same reasoning can be followed with energy demands for other processes, such as distillation, calcination, smelting, grinding, rolling, etc., in which where energy applications include steam, direct heat, and mechanical force.

3.3 FINAL ENERGY, UTILIZABLE ENERGY AND EFFICIENCY

The best way to visualize the industrial efficiency problem is to see the energy consumption process as having two stages:

- Producing steam, heat, mechanical force, etc. from energy supplies
- Using steam, heat, mechanical force, etc. in manufacturing processes

Therefore, there is a PRODUCTION EFFICIENCY and a USE EFFICIENCY. Taken jointly, the two will give you the overall efficiency or simply the efficiency. By multiplying the energy supply or final energy demand by that overall energy efficiency, you get the utilizable energy demand. The difference between the two will be losses.

If you only know the first of these efficiencies—the production efficiency—you can multiply it by the final demand to get the utilizable demand for production, i.e. the intermediate demand. One could say that final energy is what is measured at the beginning of a process, and utilizable energy is what is measured at the end. Both can be disaggregated by subsector, by output and by use.

The problem of determining efficiencies is that usually only the first—production efficiency—is known or can be estimated from manufacturers' catalogs, based on certain standard values applied with varying degrees of rigor in different countries. This approach is believed to be sufficient when demand forecasting emphasizes ways to SUBSTITUTE the various sources that compete in a price market to produce the same amounts of intermediate demand. Given this, we are not as interested in absolute efficiency values as in relative values, to reflect the fact that one source is more or less efficient than another in meeting the needs of a given technology.

The second—use efficiency—can only be obtained through measurement, which, while preferable to other methods, has the major drawback of its high cost. The only way to measure efficiency is by implementing ENERGY AUDITS to reveal the thermodynamic parameters of industrial plants. Even so, it should be possible to generalize these figures statistically from a good sampling of industries. Working with efficiency measures is needed when conducting initial assessments, developing portfolios of improvement options, and drawing up energy efficiency plans.

The two efficiencies defined above (production efficiency and use efficiency) can be seen in the three basic energy applications. Steam, as mentioned above, is where the difference between production and use can be observed most clearly.

- Mechanical force is produced at the motor shaft and transmitted via belts and gears to other systems, where it is used to cut materials, stir liquids, crush or grind materials, etc. In such cases, motors are usually highly efficient—above 84% if their magnetic circuits are in good conditions—but stirrer or ventilator blades may be worn, causing losses in motor use.

- Also, in pumping or ventilation systems, variable speed drives installed on motors can couple the torque and speed according to load variations, thereby significantly enhancing their use, by up to 35% greater efficiency overall.

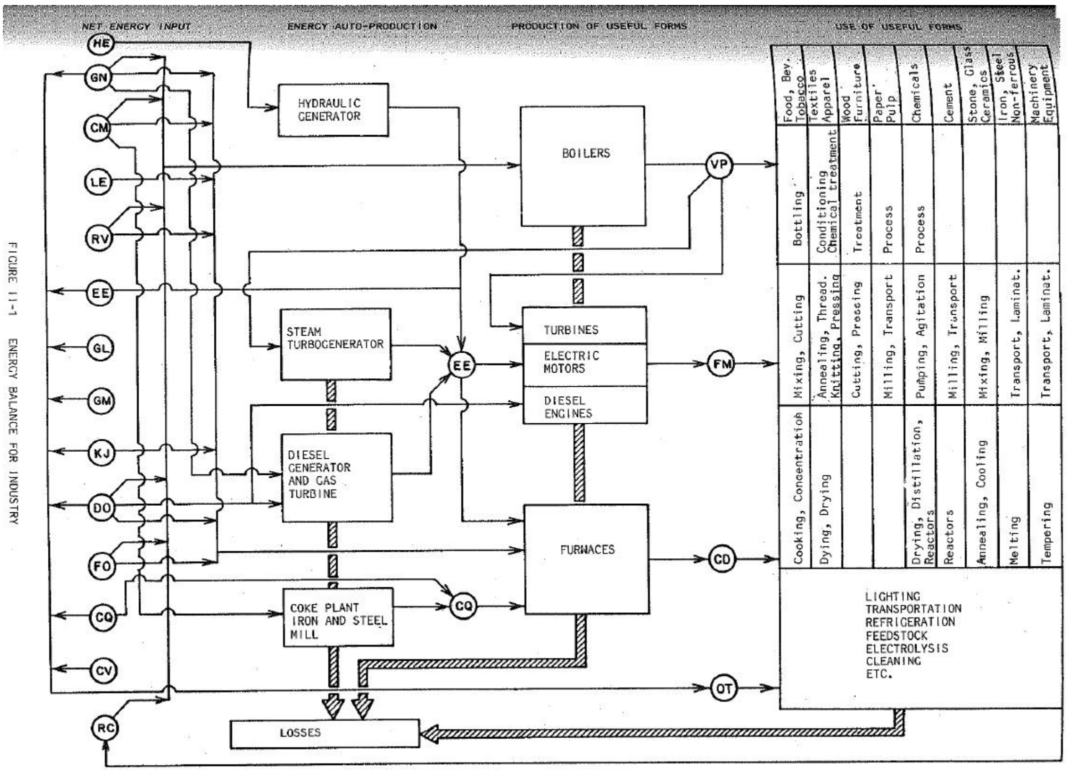
- Similarly, direct heat is produced in a furnace burner with its characteristic efficiency, but both flue gases and the agent receiving the heat are energy sources that are tapped to a greater or lesser degree (heat recycling), which characterizes their use efficiency. Insulating the furnace and heat exchange surfaces also has an effect.

As for other applications, in refrigeration, production efficiency involves the compressed-gas cooling system, while use efficiency would include the cold distribution system—ice water or an intermediate substance such as glycol—, losses in ducts, and others. In lighting, production efficiency has to do with the light bulbs, while use efficiency involves building surfacing, height and proper use (with or without occupancy).

3.4 THE UEB APPLIED TO AN INDUSTRIAL UNIT

In the following we will apply the FLOWCHART technique, the same used to design a national or regional energy balance, to industrial production plants following the energy conservation principle (Figure 14).

Figure 14. Energy balances in Industry



Source: OLADE Methodology 1984, updated

WE	Wind Energy	CP	Cane products	FO	Fuel Oil
SE	Solar Energy	OB	Other Biomass	CC	Coke Coal
HE	Hydro energy	EE	Electric Energy	CH	Charcoal
GE	Geothermal Energy	LPG	Liquified Petrolium Gas	HR	Heat Residues
NG	Natural Gas	MG	Motor Gasoline	ST	Steam
NC	Natural Coal	KJ	Kerosene, Jet Fuel	MS	Mechanical Strength
W	Wood	DO	Diesel Oil	DH	Direct Heat
				OT	OTHER

Generally speaking, an industrial plant serves the dual function of purchasing and producing energy in the form of primary and secondary sources, which are then turned into utilizable forms as defined above (steam, direct heat, mechanical force, and other applications). PURCHASED ENERGY is disaggregated by energy source, according to those on the energy balance matrix.

We should first develop the concept of NET ENERGY INPUT (NEI), defined as the energy entering the plant, disaggregated by source, with no duplications. In many cases, NEI will be equal to purchased energy, but to make treatment fully general, consider whether the plant sells energy, usually in the form of electricity, but sometimes as steam. These sales should be deducted from purchases. When calculating the NEI in the specific case of electricity, you can get a negative input when sales to other plants or to the public utility grid are based on self-production.

Some plants may have generators that use renewable energy sources such as hydro, solar, geothermal, wind, or biomass. Although these energies are not purchased, they should be included as inputs to avoid an imbalance. There are also plants that produce substances that have energy content in the form of byproducts of the production process, such as:

- Black liquor and waste pulp from the paper industry
- Reformates from the chemical industry
- Blast furnace gas from steelmaking
- LD (Linz Donawitz process) gas from Iron-metallurgy

Once the NEI has been identified, its flows for each of the sources should be determined (see Figure 12). Energy inputs can be used primarily for DIRECT SELF-GENERATION of electricity using the renewable energy systems mentioned above or with diesel generator sets, gas turbines, or any other fuel. These fuels will be deducted, and the electricity produced added to purchases. Similarly, the coal supplying steelmaking coke ovens will be a negative flow, and the coke produced will be a positive flow.

The second use for the input is INDIRECT SELF-PRODUCTION of electricity through steam. This is a bit more complicated, because the steam comes from a recycle from the boiler to feed the steam turbo-generators. Therefore, first you need to prepare the balance for the boiler that appears later in this flow, and then state that steam in terms of the fuels producing it, deduct the latter from the respective NEI and calculate the self-produced electricity as an input. A third use of purchased fuels such as gasoline, diesel and LPG is transport, which can be internal (forklifts and others) or external, for trucks carrying merchandise. In the latter case, this consumption does not pertain to industry but rather to transport, and must be deducted and recorded separately.

FINAL CONSUMPTION BY SOURCE is obtained by taking the NEI and adding or subtracting—as appropriate—the direct and indirect self-production flows and external transport. This consumption by source can then be compared to FINAL CONSUMPTION BY APPLICATION.

In the case of electricity, this can feed:

- Motors, cooling systems, compressed air, lighting, or others
- Resistance ovens and other heaters

In the case of fuel, they can be used in:

- Diesel, LPG, NG or other engines
- Furnaces
- Boilers and the resulting steam can be recycled in
- Steam turbines or centrifugal pumps for use as mechanical force.

Final consumption by source and the sum of final consumption by application should be balanced and consistent, although not equal, due to inventory variations or statistical error.

An overview of these ideas is summarized in a single form (Table 19).

Table 19. Summary Form

					Final consumption and efficiency by source and usage							
Sources	Energy Input	Direct self-production through vapor	Use in transportation	Final consumption per source	Net vapor	Efficiency %	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Crude Oil		(-)										
Natural Gas Liquids		(-)										
Natural Gas		(-)										
Coal		(-)										
Nuclear												
Hydro												
Geothermic												
Wind												
Solar												
Firewood		(-)										
Sugarcane products		(-)										
Other biomass												
Other primaries												
Electricity		(+)										
GLP		(-)										
Gasoline		(-)										
Kerosene and Jet Fuel												
Diesel Oil		(-)										
Fuel Oil		(-)										
Refinery												
Oil coke												
Other oil and gas products												
Coal coke		(+)										
Industrial gasses												
Other products from mineral sources												
Charcoal												
Ethanol												
Biodiesel												
Biogas												
Other Secondary Sources												
Non-energy												
Total												
Intermediate consumption (production of useful sources)												
Usage efficiency												
Useful consumption												
Losses												

It starts with the net energy input, which gives final consumption after subtracting or adding the self-production and transportation flows. This is disaggregated by application, and production efficiency is also given. The intermediate utilizable energy consumption is calculated at the bottom as the result of adding up the useful consumptions weighted by their respective production efficiencies. The use efficiencies (if known or calculable) are then entered, and useful consumption is calculated by multiplying the intermediate useful consumption by these efficiencies. Finally, losses are calculated as the difference between final consumption and useful consumption.

3.5 THE UEB APPLIED TO THE INDUSTRIAL SECTOR

As seen above, virtually all the data making up the UEB for an industrial plant can be shown in the form of a double-entry table. This subsection shows how to show the UEB for the entire industrial sector of a country or region.

First of all, if you want to view all the data it contains, the proposed disaggregation imposes a 4-entry table:

- By subsector
- By application
- By source
- By consumption type: final, useful, efficiency and losses

Following the OLADE balance format, i.e., the list of energy sources in the columns, you can present the UEB for the industrial sector in the two double-entry forms: a main one and an auxiliary one (see Table 20 and Table 21).

On the main form you record final consumption in the greatest detail and a summary of the data on useful consumption.

The auxiliary form is the same as the right-hand side of the table above (from the column Final Consumption by Source), but for each industrial subsector.

Table 20. Main Form

Self - Production					Final consumption and efficiency by source and usage								
Sources	Energy Input	Direct + COQ	Direct self-production through vapor	Use in transportation	Final consumption per source	Net vapor	Efficiency %	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Crude Oil			(-)										
Natural Gas Liquids			(-)										
Natural Gas			(-)										
Coal			(-)										
Nuclear													
Hydro													
Geothermic													
Wind													
Solar													
Firewood			(-)										
Sugarcane products			(-)										
Other biomass													
Other primaries													
Electricity			(+)										
GLP			(-)										
Gasoline			(-)										
Kerosene and Jet Fuel													
Diesel Oil			(-)										
Fuel Oil			(-)										
Refinery													
Oil coke													
Other oil and gas products													
Coal coke			(+)										
Industrial gasses													
Other products from mineral sources													
Charcoal													
Ethanol													
Biodiesel													
Biogas													
Other Secondary Sources													
Non-energy													
Total													
Intermediate consumption (production of useful sources)													
Usage efficiency													
Useful consumption													
Losses													

In consequence, there will be 10 forms per country, which can be part of its own BUEs, but should not necessarily be part of the OLADE balance matrix, although they should be attached for the OLADE database.

Table 21. Auxiliary Form

Presentation of energy balances disaggregated for the industrial sector			
Sources		**Primary**	**Secondary**
Final consumption			
Subsectors (10)	Steam		
	Direct heat		
	Shaft power		
	Other uses		
Total final consumption	Steam		
	Direct heat		
	Shaft power		
	Other uses		
Useful Consumption	Steam		
	Direct heat		
	Shaft power		
	Other uses		
Average Efficiency	Steam		
	Direct heat		
	Shaft power		
	Other uses		

These auxiliary forms represent the final data processing stage of the industrial survey.

Between the initial stage of the balance per plant and the final stage of the balance per subsector of a country, there are statistical instruments that show how to go from one stage to another.

The primary and secondary energy sources are:

Primary Energy Sources												
Primary Hydrocarbons			Mineral Sources		Direct energy				Biomass			Other primary sources
1	2	3	4	5	6	7	8	9	10	11	12	13
Crude Oil	Natural Liquids Gas	Natural Gas	Coal	Nuclear	Hydro	Geothermal	Wind	Solar	Firewood	Sugarcane, bagasse	Other biomass	

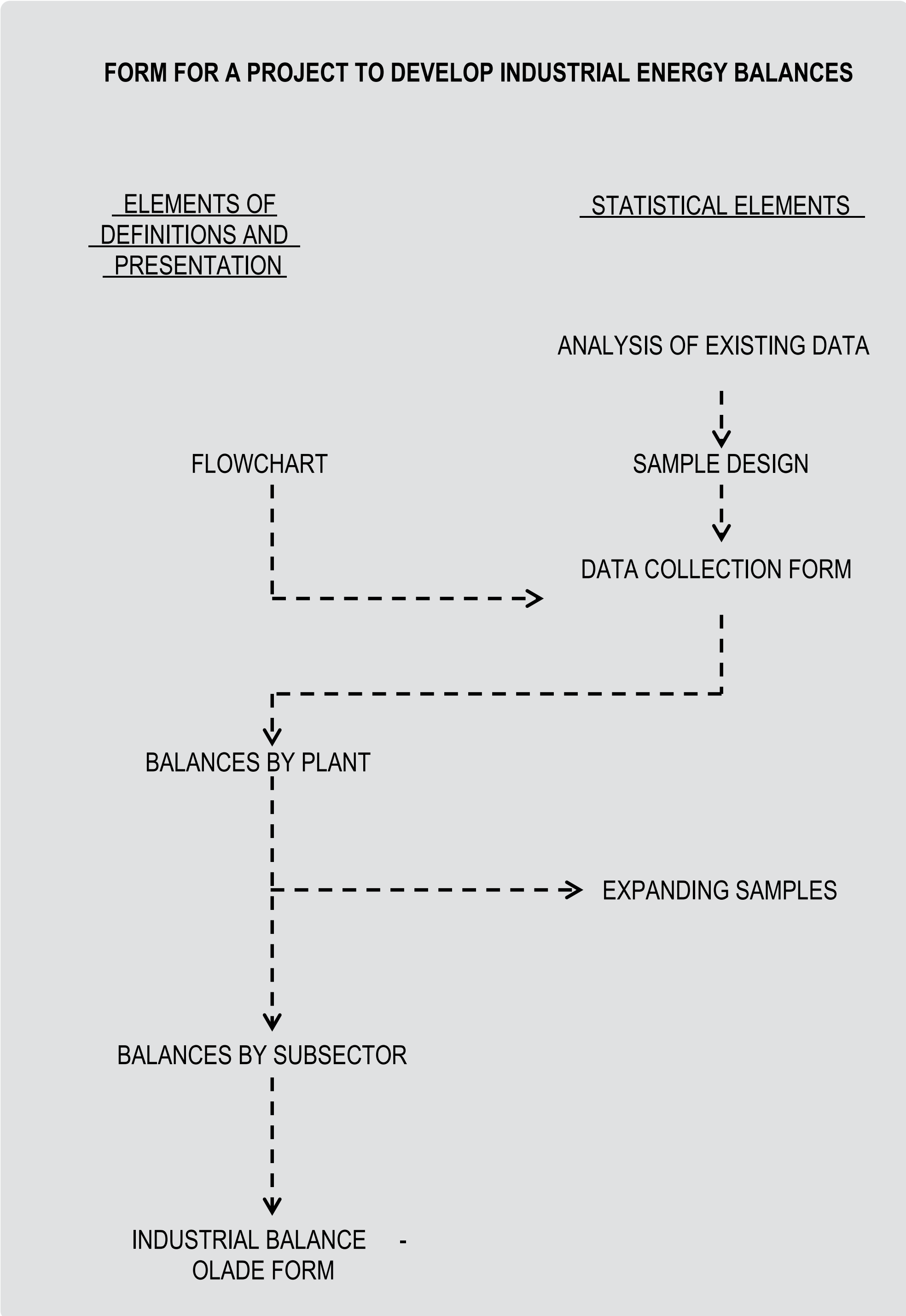
Secondary Energy Sources																	
	Oil and Natural Gas Products								Products from mineral sources			Biomass products					
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Electricity	GLP	Gasoline	Kerosene y Jet Fuel	Diesel oil	Fuel oil	Refinery Gas	Oil Coke	Other mineral products	Coal Coke	Industrial gases	Other mineral products	Charcoal	Ethanol	Biodiesel	Biogas	Other secondary sourcesras	Non - energy

Figure 15 outlines the relationships between the main components of a project to build disaggregated BUEs for the industrial sector. The primary and secondary energy sources are:

Primary Energy Sources												
Primary Hydrocarbons			Mineral Sources		Direct energy				Biomass			Other primary sources
1	2	3	4	5	6	7	8	9	10	11	12	13
Crude Oil	Natural Liquids Gas	Natural Gas	Coal	Nuclear	Hydro	Geothermal	Wind	Solar	Firewood	Sugarcane, bagasse	Other biomass	

Secondary Energy Sources																	
	Oil and Natural Gas Products								Products from mineral sources			Biomass products					
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Electricity	GLP	Gasoline	Kerosene y Jet Fuel	Diesel oil	Fuel oil	Refinery Gas	Oil Coke	Other mineral products	Coal Coke	Industrial gases	Other mineral products	Charcoal	Ethanol	Biodiesel	Biogas	Other secondary sourcesras	Non - energy

Figure 13. Form for a Project to Develop Industrial Energy Balances



Source: OLADE UEB Methodology 1984

3.6 DATA COLLECTION AND PROCESSING

Developing the proposed methodology that ends with the preparation of the UEBs requires collecting data on the industrial sector. In this regard, one must resort to the data-collection methods described in Figure 2, i.e., compiling secondary data, conducting surveys, preparing models, and taking measurements.

Prior experience in several countries shows that in this case, the best way to obtain the required data is through technical visits (with a tour of the plant) by experienced engineers who are able to interact with the maintenance staff and fill out the survey forms (more a personal interview than a survey), because companies keep inventories of goods rather than of their equipment and its power consumption profiles. So in cases where you do not have the data requested above, visiting engineers should be able to complete the inventories during the visit and request the consumption of fuels and other energy sources.

3.6.1 Survey Form

Since the data unit is the industrial plant, which has different data recording sections, we prefer the technique of building a form by MODULES, each identified with a physical section of the factory with specific processes on which you will attempt to collect data.

The contents of the form to be used in each country should be decided on after understanding its particular situation, but it is possible to determine a reference content such as that shown in Table 21 to Table 27 that include seven different modules.

Module I shows general company data such as raw materials used, main products, numbers of employees, shifts, and hours worked per year. You should attach a flowchart of the processes listed.

Table 22. Module I

MODULE I. CHARACTERISTICS OF THE INDUSTRIAL PROCESS

In 2015, what were the main raw materials used?
(It does not include those that are sources of energy like Oil, Electricity, etc.)

No.	RAW MATERIALS	QUANTITY	UNIT OF MEASURE 1 /
1			
2			
3			
4			
5			

1/ Specify units and set their equivalence to weight or volume. (Tonnes, cubic meters, etc.)

Nº	DELIVERABLES	QUANTITY	UNIT OF MEASUR E 1 /	INSTALLED CAPACITY	
				Quantity	UNIT OF MEASURE 2/
1.					
2.					
3.					
4.					
5.					

1/ Specify units and set their equivalence to weight or volume. (Tonnes, cubic meters, etc.)
2/ Specify measures in units of product per time, Barrels per year, TM / day, etc.

Hours worked per day	Days worked per month	Months worked											
		Jan	Feb	March	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Production Processes of the Main Product of the Plant in 2015.
(Mention the processes to which the raw material is subjected to, such as: grinding, drying, cooking, fermentation, washing and the used energy sources)

Attach the Flow Diagram of the production process

Number of employees	

Module II records energy purchases, pricing, sales and self-production, in order to calculate the net energy input (NEI).

Table 23. Module II

MODULE II. TOTAL PURCHASED AND SELF-DEVELOPED ENERGY

FUELS

What were the total purchases of fuels in 2015?

FUEL TYPE	UNIT OF MEASURE	AMOUNT PURCHASED OR OBTAINED	VARIATION OF STOCK 1/	ORIGIN OF THE PURCHASE OR OBTAINMENT OF FUEL			
				Production in the entity.	EDS Purchase	Purchase to the Distributor	Purchase to others. To who?
Gasolines	(Kgal / year)						
Kerosene and Jet	(Kgal / year)						
Diesel Oil	(Kgal / year)						
Fuel Oil	(Kgal / year)						
Petroleum liquid	(Kgal / year)						
Charcoal	(Tm / year)						
Firewood	(Tm / year)						
Cane products	(Tm / year)						
Another biomass	(Tm / year)						
Natural gas	(m3/ year)						

1/ It is the existence of the fuel as of December 31, 2014, deducted from the existence, as of December 31 of the previous year.

2/ Wood, Shells, Bleach, etc.

SELF-GENERATION

A1. Does the entity have Self-generation processes?	Yes. (Go to question A2.)	
	No. (Go to question A3.)	

A2. Frequency of self-generation	**Average hours per week**
SCHEDULED	
CONTINUOUS	
EMERGENCY	

A3. Indicate the following characteristics of the self-generating plants

PLANT	Used fuel									Installed power	Yield. Average kWh per gallon	Operation time	Destination of Self-Generated Electricity		
	LPG	Gasoline	Kerosene and Jet Fuel	Diesel	Fuel Oil	Coke	Coal	Other biomass					Consumption of the Entity.	Sales to the Public	SALE TO OTHERS
													KWh / year	KWh / year	KWh / year
Floor 1															
Floor 2															
Floor 3															
Floor 4															
Floor 5															

COGENERATION

B1. Does the entity have Self-generation processes?	**YES** (Go to question B2)
	NO (Go to the next module)

B2. In what process is heat used?	**B3. What percentage of cogeneration is present?**

Modules III to VI are intended to develop a balance for each device producing utilizable energy (intermediate production), as described in the flowchart on Figure 1 (p. 69). Not only energy flows, but also installed equipment and efficiencies are reported. Regarding the latter, you should note whether they are standard or catalog values, or measured values.

Table 24. Module III

MODULE III CONSUMPTION OF FUELS FOR PROCESS OF HEAT AND DIRECT HEAT

	PROCESS HEAT PRODUCTION		DIRECT HEAT	
LAST YEAR CONSUMPTION	UNIT	QUANTITY	UNIT	QUANTITY
LPG				
NATURAL GAS				
GASOLINE				
DIESEL OIL				
KEROSENE AND JET FUEL				
FIREWOOD				
COAL				
OTHER BIOMASS				
SOLAR POWER				
RECOVERY				

QUALITY	QUANTITY	PRESS	TEMPERATUR	QUANTITY	TEMPERATURE
HIGH					
AVERAGE					
LOW					
TOTAL IN KCAL					

EQUIPMENT RELATED TO THE USE OF PROCESS HEAT IN YOUR COMPANY												
Heat-utilization equipment	Used fuel								Active Amount	EFFICIENCY %	Power	Hours of average use per week
	LPG	Gasoline	Kerosene and Jet	Diesel	Fuel Oil	Coke	Coal	Other biomass			BHP	
LPG Furnace												
Other												
Other												
Other												
Other												
Other												

D2. EQUIPMENT RELATED WITH THE USE OF DIRECT HEAT IN YOUR COMPANY

	Heat-utilization equipment	Used fuel								Active Amount	EFFICIENCY %	Power	Hours of average use per week
		LPG	Gasoline	Kerosene and Jet	Diesel	Fuel Oil	Coke	Coal	Other biomass			BHP	
Direct Heat	Cast iron furnaces												
	Drying furnaces												
	Cooking Furnaces												
	Furnaces of calcination												
	Preheating furnaces												
	Direct heating systems												
	Extrusion cannon												
	Injection cannon												
	Cylinders for rubber												
	Rubber molding												
	Packaging and sealing's systems												
	Water heating												
	Other												
	Other												
	Other												

Table 25. MODULE IV

MODULE IV: CHARACTERISTICS AND CONSUMPTIONS OF SPECIAL ELECTRICITY EQUIPMENT TO GENERATE HEAT OR ELECTRO-CHEMICAL ENERGY

Specify the characteristics and power consumption of Special Electrical Equipment of the Plant (eg Furnaces, Electrolytic Cells).

EQUIPMENT	Quantity	INSTALLED POWER		FACTOR OF USE	EFFICIENCY	AVERAGE OPERATION TIME		ENERGY CONSUMPTION
		(kW)	(HP)	%	%	(h/day)	(Days / year)	(kWh/year)
Electric Arc Furnaces								
Electric induction								
Sterilization furnaces								
Electrolytic Cells								
Floor Boiler								
Furnace								
Arc Furnace								
Induction furnace								
Sterilization furnaces								
Furnance for Cement								
Drying								
Evaporators								
Distillers								
Other for heat production								
Other for heat production								
To produce cold in the								
To produce cold in the								
Compressors								
Crushers								
Mills								
Pumps								
Electrolytic cells								
Looms								
Mufflers								

TRANSPORTATION INSIDE THE INDUSTRIAL PLANT

Specify the fuel consumption of the Transport Vehicles for mobility within the Plant

No	FUELS	UNITS 1 /	TOTAL CONSUMPTION IN 2015
1	Gasolines	(gal/year)	
2	Diesel		
3	LPG		
4	Natural gas		
5	Other*		

* 1 / If the unit is different,please mention it; 2 / If it is Batteries, ask Number per year and Voltage.

Table 26. Module V

MODULE V: ELECTRIC MOTOR POWER FORCE EQUIPMENT

B1. EQUIPMENT WITH ENGINES IN YOUR INDUSTRY

Equipment with engines	Number of engines per band	Average Power		Hours of average use per week
		kW	HP	
Bands or transport ducts 1				
Bands or transport ducts 2				
Bands or transport ducts 3				
Bands or transport ducts 4				
Bands or transport ducts 5				
Bands or conveyor ducts 6				
Bands or transport ducts 7				
Bands or transport ducts 8				

B2. MOTOR POWER FORCE EQUIPMENT

Electric power equipment	Active Amount	Power (weighted average)		Hours of average use per week	EFFICIENC Y %	Power (weighted average)	
		kW	HP			kW	HP
Pneumatic Drills							
Crushing mills							
Ball mill							
Hoppers							
Extruders							
Molders							
Low Pressure Air Compressors							
High Pressure Air Compressors							
Compactors							
Massagers							
Stuffers							
Excavators							
Cut							
Wood processing							
Milling machines							
Saws							
Cutting Tools							
Mixer							
Pelletizers							
Electric cranes							
Electric Forklift Truck							
Pumping Equipment							
Pneumatic Transportation Equipment							
Thresher							
Selector machines							
Industrial Printing Machinery							
Stirrers							
Cane mills							
Plastic Injectors							
Industrial sewing machine							
Other engines							
Extractors							
Fans							
Other							
Other							

Table 27. Module VI

Module VI: MOTOR FORCE EQUIPMENT WITH FUEL AND OTHERS				
Power equipment with fuel	**Quantity**	**FUEL TYPE**	**FUEL CONSUMPTION (Gallons - hour)**	**EFFICIENCY %**
Cranes				
Lift truck				
Turnstiles				
Other internal transport equipment.				

B4. How many motors have drives?

Engines	Amount of active engines	Power (weighted)		Hours of average use per week	Number of back up motors	Power (weighted average)		Number of drives	Power (weighted average)	
		kW	HP			kW	HP		kW	HP
Type 1										
Type 2										
Type 3										
Type 4										
Type 5										
Type 6										

SECTION C. INDUSTRIAL COLD

C1. EQUIPMENT RELATED TO INDUSTRIAL COLD IN YOUR COMPANY

Refrigeration equipment	Active Amount	Power (weighted average)		Hours of average use per week	EFFICIENCY %	Power (weighted average)	
		kW	HP			kW	HP
Compressors of ammonia							
Compressors of ammonia							
Refrigeration Racks							
Refrigeration Racks							
Industrial cooling rooms							
Industrial cooling rooms							
Cold distribution system							
Cold distribution system							
Other							
Other							

Energy units are not specified in general terms, but rather it is possible to use a different drive for each flow. This is to ensure that information is passed directly from the records to the modules with no uncontrolled transformations, which are always sources of errors. It is best to do the conversions using a computer program that uses fixed factors for each of the units used in the industry.

The most complicated flow measurement is for steam, because most industries lack flow meters (or otherwise do not record measurements) at the required sites. Module III enables you to specify three different steam qualities: high, medium and low. Incidentally, it does not specify the pressure and temperature ranges for each quality a priori. Experience has shown that it is better for an informant to do this, since pressure and temperature measurements are more accurate and abundant than flow measurements. If ranges are used, the true values will be lost, and they are very important for calorific calculations using steam tables.

In Module V, the main difficulty is recording the yearly hours of electric motor use. The data to enter in the form is hours weighted by installed capacity, since what matters is how long the average kilowatt installed throughout the plant operates. This takes into account whether the installed capacity is used as a backup, is out of service, or is under maintenance.

Module VI is designed to record power consumption and examine in which processes intermediate forms of energy are used, in order to provide guidelines for determining use efficiencies.

Table 28. Module VII

MODULE VII: CONSUMPTION OF ELECTRICITY PARTICIPATION USE

How many hours of electricity do you ussually HAVE every day?		Hours

Determine the Electric Power and Power Billings in the previous year	**TOTAL BILLED ELECTRIC ENERGY**		**kWh/o $**
	MAXIMUM POWER (If applicable)		**kW**
	MAXIMUM AVERAGE POWER		**kW**

Distributor Company, Generator, Industrial Park or Other Supplier		Other	

Name the type of customer	
Not regulated	
Regulated	

Name the rate type	
BTS-1 = Low Simple Voltage 1	
BTD = Low Demand Voltage	
BTH = Low Voltage with Time Demand	
MTD-1 = Medium Voltage with Demand 1	
MTH = Medium Voltage with Time Demand	

DISTRIBUTION OF THE THREE BASIC USES BY PROCESS (Name the process' names, participation rates and efficiencies if known)

PROJECT'S NAME:	%	n %	%	n %	%	n %	%	n %	%	n %
Participation and efficiency										
Steam or process heat										
Driving force with electricity										
Driving force with fuel										
Direct Heat with Electricity										
Direct heat with fuel										

3.7 ANALYSIS OF SECONDARY DATA

Before using one of the data collection forms described above, you should prepare a SAMPLE DESIGN, and before that you need to do an INITIAL DATA ASSESSMENT. It is not possible to establish a single criterion for conducting an initial data assessment for a country, because the special circumstances of each makes energy database building for the industrial sector a case-by-case job. However, one could note the following general considerations:

First, perform an initial assessment of the REFERENTIAL UNIVERSE from which the sample is to be taken and expanded. This universe is characterized by two main figures:

- Industrial energy consumption and its disaggregation by subsector
- The number of industrial firms per subsector

You should examine existing data collection tools such as industrial censuses and surveys developed in recent years. On this basis, countries can be classified according to three (3) cases:

- You know the power and fuel consumption and the number of industrial establishments for a two-digit ISIC division.
- You know the power consumption and the number of industrial establishments, but not the fuel consumption for a two-digit ISIC classification.

- You do not know the consumption by subsector, but you do know the number of establishments.

The latter case is the most frequent in Latin American countries. Most conduct regular industrial surveys of the economic type, by which industrial plants are identified for national accounts and data is collected on production, value added, number of employees, etc. These surveys are the basis on which the input-output matrices are built, which are widespread enough to assume that all countries in the area have this instrument.

Some countries still lack this basic economic data on their industrial sectors, and the recommendation is for them to start conducting a general industrial census while collecting data on power and fuel consumption before conducting a specific energy survey with a form like the one discussed above, since a sample cannot be designed or expanded without knowing any of the properties of the universe from which sample would be taken.

Some countries know the utility sales to industrial customers (electricity, fuel, etc.) by subsector (two-digit ISIC). Sales are not strictly consumption, but closely resemble it. In addition, the most common case is that these data are incomplete, that only a few utilities have them, or that they have them only for certain energy sources. If this data is partial, it cannot be used as a universe, but rather as a SUB-UNIVERSE or SUB-POPULATION that can be very useful when designing and expanding energy samples.

As for the referential universe, we are interested in researching the relationship between energy consumption and the number of establishments. The generic experience in most countries is that a few plants account for a relatively large percentage of all industrial consumption. This is because most heavy equipment (large boilers, furnaces, heavy engines) are concentrated in a relatively few MACRO-CONSUMERS. Therefore, if the industrial plants in the universe are sorted by decreasing consumption, the following distribution is obtained:

- 10% to 20% of all establishments account for 80% of total consumption.
- 30% of all establishments account for 95% of total consumption.
- 10% of all establishments account for the consumption of 60% of electricity, 70% of diesel and 90% of fuel oil and coal.

These figures are only indicative and vary from country to country, but they express the order of magnitude of a widely-observed rule, which for ease of communication can be called the LAW OF ASYMMETRIC PROPORTIONS. This means that the distribution of two properties characterizing a population is entirely asymmetrical. This property is used to make a sample design that offers good representation both overall and by branches.

3.7.1 Guidelines for Sample Design

No one design is applicable to all countries, but depends on the data that can be collected. Nevertheless, it is possible to identify some general criteria on which to base sample design. The ideas presented below are based on some very general hypotheses that apply to a large number of countries.

Hypothesis 1: The country conducts a regular economic survey of the manufacturing industry, which provides data for the two-digit ISIC on both the number of existing facilities and their main economic features (employment, production, value added, etc.).

Hypothesis 2: The aggregate power and fuel sales of the companies in the sector by two-digit subsectors are known.

Hypothesis 3: The law of asymmetric proportions plays out between energy consumption and the number of industrial establishments.

Under the above hypotheses, it is appropriate to apply a technique of STRATIFIED SAMPLING WITH OR WITHOUT ALLOCATION. First, stratify the population. Since consumption is not known prior to sampling, the population cannot be stratified based on consumption. Instead, choose any economic variable that you believe to be strongly correlated with consumption, such as added value, production value, number of employees, spending on fuel and lubricants, etc., as mentioned above. Note that a correlated variable is required, which means that its relationship to consumption is not deterministic, but rather statistical.

Once the appropriate variable has been chosen, set the cut-off intervals to form the strata, i.e., the ranges for grouping establishments according to that variable. It is very difficult to suggest one method for making these cut-offs, and is better to treat each problem as a case study. For example, if the data show that industrial plants with over 200 employees account for 70% or 80% of the sector's added value, then that group is defined as the UPPER STRATUM. The other strata are set more or less arbitrarily according to the implicit share of the variable, e.g., 200-150 employees, 150-100, 100-50, less than 50, etc.

The important thing is to isolate the top stratum, which MUST BE INCLUDED and will have a sample size equal to 1% of the total population without allocation, or a representative sample of the stratum will be taken with some allocation criterion.

For the rest of the strata, we recommend a sub-participation by subsectors. This will provide new strata containing a high percentage of the establishments. If consumption per output and byproduct can be calculated reasonably well using company sales and distribution statistics, it will suffice to sample the upper stratum and expand its results by uses, equipment and efficiencies against that consumption for each of the industrial branches.

Where there is no data on consumption by subsector to meet the second scenario above, but consumption of all sources for the entire industrial sector is known, and the exact subsector consumption has to be ascertained by this survey, take samples from each of the new strata into which the population was divided. The reference universe will no longer be consumption, but rather the number of establishments in each group, and you will work with 30 or 40 sub-populations to estimate the average consumption of each energy source. Within each stratum, take a simple random or systematically equal sample.

When possible, it is preferable to infer consumption by subsector using a larger survey than solely the applications under study. This is achieved by adding Module II on purchased energy and comparing it to the economic census or survey for the industrial sector, which is assumed to exist in the country. This module is very simple and does not require visits by specialized interviewers. The same agency that conducts the economic survey can collect and process the data. This will provide information on the population and sub-populations before applying the use survey, which is much more complicated and expensive.

The methodology explained so far applies conveniently to centralized industries. The so-called rural industries (bakeries, brickworks, lime and coke producers, boilers, brown sugar or molasses mills, etc.) are usually not included in economic survey systems or national accounts. These industries, which often consume non-commercial energy at low efficiencies and high volumes, are a special sub-population about which little or nothing is usually known. The survey to be applied to them is usually resolved by using only Module V on direct heat, which consists of operating an oven with discontinuous loading. The production value is estimated from the number of loads per year. In the case of these industries, sample designs should be based on the most distant demographic properties, such as making bricks, bread or lime in small-scale units, and you should proceed with inquiries and pilot surveys to gage the order of magnitude before taking the actual samples.

As we have seen, stratified sampling depends on the possibility of ordering industrial establishments according to a criterion expressed by some variable that is correlated with consumption. This stage of the sample design should be completed carefully, because good stratification will result in sample sizes ranging from 1% to 2% of all individuals in the universe, and reliabilities of 90% to 95% for the main variables.

In any case, a good sampling design is a necessary but insufficient condition for success. You must also ensure that the data collected are correct, and this is achieved by having specialized surveyors visit industrial plants, who should preferably be chemical, mechanical or industrial engineers. It is only by talking with industry colleagues that they will be able to turn a mass of often unorganized data into the information needed for the data collection form.

3.8 APPLICATION: THE PARAGUAYAN CASE

For the Paraguayan industrial sector, we used the 2011 National Economic Census as a sampling framework. First, the branches of activity were grouped by the two-digit ISIC denomination in all cases except for the food industries, where refrigerators were separated from the other activities based on the four-digit ISIC. The subsectors used are shown in the following table:

Table 29. Subsectors defined for the industrial sector and associated ISIC divisions

AREA	SUB-SECTOR	CIUU ACTIVITIES
1	Refrigerators	1010
2	Food Leftovers	Rest of CIIU 10
3	Drinks and Tobacco	11 and 12
4	Textile and Leather	13,14 and 15
5	Paper and printing	17 and 18
6	Wood and Furniture	16 and 31
7	Chemistry, Rubber and Plastic	20,21 and 22
8	Non metallic	23
9	Metals	24,25 and 26
10	Other Manufacturing areas	Remaining between 10 and 33

Source: the authors

After defining the branches, they were regionalized into 'Metropolitan Area' (Asuncion and Central department) and 'Rest of the Country'. Both the stratification by size and the statistical calculations were obtained from the 'Employed Personnel' census variable. Although it would have been preferable to work with the Value Added variable, it was not available when the sampling framework was prepared.

After defining the establishments associated with each subsector to be considered, we stratified them by size following the DGEEC criteria and added a smaller module for micro-enterprises. Stratification by size included the following sections:

- Large: more than 50 employees
- Medium: more than 10 and less than or equal to 50
- Small: more than 3 and less than or equal to 10
- Micro: less than or equal to 3 employees

The criterion for stratification by size was supplemented by a declared power purchase criterion (a question included in the 2011 National Economic Census, but with few responses). Establishments whose number of employees put them in the Micro stratum but that showed significant consumption were promoted to the Small stratum, when their declared electricity or fuel purchases exceeded either 5,000 kW/h year or 10,000 Ktoe.

Finally, we extracted the 100 largest industrial establishments for obligatory surveying, which represented 0.5% of the total establishments but 20% of all employed personnel. After removing them from the sampling framework, the stratification was left as shown in Table 30 (Stratification).

In the case of the industrial sector, given its relative significance in national energy consumption, we established a subsector error of 5% for the most energy-intensive branches and 10% for the rest, as shown in Table 14. Likewise, the implicit maximum permissible error for homogeneous modules was set at 40%, with many of the MH at values of less than 25%, making sure that the most important branches were below 10%.

Defining the sampling framework yielded a total of 1,057 surveys to represent the total establishments, in addition to the 100 surveys previously defined for the larger companies.

Table 30. Stratification

Branch	Region	Size	No. establishments	Employed personnel	Average personnel
		Refrigerators	122	1.036	
		Am.	59	561	
1	Metropolitan Area	1-Large	3	188	63
1	Metropolitan Area	2-Medium	11	198	18
1	Metropolitan Area	3-Small	19	114	6
1	Metropolitan Area	4-Micro	26	61	2
		Rest	63	475	
1	Rest of the country	1-Large	3	251	84
1	Rest of the country	2-Medium	3	52	17
1	Rest of the country	3-Small	18	87	5
1	Rest of the country	4-Micro	39	85	2
		Other Food	2.672	14.188	
		Am.	1.095	6.106	
2	Metropolitan Area	1-Large	21	1.264	60
2	Metropolitan Area	2-Medium	110	1.982	18
2	Metropolitan Area	3-Small	272	1.406	5

Branch	Region	Size	No. establishments	Employed personnel	Average personnel
2	Metropolitan Area	4-Micro	692	1.454	2
		Rest	1.577	8.082	
2	Rest of the country	1-Large	19	1.243	65
2	Rest of the country	2-Medium	128	2.12	17
2	Rest of the country	3-Small	451	2.374	5
2	Rest of the country	4-Micro	979	2.345	2
		Beverages and Tobacco	129	1.235	
		Am.	96	718	
3	Metropolitan Area	1-Large	5	375	75
3	Metropolitan Area	2-Medium	10	195	20
3	Metropolitan Area	3-Small	17	59	3
3	Metropolitan Area	4-Micro	64	89	1
		Rest	33	517	
3	Rest of the country	1-Large	5	324	65
3	Rest of the country	2-Medium	5	127	25
3	Rest of the country	3-Small	7	40	6
3	Rest of the country	4-Micro	16	26	2
		Textiles and Leather	5.04	14.72	
		Am.	2.663	9.123	
4	Metropolitan Area	1-Large	23	1.256	55
4	Metropolitan Area	2-Medium	128	2.209	17
4	Metropolitan Area	3-Small	531	2.119	4
4	Metropolitan Area	4-Micro	1.981	3.539	2
		Rest	2.377	5.597	
4	Rest of the country	1-Large	4	182	46
4	Rest of the country	2-Medium	60	970	16
4	Rest of the country	3-Small	440	1.476	3
4	Rest of the country	4-Micro	1.873	2.969	2
		Paper and Print	822	4.954	
		Am.	614	4.101	
5	Metropolitan Area	1-Large	17	1.157	68
5	Metropolitan Area	2-Medium	75	1.27	17
5	Metropolitan Area	3-Small	150	845	6
5	Metropolitan Area	4-Micro	372	829	2
		Rest	208	853	
5	Rest of the country	1-Large	0	0	0
5	Rest of the country	2-Medium	16	252	16
5	Rest of the country	3-Small	59	308	5
5	Rest of the country	4-Micro	133	293	2
		Wood & Furn.	4.923	16.55	
		Am.	2.268	7.954	
6	Metropolitan Area	1-Large	15	851	57
6	Metropolitan Area	2-Medium	102	1.746	17
6	Metropolitan Area	3-Small	425	1.929	5

Branch	Region	Size	No. establishments	Employed personnel	Average personnel
6	Metropolitan Area	4-Micro	1.726	3.428	2
		Rest	2.655	8.596	
6	Rest of the country	1-Large	16	902	56
6	Rest of the country	2-Medium	97	1.545	16
6	Rest of the country	3-Small	432	2.065	5
6	Rest of the country	4-Micro	2.11	4.084	2
		Ch. Rub. & Plast.	641	5.868	
		Am.	412	4.965	
7	Metropolitan Area	1-Large	30	2.075	69
7	Metropolitan Area	2-Medium	100	2.016	20
7	Metropolitan Area	3-Small	99	510	5
7	Metropolitan Area	4-Micro	183	364	2
		Rest	229	903	
7	Rest of the country	1-Large	3	133	44
7	Rest of the country	2-Medium	15	295	20
7	Rest of the country	3-Small	44	158	4
7	Rest of the country	4-Micro	167	317	2
		Non-metal	1.8	8.619	
		Am.	801	3.981	
8	Metropolitan Area	1-Large	8	548	69
8	Metropolitan Area	2-Medium	56	1.006	18
8	Metropolitan Area	3-Small	216	1.114	5
8	Metropolitan Area	4-Micro	521	1.313	3
		Rest	999	4.638	
8	Rest of the country	1-Large	8	310	39
8	Rest of the country	2-Medium	66	1.08	16
8	Rest of the country	3-Small	312	1.635	5
8	Rest of the country	4-Micro	613	1.613	3
		Metal	3.221	10.566	
		Am.	1.676	6.373	
9	Metropolitan Area	1-Large	9	475	53
9	Metropolitan Area	2-Medium	99	1.86	19
9	Metropolitan Area	3-Small	321	1.527	5
9	Metropolitan Area	4-Micro	1.247	2.511	2
		Rest	1.545	4.193	
9	Rest of the country	1-Large	0	0	0
9	Rest of the country	2-Medium	42	624	15
9	Rest of the country	3-Small	280	1.161	4
9	Rest of the country	4-Micro	1.223	2.408	2
		Other Ind.	2.456	8.182	
		Am.	1.316	5.085	
10	Metropolitan Area	1-Large	6	441	74
10	Metropolitan Area	2-Medium	98	1.731	18

Branch	Region	Size	No. establishments	Employed personnel	Average personnel
10	Metropolitan Area	3-Small	267	1.161	4
10	Metropolitan Area	4-Micro	945	1.752	2
		Others	1.14	3.097	
10	Rest of country	1-Large	3	100	33
10	Rest of country	2-Medium	39	697	18
10	Rest of country	3-Small	194	735	4
10	Rest of country	4-Micro	904	1.565	2

3.8.1 Net Energy Consumption by Sources and Applications

In 2011 (Table 31), the Paraguayan industrial sector consumed a total of 1,922 ktoe of energy, recorded in terms of net or final energy, i.e., the amount entering all industrial establishments, measured before consumption by different end-use devices and equipment.

Table 31. Total industry - net energy consumption by sources and applications (Ktoe)

USES	GL	MN	DO	FO	CM	LE	CV	RB	EE	Total
Lighting									5225	5225
Steam	240		555	185		194184		94502	523	290189
Direct Heat	1696		74	41404	780	252513	47340	12393	8249	364449
Shaft Power		2	499			1491		401209	83874	487075
Process Cold									10265	10265
Internal Transportation	209	28	2561						245	3043
Electrical-Chemical Proc.									24	24
Non-productive Uses	66								6652	6718
TOTAL	2211	30	3689	41589	780	448188	47340	508104	115057	1166988
Legend	Liquefied Gas	Naphthas	Diesel	Fuel Oil	Coal	Firewood	Charcoal	Biomass Waste	Electricity	

Source: National Energy Balance of Paraguay

3.8.2 Utilizable Energy Consumption by Source and Application

As shown in Table 32, Paraguay's industrial sector consumed 754.3 Mtoe of usable energy in 2011, for an average energy-use performance of 64% for the sector.

Table 32. Total Industry - utilizable energy consumption by sources and applications (ktoe)

USES	GL	MN	DO	FO	CM	LE	CV	RB	EE	Total
Lighting									940	940
Steam	202		452	170		164514		83030	458	248826
Direct Heat	1169		55	30639	577	176787	33138	9171	6394	257930
Shaft Power		0	499					160483	72678	233660
Process Cold									7164	7164
Internal Transportation	38	5	615						196	854
Electrical-Chemical Proc.									12	12
Non-productive Uses	30								4911	4941
TOTAL	1439	5	1621	30809	577	341301	33138	252684	92753	754327
Legend	Liquefied Gas	Naphthas	Diesel	Fuel Oil	Coal	Firewood	Charcoal	Biomass Waste	Electricity	

Source: National Energy Balance of Paraguay

3.8.3 Use and Production Performance (Table 33)

We should mention that the performance levels adopted are standard values taken from manufacturer tables and technical studies, considering the average for each type of device. In other words, these performance levels come neither from measurements nor from specific energy efficiency studies. However, the numbers adopted are believed to provide adequate accuracy for comprehensive energy planning purposes, including analyses of substitutions among sources and estimates of potential savings by implementing energy efficiency measures.

Another caveat is that these performance levels do not include losses due to different forms or modes of operation or poor equipment maintenance. They are solely technical losses due to energy conversion according to the energy source and the equipment technology, considering normal modes of operation and maintenance.

The average use performance for energy consumption in the Paraguayan industrial sector is 64.6%. The best performing use is boilers for steam, with an average of 85.7%, not including losses in steam distribution or in the various devices that use steam as heat for industrial processes. Nonproductive uses have a performance of 73.5%, similar to direct heat, whose performance is 70.8%. Driving force has an average performance of 48.0%, because electric motors have a performance of 86.7%, biomass waste and diesel have 40%, and gasoline has 18%, weighted by share of consumption for each source. In the case of waste, the performance shown is for bagasse-burning steam turbines that drive mills in the sugar industry.

Table 33. Total industry – use performance (%)

USES	GL	MN	DO	FO	CM	LE	CV	RB	EE	Total
Lighting									18	18
Steam	84		81.5	92		84.7		87.9	87.5	85.7
Direct Heat	68.9		74	74	74	70	70	74	77.5	70.8
Shaft Power		18	40					40	86.7	47.9
Process Cold									69.8	69.8
Internal Transportation	18	18	24						80	28
Electrical-Chemical Proc.									50	50
Non-productive Uses	45								73.8	73.5
TOTAL	65	18	43.9	74.1	74	76.2	70	49.7	80.6	64.6
Legend	Liquefied Gas	Naphthas	Diesel	Fuel Oil	Coal	Firewood	Charcoal	Biomass Waste	Electricity	

Source: National Energy Balance of Paraguay

3.8.4 Final Energy Consumption by Subsector

Industrial energy consumption will depend primarily on the production structure and the technologies used to produce goods. The Paraguayan industry is influenced by the significant consumption of bagasse because, due to its low performance when used for driving force, its net energy consumption increases significantly and gives the Food Waste subsector a notable share in net consumption.

Thus, the Other Foods subsector consumes the most energy, with 571.3 ktoe of net or 49.0% of industrial. It is followed by the Non-Metal subsector, whose main consumer is the cement industry with 25.3% of industrial consumption.

Table 34. Net Energy Consumption by Subsector (ktoe)

USES	GL	MN	DO	FO	CM	LE	CV	RB	EE	Total
Refrigerators	12		9	185		27501		322	5877	33906
Food leftovers	999		228			53501	203	488325	28055	571311
Drinks and Tobacco	1		189			15214			6735	22139
Textile and Leather	22	1	4			59070			10482	69579
Paper and Printing	10	9	253			50874		3688	12846	67680
Wood and Furniture	735	2	39			25972		262	3989	30999
Chemistry, rubber and Pl	340	18	695			2		3113	15685	19853
Non-metallic			2000	41404		215693		12393	24246	295736
Metallic	2		246		780	292	47137		2751	51208
Other Manufacturing	89		25			69			4392	4575
TOTAL	2210	30	3688	41589	780	448188	47340	508103	115058	1166986
Legend	Liquefied Gas	Naphthas	Diesel	Fuel Oil	Coal	Firewood	Charcoal	Biomass Waste	Electricity	

Source: National Energy Balance of Paraguay

Net and utilizable energy consumption tables by energy sources and applications can also be developed for each of the subsectors. The average efficiencies for conversion equipment in the subsector are used. For example, for the refrigerator subsector:

Table 35. Refrigerators – net energy consumption by source and application (ktoe)

USES	GL	MN	DO	FO	LE	CV	RB	EE	Total
Lighting								186	186
Steam				185	27025		322		27532
Direct Heat	9				476			4	489
Shaft Power								2129	2129
Process Cold								3097	3097
Internal Transportation	1		9					64	74
Electrical-Chemical Proc.									0
Non-productive Uses	2							397	399
TOTAL	12	0	9	185	27501	0	322	5877	33906
Legend	Liquefied Gas	Naphthas	Diesel	Fuel Oil	Coal	Firewood	Charcoal	Biomass Waste	Electricity

Source: National Energy Balance of Paraguay

Table 36. Refrigerators – usable energy consumption by source and application (ktoe)

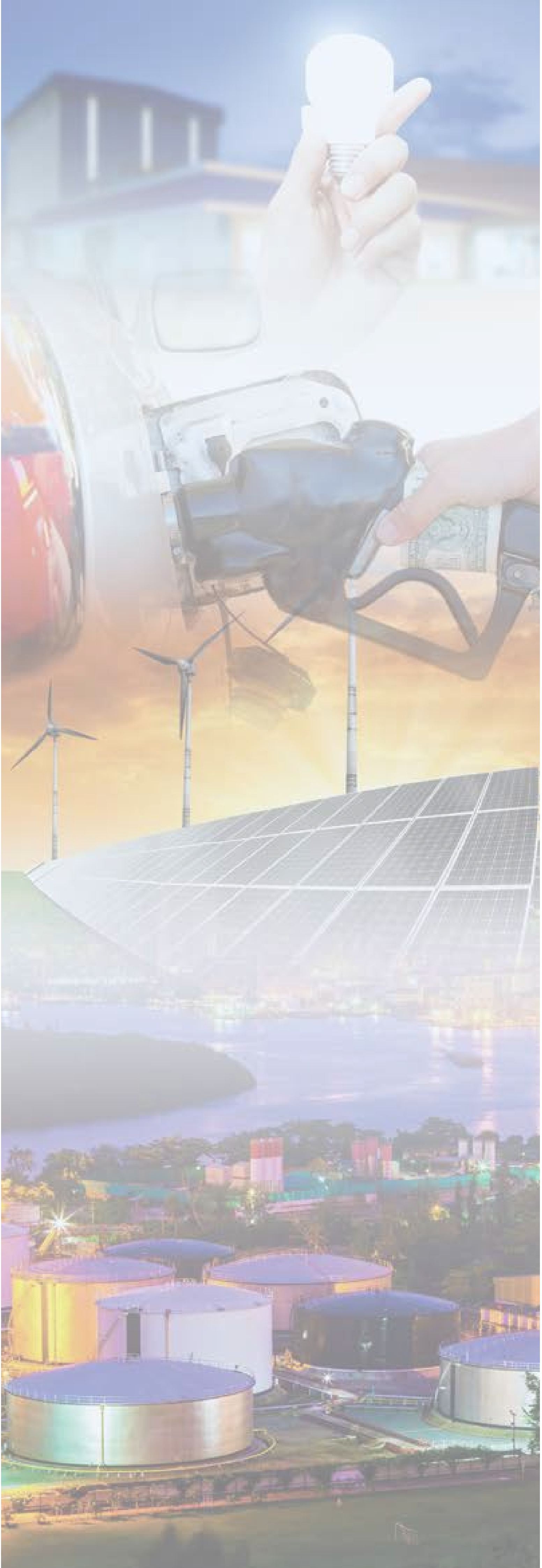
USES	GL	MN	DO	FO	LE	CV	RB	EE	Total
Lighting								34	34
Steam				170	23311		264		23745
Direct Heat	7				354			3	364
Shaft Power								1821	1821
Process Cold								2166	2166
Internal Transportation	0		2					51	53
Electrical-Chemical Proc.									0
Non-productive Uses	1							286	287
TOTAL	8	0	2	170	23665	0	264	4361	28470
Legend	Liquefied Gas	Naphthas	Diesel	Fuel Oil	Coal	Firewood	Charcoal	Biomass Waste	Electricity

Source: National Energy Balance of Paraguay

Table 37. Refrigerators – use performance levels (%)

USES	GL	MN	DO	FO	LE	CV	RB	EE	Total
Lighting								18.2	18.2
Steam				92.0	86.3		82.0		86.2
Direct Heat	75.0				74.4			69.8	74.4
Shaft Power								85.5	85.5
Process Cold								70.0	70.0
Internal Transportation	18.0		24.0					80.0	72.1
Electrical-Chemical Proc.									0.0
Non-productive Uses	45.0							72.1	71.9
TOTAL	64.5	0.0	24.0	92.0	86.1	0.0	82.0	74.2	84.0
Legend	Liquefied Gas	Naphthas	Diesel	Fuel Oil	Coal	Firewood	Charcoal	Biomass Waste	Electricity

Source: National Energy Balance of Paraguay



CHAPTER IV

The Residencial Sector

4. THE RESIDENTIAL SECTOR

4.1 DISAGGREGATION BY SUBSECTOR

Most of OLADE's member countries have migration from rural to urban areas, so from a planning viewpoint, disaggregating the residential sector into rural and urban is justified. From an energy consumption perspective, they also have clearly differentiated consumption profiles in terms of the type of end-use devices utilized and the energy sources used.

The urban subsector uses conventional energy sources with monitored prices, production, distribution and marketing by large utilities, whereas the rural sector uses unmonitored energy sources such as firewood, charcoal and animal and plant waste. This shows that migration significantly affects energy demands.

It is also clear that both rural and urban areas have groups that are differentiated by income level, which warrants disaggregating their various consumption profiles. Whatever subsectors are defined, they should be compatible in all countries with those used in quality-of-life censuses and surveys to facilitate data management and reduce fieldwork. Most countries have socioeconomic groups that can always be classified as low, middle and high.

4.2 DISAGGREGATING BY APPLICATION

The aforementioned subsectors consume energy to meet their needs using various appliances and energy sources. The disaggregation by end uses and associated equipment is as follows:

- ***Heating***

Energy is consumed for space heating in homes using hot water radiators, electric radiation heaters with or without fans, and heaters that burn gas, coal, wood, or others.

- ***Air Conditioning / Ventilation***

Energy is used to power electrical appliances that produce cold air for air conditioning of spaces (package, split, or minisplit types), ventilators, extractors, etc.

- **Cooking**

Energy is used to cook food with stoves, cooktops, stand-alone conventional or microwave ovens, immersion heaters, and appliances using power or various fuels such as LPG, NG, coal, firewood, and others.

- ***Water Heating***

Energy is used to heat water for personal hygiene or household use using electric showers and storage or tankless heaters, whether electrical or fuel-burning.

- ***Refrigeration***

Energy is used for food preservation using or electric or fuel-based refrigerators, freezers, etc.

- ***Mechanical force***

Energy is used to drive electric motors or fuel-burning engines in various home appliances such as water pumps, blenders, floor polishers, vacuum cleaners, and others.

- ***Lighting***

Energy is consumed for internal and external lighting of homes using incandescent light bulbs, linear and compact fluorescent lamps, LEDs and micro-LEDs, mercury or sodium vapor lights, gas or kerosene vapor lamps, wick lamps burning kerosene or other oils, night lights, flashlights, candles, etc.

- ***TV, radio and office automation***

Energy is used for appliances such as TVs, radios, audio equipment, computers, communications, and others.

4.3 FINAL ENERGY, UTILIZABLE ENERGY AND EFFICIENCY

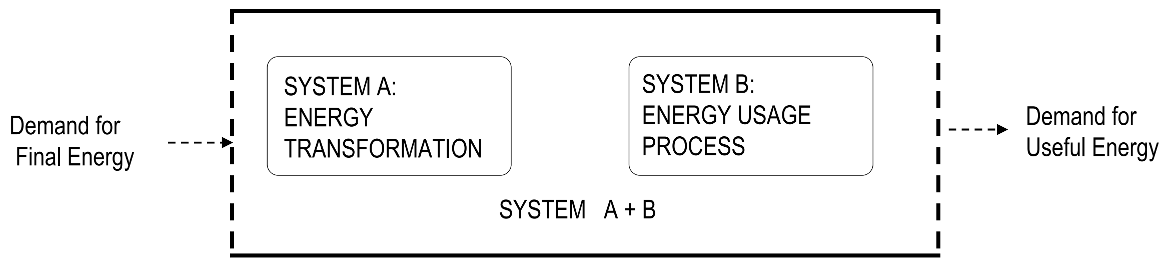
Final energy is consumed in homes to meet specific needs such as lighting, food preservation, cooking, water heating, etc. It is usually possible to know the total monthly energy consumption of a home, since power and gas utilities install meters at the entrance of each dwelling to record consumption. The problem is that to know the energy consumption for each application, we would need a meter on each device or at least a model to calculate the consumption of a device based on its technical features and time of use (use habits).

For example, in the case of electricity—the most used energy source in the residential sector—, daily, weekly or monthly consumption can be calculated from data on the power demanded by each appliance and its hours of use. The power demand of some appliances is not constant, such as refrigerators, washing machines, etc., in which case you need to estimate the average power demand and usage time.

The same applies to other energy sources, particularly LPG or NG, which can be connected to more than one appliance (stove, water heater, oven) at the same time. It is easy to get the total monthly LPG consumption, but to disaggregate it by devices you need data on the variables that determine their consumption and lab measurements to know, for example, how much gas each burner consumes in an hour, etc.

Conceptualizing utilizable energy involves two stages: production and use. The first relates to measuring the efficiency of energy transformation equipment, and the second has to do with to how it is used. For example, in the case of storage water heaters, electricity or fuel is used to heat the water in a vessel, and when a faucet is opened, the heated water goes through pipes to the point of use. Thus one can think of a transformation efficiency of electricity or fuel to heat (sometimes called production efficiency) and a use efficiency, which in the example is due to heat losses by insulating the walls of the vessel and pipes.

Figure 14. Transforming final energy into utilizable energy



In refrigerators and air conditioners, conversion efficiency includes not only compression motors but also the refrigeration cycle, refrigerant gas, and exchangers in the evaporator and the condenser.

Including losses in utilization systems requires measuring appliance consumption under actual operating conditions. This second efficiency can be very important for equipment such as stoves, refrigerators and air conditioners. As for cooking, combustion efficiency can be viewed as conversion efficiency, while the efficiency of heat transfer between the burner and the vessel (including the ambient air if there is ventilation, for example) is the use efficiency. In the case of refrigeration and air conditioning, locating the appliance near a window where it receives sunlight, or near a stove where it receives heat, can decrease its use efficiency.

To determine utilizable energy in the residential sector, it is necessary to know:

- The main types of equipment used by final energy consumers
- The final energy amounts actually consumed by these appliances
- The efficiencies of those devices under normal operating conditions

Appliance efficiency should be subject to specific research in each country, because experience shows that the actual values found in practice are often different from those given by manufacturers. Measurements should be taken in homes to find the actual values, but if this is not possible, you should preferably use data available from prior studies or, lacking these, from technical literature from the manufacturer.[4]

4.4 THE UEB APPLIED TO A RESIDENTIAL UNIT

The energy entering a home is purchased or gathered (in cases such as firewood and plant waste) in the rural sector, and is sometimes self-generated using renewable sources (solar, wind or others). This gives the Net Energy Input (NEI), or energy entering the residential unit, disaggregated into various sources and then transformed into usable forms. For residential units that include an economic activity or provide small-scale services that require energy, such as restaurants, salons, shops or the manufacture of goods, consumption should be deducted from the NEI and transferred to the appropriate sector to avoid errors in determining the consumption of the residential sector.

The NEI can be assumed to be equal to final consumption by source, since in most cases there is no inventory or it is negligible in relation to the yearly energy consumption. Final consumption by source can be related to final consumption by use. The electrical appliances that account for the various energy applications in a residence (refrigeration, air conditioning, lighting, driving force, etc.) will have their consumption aggregated and related to final electricity consumption in the power bill. Likewise, fuels should be considered according to their different applications and related to the final consumption for the residence.

For example, the power consumption of appliances is determined by direct measurement over a period of time, determining or estimating it using a combination of measurements and survey data.

The appliances available in a home include those whose power demand during operation has one of the following characteristics:

- Constant power demand
- Variable power demand

These characteristics enable different methods for measuring power demand and estimating power consumption, as follows:

Constant power demand: Examples of this type of device include light bulbs, CFLs, fluorescent lamps, radios, TVs, computers, and microwave ovens. Power demand is determined from measurements or plate readings. Surveys determine the numbers of the same appliances and their daily use in hours/day. From there, the daily consumption of the devices is calculated. Extrapolating daily to monthly consumption (kWh/month) requires determining daily or weekly use based on survey data. For example, if daily use on weekdays is different from weekends, this regime is determined and taken into account when calculating monthly consumption.

Variable power demand: Examples of this type of equipment are washing machines, refrigerators and air conditioners. In this case, you can either average out the power used by the equipment and use the calculation suggested above, or else measure the electricity consumed by the equipment in a day and extrapolate it to a month. If the equipment is operated on a different regime, such as weekends, its consumption is also measured over the weekend. These consumption levels (weekday regime and weekend regime) are used to extrapolate the monthly consumption.

Table 38 illustrates a summary the above observations.

4 Indicative values from studies of Brazil’s labeling program: http://www.inmetro.gov.br/consumidor/tabelas.asp.

Table 38. Methodology for Estimating Power Consumption

ORIGIN OF THE INFORMATION					
Power demand	Estimate	Survey	Measurement	Survey	Regime
Constant Use Regime 1 - R1	E(kWh/month) = # of units x power(W/unit) x daily use@R1(hrs/day) x # of days@R1(days/month)				
Constant Use Regime 2 - R2	E(kWh/month) = # of units x power(W/unit) x daily use@R2(hrs/day) x # of days@R2(days/month)				
....					
Variable Use Regime 1 - R1	E(kWh/month) = E(Wh/day) x daily use@R1(hrs/day) x # of days@R1(days/month)				
Variable Use Regime 2 - R2	E(kWh/month) = E(Wh/day) x daily use@R2(hrs/day) x # of days@R2(days/month)				

Source: The Consultant

The monthly power consumption, thus calculated for each appliance, is grouped by end uses to calculate their consumption. Finally, total consumption is calculated by adding all consumption levels by all end uses.

In the case of fuels, measuring consumption by application is more complex. For example, you know the monthly NG or LPG consumption, but need specific lab tests with home measurements to determine what percentage is used for hot water, for heating or for cooking.

Table 39 shows the analytical procedure for preparing the residential balance. You start with final consumption per energy source, which should be consistent with consumption disaggregated by application. At the bottom of the table, the final consumption totals are calculated by application and by usable consumption as the sum of all final consumption levels weighted by their production efficiencies.

Table 39. Residential Energy Balance

RESIDENTIAL SECTOR ENERGY BALANCE APPLIED TO ONE SINGLE HOME								
SOURCES	HEAT	AIR CONDITIONING / VENTILATION	COOKING	WATER HEATING	REFRIGERATION	SHAFT POWER	LIGHTING	TOTAL CONSUMPTION BY SOURCES AND AVERAGE EFFICIENCY
Crude Oil								
Natural Gas Liquids								
Natural Gas								
Coal								
Nuclear								
Hydro								
Geothermic								
Wind								
Solar								
Firewood								
Sugarcane products								
Other biomass								
Other primaries								
Electricity								
GLP								
Gasoline								
Kerosene and Jet Fuel								
Diesel Oil								
Fuel Oil								
Refinery gas								
Oil coke								
Other oil and gas products								
Coal coke								
Industrial gasses								
Other products from mineral sources								
Charcoal								
Ethanol								
Biodiesel								
Biogas								
Other Secondary Sources								
Non-energy								
Total								
Average efficiency per uses								
Useful Energy consumption								
Losses								

Source: OLADE UEB Methodology 1984

Finally, losses are calculated as the difference between final consumption and useful consumption. This procedure only considers the efficiency of the first transformation. To include use efficiency as well, measure or estimate the consumption under the actual operating conditions of the equipment.

4.5 THE UEB APPLIED TO THE RESIDENTIAL SECTOR

The Energy Balance for the Residential Sector can be presented with the help of Tables 39 and 40, which summarize the statistical findings of the surveys and/or measurements.

To make the calculation approach transparent, you should present a similar table to the above, including efficiencies by use and by source. This should be the result of specific studies on the conversion efficiencies for appliances on the market and those found in homes. These results will enable you to monitor efficiency factors and technology improvements in the future. These tables represent the final output of the work done to prepare the UEB for the residential sector.

As shown above, virtually all the data making up the UEB for a residence can be placed in the form of a double-entry table. This sub-section shows how to present the UEB for the entire residential sector of a country or region. First of all, if you want to view all the data it contains, the proposed disaggregation imposes a 4-entry table:

- By subsector (rural, urban, and strata)
- By use (space heating, air conditioning, cooling, water heating, driving force, lighting, and others)
- By source (according to the OLADE Balance, 21)
- By consumption type (4): final, usable, efficiency and losses

Following the OLADE balance format, i.e., listing energy sources in the columns, you can present the UEB for the residential sector with the two double-entry forms.

We propose a system with one main form and another auxiliary one. The main form contains the maximum level of detail for final consumption and a summary of useful data for consumption, as shown in Table 40.

Table 40. Main Form

	SELF PRODUCTION				FINAL CONSUMPTION (AND EFFICIENCY) BY SOURCES AND USES											
Sources	Energy Input	Fuels	Renewables	Final Consumption by sources	Heat		Ari conditioning		Cooking		Cooling		Driving Force		Lighting	
					Unit	$n\%$	Unit	$n\%$	Unit	$n\%$	Unit	$n\%$	Unit	$n\%$	Unit	$n\%$
Crude Oil																
Natural Gas Liquids																
Natural Gas																
Coal																
Nuclear																
Hydro																
Geothermic																
Wind																
Solar																
Firewood																
Sugarcane products																
Other biomass																
Other primaries																
Electricity																
GLP																
Gasoline																
Kerosene and Jet Fuel																
Diesel Oil																
Fuel Oil																
Refinery gas																
Oil coke																
Other oil and gas products																
Coal coke																
Industrial gasses																
Other products from mineral sources																
Charcoal																
Ethanol																
Biodiesel																
Biogas																
Other Secondary Sources																
Non-energy																
Total																
Intermediate consumption (production of useful forms)																
Efficiency of use																
Useful Energy consumption																
Losses																

Source: OLADE UEB Methodology 1984

The auxiliary form is simply the same as the right side of the above table (from the Final Consumption by Source column), but for each subsector.

Thus, there will be 5 forms (R, U, Strata) per country, which will be part of their own BUEs, but should not necessarily be part of the OLADE balance matrix, although they should be attached for its database.

Table 41. Auxiliary Form

Presentation of energy balances disaggregated for the residential sector			
Sources		**Primary**	**Secondary**
Final consumption			
	HEAT		
Subsectors (5)	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	Other uses		
Total final consmption	HEAT		
	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	Other uses		
Usegul Consumption	HEAT		
	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	Other uses		
Average Efficiency	HEAT		
	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	Other uses		

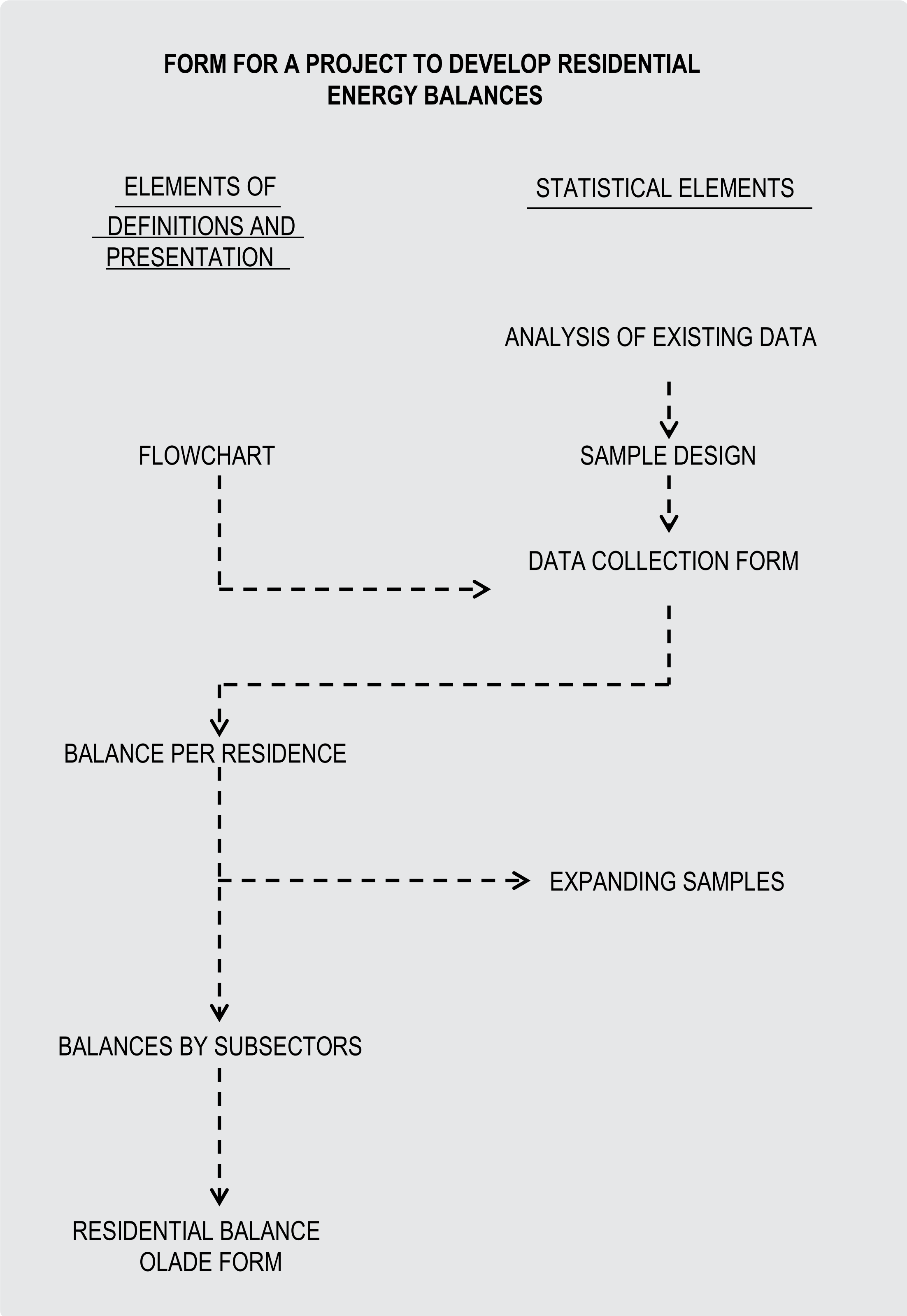
Source: OLADE UEB Methodology 1984

The primary and secondary energy sources are:

Fuentes de energía primaria												
Hidrocarburos Primarios			Fuentes Minerales		Energía Directa				Biomasa			Otras Fuentes Primarias
1	2	3	4	5	6	7	8	9	10	11	12	13
Petróleo crudo	Líquidos de gas Natural	Gas natural	Carbón mineral	Nuclear	Hidroenergía	Geotermia	Eólica	Solar	Leña	Productos de caña	Otra biomasa	

Fuentes de energía secundaria																	
	Productos de petróleo y gas natural								Productos de fuentes minerales			Productos de biomasa					
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Electricidad	GLP	Gasolina	Kerosene y Jet Fuel	Diesel oil	Fuel oil	Gas de refinería	Coque de petróleo	Otros productos de petróleo y gas	Coque de carbón mineral	Gases industriales	Otros productos de fuentes minerales	Carbón vegetal	Etanol	Biodiesel	Biogás	Otras fuentes secundarias	No energético

The Figure below outlines the relationships between the main components of a project to build disaggregated BUEs for the residential sector.



4.6 DATA COLLECTION AND PROCESSING

Developing the proposed methodology that ends with UEB development requires collecting data on the residential sector. Accordingly, one must resort to the data-collection methods described in the base document, i.e., use secondary data, surveys and modeling, and to take measurements.

Prior experience in several countries has shown that in this case, the best way to obtain the required data is using surveys and measurements. As described in section 4.4, measurements and lab work are needed to divide consumption by application for each source, in addition to information on the appliances owned and how they are used.

The measurements and other data require a sample design and surveying, for which we have two important recommendations. The first is that to ensure the quality of the results, the project must have the help of a statistician, preferably with experience in the country under study, who should follow the methods and subsamples of other data surveying processes at the local official level.

The second is the need for a preliminary study of the universe to be surveyed, analyzed or measured. Another aspect of the sector is that the unit of study is the home or residence, although there are special situations such as complexes of houses or apartments with communal areas whose energy consumption should be distributed among all users. Other situations are cases of communal meters (one meter for several homes), housing that is only used on weekends, etc.

The energy consumption of a household is determined by the appliances it owns and its pace and lifestyle. The variable that most affects consumption is the income levels of household members, as this determines the appliances they purchase and their budget to pay for utilities.

In countries with high income stratification, as is the case in Latin America, energy consumption—especially commercial energy, electricity and oil products—can be concentrated in small sectors of the population. For example, 10% to 20% of the population accounts for 50% or more of all residential consumption.

In a survey that uses sampling, ensuring the representativeness of small sectors implies a substantial increase in the number of observations to be analyzed. However, stratified sampling is an alternative solution to reduce sample sizes and should be used for energy consumption whenever possible. Low power consumption shows that it is being used to meet the basic needs of the home, such as lighting, food preservation and cooking. As consumption increases, other needs are being met and there is greater variation in appliances and expenses, which warrants a larger number of surveys and measurements.

4.6.1 Prior Study of the Universe

Sources of information on the universe vary from country to country and from one region to another, but can be grouped into three distinct categories:

- General sources
- Sources of energy information
- Sources of equipment information

4.6.1.1General Sources

The largest source of data is the population census, conducted every ten years in almost all countries. A census, no matter how short, provides at least an overall picture of the makeup and distribution of the population within the country, including the number of families and homes, the number of components per family, age ranges, and dwelling sizes or numbers of rooms. An essential element in most surveys is household distribution by income, which is very useful because the distribution of energy consumption is strongly correlated to income levels. Therefore, this figure can be used to build a number of preliminary hypotheses about the distribution of energy consumption.

In addition to the census, any specific surveys may be essential to obtaining a better understanding of the universe. The most common surveys are:

- National sample surveys on the economic situation and the cost of living usually survey data on energy consumption by residence and the influence of energy consumption on the cost of living and the family budget. They are important not only for the data they contain, but also because they offer a model sample that has been tested in the country.

- Local sample surveys, usually conducted by local authorities, prefectures, regional bodies, and development organizations, can provide detailed information on specific regions.

4.6.1.2 Sources of Energy Information

For sources of commercial energy in general, annual BUEs are published by the appropriate ministries or departments (depending on the country, Mines and Energy, Energy, Industry and Trade, etc.). The data are usually available with different levels of territorial aggregation or by source. Crossing socioeconomic data from the census with consumption data by territory usually gives a good indication of a country's energy profile, with some details on residential consumption by energy source.

This makes it possible to reconstruct elements such as percentage of electrified homes, average consumption of electrified residences, total electricity consumption in the residential sector, and distribution/consumption of oil-based energy sources for residential use. In some cases, this will enable you to identify cooking, lighting, water heating and space heating, primarily from sources such as LPG, kerosene and other fuels.

Power and oil product distributors, whether public or private, can provide more detailed residential consumption data. It is important to have access to these data and any surveys conducted by these companies, because they usually have levels of detail far beyond what is available at the national level.

Residential use of biomass is usually hard to survey. In any case, it is important to consult official sources such as the Ministry of Agriculture or bodies responsible for forest control.

4.6.1.3 Sources of Equipment Information

Residential energy consumption depends heavily on the appliances used, so to provide an initial overview of the country and complete the appropriate form, it is essential to know the availability and quality of the devices used in the country. The search for data on the availability of home appliances can be divided into two parts: the number of devices and their consumption characteristics.

From a quantitative viewpoint, you can review production or importation statistics available from public bodies and commercial organizations. Trading companies also have market surveys and consumer profiles that can help you to build consumer profiles and to relate the possession of specific appliances such as refrigerators and air conditioners to household income. Historical data on equipment sales, together with estimates of their useful life, will enable you to develop preliminary hypotheses on appliance ownership, to be confirmed by the survey, and energy consumption.

An analysis of the consumption characteristics of appliances sold in the country can be entrusted to a research lab of a university or other accredited organization, or to specialized consultants. In the case of imported appliances, you can request data from the efficiency tests conducted in most industrialized countries. The most important equipment to test is lighting, refrigeration, water heating, and air conditioning.

Note that measurements taken in labs under certain protocols do not provide data that is directly applicable to the field. It is usually necessary to include correction factors to adapt them to local conditions, such as temperature, supply voltage and the heating value of oil products used. Furthermore, in actual operation, these consumption levels will be affected by the use practices of each household.

In countries that implement energy labeling, consumption ranges are known for each category and for each electric or gas appliance on the market, as measured and certified in specialized labs.

4.6.2 Sampling Guidelines

After collecting and analyzing data on the country's overall energy situation, you can start studying selection plans and sampling techniques. Depending on the availability of data and/or funds, you can use three basic surveys and sampling techniques:

1. Surveying the entire residential universe on a geographic basis
2. Surveying the universe with the most coverage, using the register of utility companies for sampling purposes and defining whether it is by primary or secondary energy source
3. Typological surveys, using intentional selection, choosing homogeneous classes of consumers and trying to trace their energy consumption profile

Sampling on the entire universe is shown as preferable, but is complex, may require much time and cost to implement, and is only justified in countries where statistical data is scarce or electrification rates are lower than 50%. Where more data is available and electrification rates exceed 50%, it is always preferable to conduct the survey by dividing the universe into two sub-universes: electrified and non-electrified residences. This division makes it possible to use different sampling systems.

The first sub-universe—electrified residences—is usually the most advanced segment of the economy, near major production and consumption centers. The registry of utility companies will provide prior knowledge to facilitate the survey and enable you to identify consumers immediately. Finally, this sector represents the degree of evolution to be reached by the second sector when it enters the electrification phase.

The second sub-universe—residences not connected to the grid—usually represents less economically developed strata, far from large centers. This is the essential characteristic of the stratum, so it is important to verify its homogeneity. In fact, some regions may have relatively affluent residences that are not connected to the power grid. To identify them, you can do a preliminary test by studying the penetration of specialized equipment such as absorption refrigerators that use LPG or kerosene, stationary generators and the like.

The ***typological survey*** is more suited to specific measurements, because you want to typify consumption patterns by selecting homogeneous clusters or groups that represent similar income strata. In this case, in the end you should take a random sample within each selected group.

The basic problem with ***geographically-based survey samples*** of a country, region or city is the need to know clearly the population distribution within the area (and sometimes its features) in order to distribute the surveys among different areas and establish homogeneous criteria of random selection in the households to be surveyed. The sample should be distributed over the national territory and, according to the proposed classification, identified as urban or rural and its socioeconomic strata.

Geographically, the country can be divided into regions of interest. The sampling framework required to decide how many elements to survey and to select them at random requires databases to identify the total possible units to be surveyed, together with secondary information to classify them by location (rural and urban) or strata (high, middle and low), e.g., energy consumption, income level, etc.

The needed data, such as the sampling framework, is provided by the census conducted in all countries, which gives the number of rural and urban homes in each region, province and municipality of the country. The database usually makes it possible to distribute the sample among regions, provinces, municipalities, etc. However, there is not enough data to locate each property, so you need to select homes using maps to identify the residential segments that will make up the sampling framework.

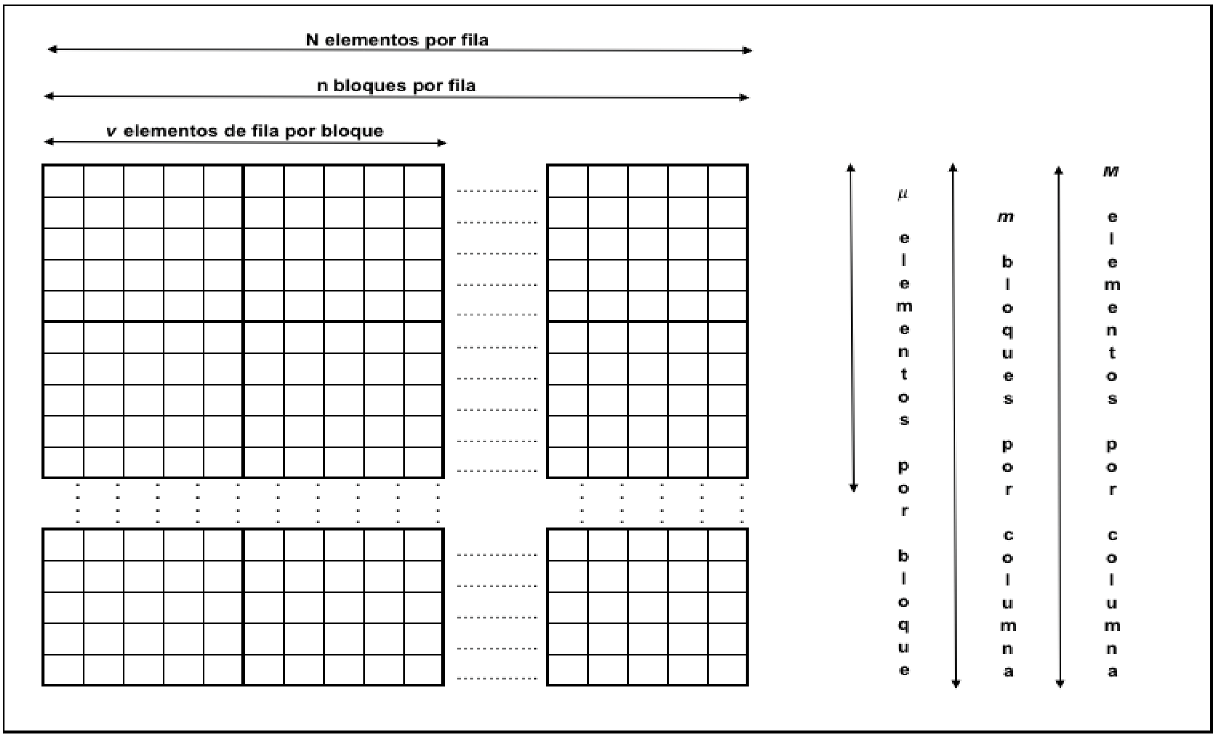
One way to reduce the number of interviews is to stratify the samples in regions with the highest energy consumption. This demands geographically-based data on consumption distribution, disaggregated by source if possible, and using total consumption of all energy sources as a parameter. There may be distortions, depending on the different efficiencies among sources, e.g., traditional fuels, mainly firewood, have relatively low efficiency levels. Adding traditional fuels to the commercial ones, you can level out the differences between use patterns.

4.6.2.1Sampling by Area

When sampling by area, maps are the most suitable framework for selection. Since maps enable you to divide the territory into squares or rectangles, a design with grids or meshes (rows and columns) is often used. This type of data collection design is frequently used in agricultural and other soil-related studies.

A discrete, finite population of elements is used, arranged in grids of N rows by M columns. **In other words, we must know the number of potential sampling units in each municipality.** The elements of this population can be grouped into square blocks of *Vµ* elements each (*V* elements per row and µ elements per column). Let n be the number of blocks per row and m the number of blocks per column. You find for N=n*V*, M=mµ and NM=nm*V*µ. This generic population is illustrated in Figure 15.

Figure 15. Outlining the Population in Grids



Below is an example of how to use selection by areas for the entire territory. This method is applied to each of the selected municipalities. The study population in this case is the territory of Dominican Republic, comprising a rectangle of about 275 km wide by 200 km long (Figure 16). Based on a 12 * 9 grid, ten regions of interest were chosen (Figure 17 and Figure 18). The region is shown delimited by the largest block number 10 (Figure 18), which can then be stratified in the same way, followed by a division by four (12.5 km * 12.5 Km) and then a new division of 25 columns per table (following the example in Figure 19).

Figure 16. Dominican Republic study grid

Figure 17. Largest blocks 10 regions of interest

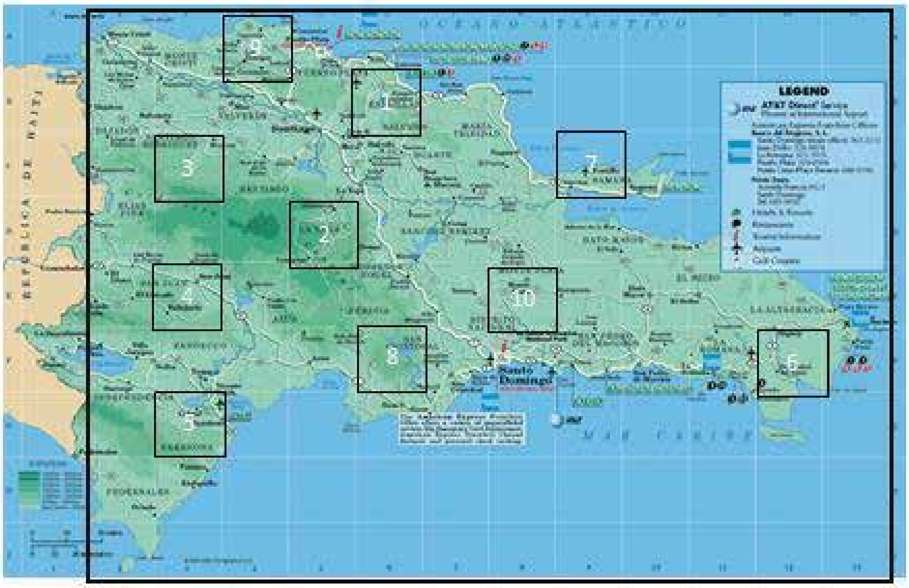
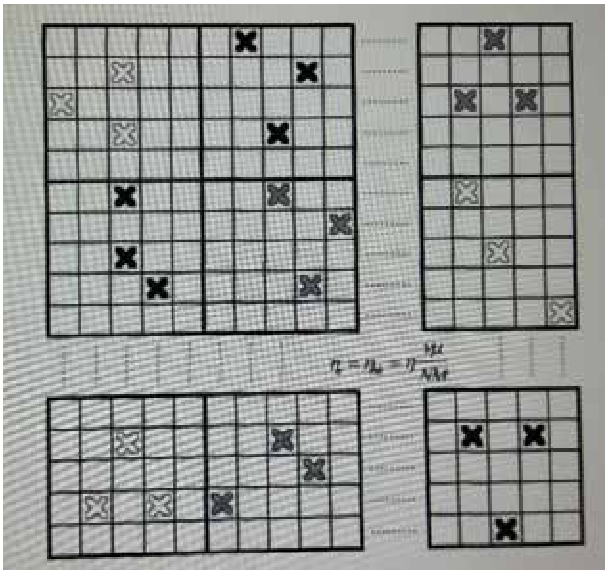


Figure 18. Stratification of the largest grids

For example, in the block marked **1** in Figure 18, a new grid of 25 lines by 25 rows is formed. That is 625 small blocks representing areas of 500m * 500m, 200 of which can finally be selected at random (the grid could be finer and have units the size of a 100m * 100m town block).

Figure 19 illustrates how to design a random sampling plan, in this case with only 3 elements per stratum.

Figure 19. Example of a stratified random sample of 3 elements per stratum within the stratification of the largest blocks



Finally, within each of the selected grids, you proceed to survey some or all of the units contained. If there is more than one, determine which by applying a random selection methodology such as the systematic one. The housing, household or industry census in each selected area and the number of grids that constitute the population will serve as a reference when developing the expansion factors.

4.6.2.2 Survey by Registry of Companies

This surveying technique supplements the one described above. Some countries may have information on service companies, although most do not have only one company, but rather one or more per region. These companies have very valuable data, such as the latest consumption, historical consumption levels, voltage levels and, in some cases, type of construction, location, urban/rural, stratum (socioeconomic status), and type of use (residential, commercial, agricultural, etc.). One advantage is that we can gather the universe or sub-universe in a database to choose from randomly at the national or regional level.

In countries with seasonal changes, the data will make it possible to average consumption over 12 months, while in other countries three to six months will suffice. In any case, it is better to work with averages to avoid biases due to atypical consumption levels in a month. It is also possible to order homes by size of monthly consumption and thus establish layers with different consumption ranges.

Once you know the distribution of consumers per consumption range within the universe, you can calculate the sample size and draw the lots. Take care, because if the sample is distributed proportionately to the number of users within the same range, the majority of respondents will probably be within the most common range, which will likely have the least variance, while the minority of large consumers will have greater variance and warrant a larger sample. There are statistical techniques available to correct this bias.

4.6.2.3 Typological Surveys

This type of sampling technique is recommended to select the sample on which specific energy consumption measurements will be performed regarding electric and gas appliances. In this case, you choose a representative sample of users within a region that is defined by type of climate, available energy sources, subsector (rural or urban), and within a specific consumption range (socioeconomic stratum).

It this way, home measurements are taken to determine household consumption per application by placing meters on each appliance, especially those with variable power demand such as refrigerators, air conditioners and washing machines. The results of measuring operating equipment under real conditions will provide data on how energy consumption is affected by use practices and how close our consumption calculations are to the manufacturers' nominal values and the actual values. You can also estimate the influence of home construction types and materials, thermal insulation and other architectural aspects of monthly energy consumption.

4.6.3 The Survey Form

Since the data unit is the home and the aim is to collect data on energy consumption per application, it is advisable to use the technique of developing a form by sections, where each section specializes in recording the different energy applications in the home. The contents of the form to be used in each country should be decided on once its particular situation is known. However, one can also identify referential contents such as those shown in Tables 5 to 11 below, which cover sections A to K:

- **Section A:** Specific details of the establishment, identification, type, subsector and location (Table 42)
- **Section B:** Lighting (Table 43)
- **Section C:** Refrigeration, food preservation (Table 43)
- **Section D:** HVAC (ventilation, air conditioning) (Table 43 and Table 44)
- **Section E:** Driving force (Table 44)
- **Section F:** Office equipment (Table 45)
- **Section G:** Direct heat and process heat (Table 46)
- **Section H:** Other equipment (Table 46)
- **Section I:** Fuels used and self-generation (Table 46 andTable 47)
- **Section J:** Rational energy usage (Table 48)
- **Section K:** Electricity bill (Table 48)

Table 42. Section A

NATIONAL SURVEY TO FINAL ENERGY CONSUMPTION SECTORS

RESIDENTIAL SURVEY

GEOGRAPHICAL IDENTIFICATION

CONGLOMERATE

HOUSING SELECTION NUMBER

HOUSEHOLD NUMBER IN HOUSING SELECTION

PROVINCE: ______

MUNICIPALITY: ______

NEIGHBORHOOD: ______

ADDRESS: ______

NAME OF SURVEYED: ______ PHONE NUMBER: ______

You live in: Home [ ] Apartment [ ] Other [ ] Which one?:______

Mr. Surveyor: According to your observation, please mention which type of housing this survey corresponds to, according to the following economic groups classification:

LOW	
AVERAGE	
HIGH	

RURAL	
URBAN	

SECTION A. PERSONAL DATA

A1. Do you develop any productive economic activity in your home? [ ] YES (Go to A2) [ ] NO (Go to A3)

A2. Do you have a different meter for the commercial activity other than it is used for your household consumption?	Yes	
	No (Go to A3)	

A3. Do more than one family live in your household? Yes [ ] No [ ] How many?______

Note: If there are more than one family in the HOUSE, IT IS NECESSARY TO INVESTIGATE EACH OF THE FAMILIES LIVING IN THE HOUSE (one form per household)

A4. Number of people living in the houseld

Adults			
Children			

FINAL VISIT

NAME OF THE INTERVIEWER ______

CODE [ ][ ][ ][ ][ ]

DAY ....

MONTH ....

YEAR 2 0 1 6

RESULTS [ ][ ]

1	COMPLETE INTERVIEW
2	ABSENT
3	PARTIALLY ANSWERED
4	REJECTED

	SUPERVISOR	CRITICAL / DIGITED IN THE FIELD BY:
NAME	[ ][ ][ ]	[ ][ ][ ]

DATE ______

Table 43. Sections B, C and D

SECTION B. WATER HEATING

B1. Do you have a water heater?	Yes (Continue)		B2. Do you use a water heater every	Yes (Continue)	
	No (Go to Question C1)			No (Go to Question	

B3. Please fill out the following information

TYPE OF DEVICE	CAPACITY OR POWER		Minutes of daily use
	Capacity	Unit	
Water Heaters LPG		Gallons	
Electric water heater		Gallons	
Electric shower		kW	
Solar panel		m^2	
Other (Specify)			
Other (Specify)			

SECTION C. FOOD CONSERVATION

C1. Do you have a fridge or freezer?	Yes (Continue)	
	No (Go to Question D1)	

C2. Please fill out the following information

TYPE OF DEVICE	Capacity (Cubic feet)	Antiquity (Years)
Fridge		
Executive Refrigerator		
LPG Refrigerator		
Freezer		
Speaker		
Other (Specify)		
Other (Specify)		

SECTION D. AIR CONDITIONING - VENTILATION

D1. Do you have fan or air conditioning?	Yes (Continue)		D2. Do they use fan or air conditioning?	Yes (Continue)	
	No (Go to Question E1)			No (Go to Question	

D3. Please fill out the following information

Type of equipment		Quantity	BTU / h capacity							Total hours of use per day
			9,000	12,000	18,000	24,000	36,000	60,000	Other (Specify)	
Fan	Pedestal									
	Ceiling									
	Table									
	Floor									
	Wall									
Air conditioner	Ventana									
	Traditional Split									
	Split Inverter									
	Central									

EXAMPLE: 4 Pedestal fans: I use two fans for two hours and two fans for three hours.
SO: (2 pedestal fans x 2 hours) PLUS (2 pedestal fans x 3 hours) = 4 + 6 = 10 hours.
2 Wall Fans: I use a Fan for five hours and a Wall Fan for two hours.
SO: (1 wall fan x 5 hours) PLUS (1 Wall fan x 2 hours) = 5 + 2 = 7 hours.
Continued use of other fans and air conditioners

Table 44. Sections D and E

SECTION D. ENVIRONMENTAL CLIMATIZATION

D1. Do you have an environmental heater	**Yes (Continue)**		**D2. Is the heating individual or share by the community?**	**Individual**	
	No (Go to Question E1)			**Community**	

D3. Please fill out the following information

Type of equipment	Number	Total capacity	Unit of measure	Daily consumpti	Monthly consump	Months / year
Electric heater			kW			
LPG heater			lb / h			
Natural gas heater			Liters / hr			
Coal heater			lb / h			
wood Heater			lb / h			
Other ___________________						

EXAMPLE: 4 Electric heaters: Two of 1kW which I use 3 hours / day, and two of 2kW which I use 2 hours / day,
THEN: Daily consumption = (2 of 1kW x 3 hours) PLUS (2 of 2 kW x 2 hours) = 6 + 8 = 14 kWh / day Total capacity = (2 x 1 kW + 2x 2kW) = 6kW

SECTION E. LIGHTING

E1. What kind of lighting do you use in your home?

	Number	Total hours of use per day
Traditional (Incandescent)		
LFC (Low consumption)		
LF		
LED		
Candles		
Kerosene		

NOTE: The counting of light bulbs is performed in the same way as the fan and air conditioning

Table 45. Section F

SECTION F. OTHER EQUIPMENT

F1. Do you have a TV?	Yes (Continue)		F2. Do you watch the TV every day?	Yes (Continue)	
	No (Go to Question F4)			No (Go to Question F4)	

F3. Please fill out the following information

TV No.	Type of device				Total use (hours)
	CONVENTIONAL	LED	PLASMA	LCD	
TV 1					
TV 2					
TV 3					
TV 4					
TV 5					

F4. Do you have a washing	Yes (Continue)		F5. Do you use the washing machine	Yes (Continue)	
	No (Go to Question F7)			No (Go to Question F10)	

F6. Please fill out the following information

	Use x week (No. of days)	Antiquity (Years)
Washing machine 1		
Washing machine 2		

F7. Do you have a dryer?	Yes (Continue)		F8. Do you use a dryer on a daily	Yes (Continue)
	No (Go to Question F10)			No (Go to Question F10)

F9. Please fill out the following information

Energetic used	Quantity	Capacity (POUNDS)	Use x week (No. of days)	
LPG				
ELECTRICITY				
OTHER (specify)				

F10. Mention the number and hours of use of the following equipment USE AT THE HOUSELD AT LEAST ONCE A WEEK:

EQUIPMENT	QUANTITY	Total use (hours per week)
Iron		
Hair dryer		
Personal Computer / Laptop		
Microwave		
Crockpot		
Other Specify:		
Other Specify:		
Other S pecify:		

Table 46. Sections G, H, I

SECTION G. WATER PUMP AND GRASS CUTTER

G1. Do you have a water pump?	Yes (Continue)		G2. Do you use a water pump every	Yes (Continue)	
	No (Go to Question			No (Go to Question G4)	

G3. Please fill out the following information

Energetic used	Quantity	HP Capacity				Hours of use per week
		1/2	1	1.5	Other	
ELECTRICITY						
OTHER (specify)						

G4. Do you have a lawn mower?	Yes (Continue)		G5. Do you use lawn mowers daily?	Yes (Continue)	
	No (Go to Question			No (Go to Question H1)	

G6. Please fill out the following information

Energetic used	Quantity	HP Capacity	Hours of use per month
GASOLINE			
OTHER (specify)			

SECTION H. COOKING

H1. Do you cook at home?	Yes*	
	No (Go to Question 11)	

* Please mention the type of device YOU USE EVERY DAY ____________________

H2. Please fill out the following information

Type of equipment	LPG	Electric	Firewo od	Charcoal	Other biomass	Use of Equipment			Total use (hours per
						Breakfast	Lunch	Dinner	
Stove									
Fireplace									
Anafe									
Barbecue									
Furnace									

SECTION I: USED FUELS

I1. DO NOT INCLUDE VEHICLE CONSUMPTION: Do you use LPG -	Yes (Continue)	
	No (Go to Question I3)	

I2. Please fill out the following information

Used fuel	How much do you buy?		How often do you buy it ?
	Gal/m^3	$	
LPG			
GASOLINE			
DIESEL OIL			
NATURAL GAS			

I3. At home do you use COAL - KEROSENE - CANDLES?	Yes**	
	No (Go to Question I5)	

** Mention the characteristics and frequency of use ____________________

I4. Please fill out the following information

Used fuel	How much do you buy?			How often do you buy it ?
	Qua	Units	$	
COAL		Pounds		
KEROSENE		Gallon		
Candles		Units		

Table 47. Section I (continued)

I5. Do they use FIREWOOD AND WASTE at home?	Yes*	
	No (Go to Question I7)	

* Mention the characteristics and frequency of use ______

I6. Please fill out the following information

Used fuel	Why do you use firewood or waste and no other fuels?					Obtaining			How many pounds do you get?	How often do you get it?
	Price	Shortage of other fuels	Easy acquisition	You have used it in a traditional way and you do not want to stop doing it	Other	Purchases	Collect	Both		
Firewood										
Waste										

I7. How many hours of electricity do you ussually have every day?	

I8. Do you have a power plant?	Yes (Continue)	
	No (Go to Question I11)	

I9. Why do you have a plant?

High Rate	Frequent Power outage	Variations of Voltage	Lack of electricity	Others

I10. Mention the characteristics of the plant.

TYPE OF FUEL USED	POWER (kW)	Frequency of use			Hours of use
		Weekly	Monthly	Seldom	
GASOLINE					
DIESEL OIL					
OTHER specify					

I11. Do you have solar panels for electricity generation?	Yes (Continue)	
	No (Go to Question I16)	

I12. Why do you have solar panels?

High Rate	Frequent Power outage	Variations of Voltage	Lack of electricity	Others

I13. Mention the characteristics of your solar panel.

POWER (Watts)	Do you have an accumulation battery for your panel?				Battery Capacity (Amp-h)	Cost of acquisition
	YES		No (Go to acquisition cost)			
	YES		No (Go to acquisition cost)			

NET MEASUREMENT PROGRAM

The Net Measurement program is a system that allows you to inject your surplus energy into the grid and thus decrease your electric bill

I14. Are you registered in the Net Measurement system?	Yes (Go to question I16)	
	No (Continue)	

I15. Why aren´t you registered yet in the Net Measurement system?	I do not know about it	
	I do not trust the distributor	
	OTHER specify	
	OTHER specify	

I16. Do you have Investors for electricity generation?	Yes (Continue)	
	No (If you answered yes in question A2, go to question J1, Otherwise go to K1)	

I7. Please fill out the following information

POWER (kw)	Frequency of use			Hours of use per week	Approximate acquisition cost
	Balance	Weekly	Monthly		

Table 48. Sections J, K, L

J: ONLY IF YOUR ANSWER WAS YES TO THE ANSWERED TO ECONOMIC ACTIVITY IN QUESTION A2

J1. Mention the characteristics and frequency of use of the ADDITIONAL DEVICES TO THOSE ALREADY DESCRIBED as used in this activity

TYPE OF DEVICE	QUANTITY	Capacity	Unit	Hours of daily use
Fridge			Cubic feet	
Bottle rack			Cubic feet	
Freezer			Cubic feet	
Electric stove			Burners	
LPG Greenhouse			Burners	
Electric oven			kW	
LPG Oven			Gallons / month	
LPG Toaster			Gallons / month	
Iron			kW	
Blender			kW	
Food processor			kW	
Washing machine			Pounds	
Electric Dryer			kW	
LPG Dryer			Gallons / month	
Sewing machine			kW	
Personal computer			kW	
Printer			kW	
Hair dryer			kW	
Electric drill			kW	
Chainsaw			kW	
Electric welder			kW	
Oth er Specify:				
Other Specify:				

K. ELECTRICITY INVOICE

K1. Please state:		Identification number								Does not have an identification
	Meter 1									
	Meter 2									

K2. Mention the type of contract and the amount you pauy for your electricity consumption

Invoice	$		Other	$S
Fixed invoice	$		Not regulated	
Prepaid Electricity	$			

K3. Name the rate type:	B T S 1	
	B T S 2	

K4. What is the electricity bill monthly consumption (kWh) of the year 2015.

M O N T H	CONSUMPTION kWh			
	Meter 1		Meter 2	
	$ S	k W h	$ S	k W h
LOWEST amount paid last year				
HIGHEST amount paid last year				
Monthly average				

SECTION L: Mention the share in % for each one of the uses and the efficiencies in each one, if any

Applications	Lighting		Cooking		Cooling		Air conditioner		Heating		Hot water		Others	
Energy sources:	%	η %	%	η %	%	η %	%	η %	%	η %	%	η %	%	η %
Electric power														
LPG														
Natural gas														
Other fuels														

4.7 APPLICATION: THE BRAZILIAN CASE

Presented below are the findings of the residential sector analysis, obtained from the UEB developed for Brazil by the Ministry of Mines and Energy (MME) in 2005. The findings shown here can serve as a reference for implementing the proposed methodology, in addition to including bibliographic references to be consulted by interested countries.

The UEB basically comprises the following steps:

- Identifying applications for the various energy sources
- Identifying consumer appliances and collecting their efficiency values
- Evaluating the final energy shares of the various applications
- Determining usable energy by multiplying final energy consumption by the appropriate performance (production efficiency), as described above

The balance was prepared using the OLADE methodology, with tables published by INMETRO[5] as the main reference to determine the energy efficiency of the residential sector, which reflects the efficiency values of all appliances approved by the labeling program. These tables are updated periodically and represent the status of the energy consumption or energy efficiency of the different devices available on the market.

Table 49 shows the final energy consumption by source in Mtoe and the share ratios by application for each of the energy sources used in the sector.

Table 49. Final energy consumption by source

Residential Sector									
Energy sources	Final Energy	Participation coefficients							
	1000 Toe	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other	Total
NATURAL GAS	181.30	-	0.10	0.90	-	-	-	-	1.00
FIREWOOD	8,073.60	-	-	1.00	-	-	-	-	1.00
SUGARCANE PRODUCTS	-	-	1.00	-	-	-	-	-	1.00
OTHER PRIMARY SOURCES	-	-	-	1.00	-	-	-	-	1.00
DIESEL	-	0.50	0.25	0.25	-	-	-	-	1.00
FUEL OIL	-	-	0.50	0.50	-	-	-	-	1.00
GASOLINE	-	1.00	-	-	-	-	-	-	1.00
LPG	5,828.30	-	0.10	0.90	-	-	-	-	1.00
KEROSENE	13.30	-	-	-	-	1.00	-	-	1.00
GAS	-	-	0.18	0.82	-	-	-	-	1.00
ELECTRICITY	6,757.60	0.03	0.26	0.08	0.32	0.24	-	0.07	1.00
CARCOAL	503.00	-	-	1.00	-	-	-	-	1.00
ETHANOL	-	1.00	-	-	-	-	-	-	1.00
OTHER OIL PRODUCTS	-	-	0.50	0.50	-	-	-	-	1.00

Source: Utilizable Energy Balance (UEB) for Brazil, 2005

Table 50 shows how final energy consumption levels are distributed by source by use in the residential sector.

5 See http://www.inmetro.gov.br/consumidor/tabelas.asp

Table 50. Final Energy by Source and Use

Residential Sector								
Energy sources	**Participation coefficients**							
	Shaft Power	**Process Heat**	**Direct Heat**	**Refrigeration**	**Lighting**	**Electro-Chemical**	**Other**	**Total**
NATURAL GAS	-	18.10	163.20	-	-	-	-	181.30
FIREWOOD	-	-	8,073.60	-	-	-	-	8,073.60
SUGARCANE PRODUCTS	-	-	-	-	-	-	-	-
OTHER PRIMARY SOURCES	-	-	-	-	-	-	-	-
DIESEL	-	-	-	-	-	-	-	-
FUEL OIL	-	-	-	-	-	-	-	-
GASOLINE	-	-	-	-	-	-	-	-
LPG	-	582.80	5,245.50	-	-	-	-	5,828.30
KEROSENE	-	-	-	-	13.20	-	-	13.20
LPG	-	-	-	-	-	-	-	-
ELECTRICITY	202.70	1,757.00	540.60	2,162.40	1,621.80	-	473.00	6,757.60
CARBON VEGETAL	-	-	503.20	-	-	-	-	503.20
ETHANOL	-	-	-	-	-	-	-	-
OTHER OIL SOURCES	-	-	-	-	-	-	-	-
Total	202.70	2,357.90	14,526.10	2,162.40	1,635.00	-	473.00	21,357.00

Source: Utilizable Energy Balance (UEB) for Brazil, 2005

Table 51 shows energy efficiency rates as assessed in Brazil's residential sector for each application and energy source.

Table 51. Efficiency ratios by source and use

Residential Sector							
Energy sources	**Participation coefficients**						
	Shaft Power	**Process Heat**	**Direct Heat**	**Refrigeration**	**Lighting**	**Electro-Chemical**	**Other**
NATURAL GAS	0.330	0.800	0.500				
FIREWOOD		0.460	0.320				
SUGARCANE PRODUCTS			0.320				
OTHER PRIMARY SOURCES			0.320				
DIESEL	0.430	0.800	0.500				
FUEL OIL		0.800	0.500				
GASOLINE	0.280	0.800					
LPG	0.280	0.800	0.500		0.002		
KEROSENE	0.280		0.500		0.002		
LPG	0.330	0.800	0.500				
COAL COKE							
ELECTRICITY	0.750	1.000	0.700	0.600	0.090		1.000
CARBON VEGETAL			0.320				
ETHANOL	0.340						
OTHER OIL SOURCES							

Source: Utilizable Energy Balance (UEB) for Brazil, 2005

Table 52 shows referential efficiency ratios, i.e., those assessed using the best technology available.

Table 52. Referential Ratios

Residential Sector							
Energy sources	Participation coefficients						
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other
NATURAL GAS	0.350	0.870	0.500				
FIREWOOD		0.500	0.350				
SUGARCANE PRODUCTS			0.350				
OTHER PRIMARY SOURCES			0.350				
DIESEL	0.450	0.870	0.620				
FUEL OIL		0.870	0.620				
GASOLINE	0.300	0.870					
LPG	0.290	0.870	0.620		0.002		
KEROSENE	0.300		0.620		0.002		
LPG	0.370	0.870	0.620				
COAL COKE							
ELECTRICITY	0.830	1.000	0.800	0.700	0.172		1.000
CARBON VEGETAL			0.350				
ETHANOL	0.350						
OTHER OIL SOURCES							

Table 53 shows utilizable energy consumption levels by application and by energy source, which result from multiplying the final energy consumption matrix by the efficiency rate matrix. The last column shows the loss calculations, assessed as the difference between final consumption and utilizable energy (the latter being energy production, which does not account for use practices).

Table 53. Utilizable energy consumption by application and source

Residential Sector									
Energy sources	Participation coefficients								Losses
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other	Total	1000 Toe
NATURAL GAS	-	14.50	81.60	-	-	-	-	96.10	85.20
FIREWOOD	-	-	2,583.60	-	-	-	-	2,583.60	5,490.10
SUGARCANE PRODUCTS	-	-	-	-	-	-	-	-	-
OTHER PRIMARY SOURCES	-	-	-	-	-	-	-	-	-
DIESEL	-	-	-	-	-	-	-	-	-
FUEL OIL	-	-	-	-	-	-	-	-	-
GASOLINE	-	-	-	-	-	-	-	-	-
LPG	-	466.30	2,622.70	-	-	-	-	3,089.00	2,739.30
KEROSENE	-	-	-	-	-	-	-	-	13.10
LPG	-	-	-	-	-	-	-	-	-
ELECTRICITY	152.00	1,757.00	378.40	1,297.50	146.00	-	473.00	4,203.90	2,553.70
CARBON VEGETAL	-	-	161.00	-	-	-	-	161.00	342.20
ETHANOL	-	-	-	-	-	-	-	-	-
OTHER OIL SOURCES	-	-	-	-	-	-	-	-	-
Total	152.00	2,237.80	5,827.40	1,297.50	146.00	-	437.00	10,133.60	11,223.60

Finally, Table 54 shows the energy recovery potential, calculated as the difference between the previous utilizable energy and that resulting from multiplying the final energy matrix by the reference rates.

Table 54. Potential for economically viable energy recovery

Residential Sector								
Energy sources	**Participation coefficients**							
	Shaft Power	**Process Heat**	**Direct Heat**	**Refrigeration**	**Lighting**	**Elec-tro-Chem-ical**	**Other**	**Total**
NATURAL GAS	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.5
FIREWOOD	0.0	0.0	692.0	0.0	0.0	0.0	0.0	692.0
SUGARCANE PRODUCTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTHER PRIMARY SOURCES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIESEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FUEL OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	0.0	46.9	1,015.3	0.0	0.0	0.0	0.0	1,062.2
KEROSENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COAL COKE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	19.5	0.0	67.6	308.9	773.2	0.0	0.0	1,169.2
CARBON VEGETAL	0.0	0.0	43.1	0.0	0.0	0.0	0.0	43.1
ETHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTHER OIL SOURCES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	19.5	48.4	1,818.0	0.0	0.0	0.0	0.0	2,968.0

CHAPTER V

The Trade, Service and Public Sector

5. THE TRADE, SERVICE AND PUBLIC SECTOR

5.1 DISAGGREGATION BY SUBSECTOR

This sector is characterized by including a large variety of activities having very different energy consumption characteristics. However, since the UEB is intended to be used as a diagnostic tool and as a starting point for demand forecasting studies, it is essential to disaggregate this sector into sets of relatively homogeneous activities in terms of both energy demand and level of evolution. Defining subsectors should also be linked to organizing macroeconomic data, the basic inputs for demand forecasting studies.

Therefore, we propose disaggregating this sector based on the ISIC (International Standard Industrial Classification) Rev. 4, as was done in the industrial sector. The branches of activity included in this sector, according to the international two-digit ISIC denomination, lie between branches 45 and 96, in addition to branches 36, 37 and 38.

Since the number of subsectors is very large, we propose a reduction by disaggregating them into the eight subsectors shown in Table 55 below.

The ones considered for disaggregation are:

Table 55. Disaggregation into subsectors and comparison with ISIC Rev. 4

Groups Balance	CIIU Rev 4 Correspondence	Denomination of the subsector
1	45,46,47	Wholesale and retail trade
2	55, 56	Hotels and Restaurants
3	64, 65, 66, 68	Banking, Insurance, Real State, Services to enterprises
4	84	Public administration, government, defense
5	85	Education
6	86, 87, 88	Public health, social assistance
7	36, 37, 38	Water, residues, street lighting
8	Others between 52 and 99	Other services, transport activities, communications, etc

Source: Prepared by author

This achieves a relative uniformity in each subsector's type of energy use and disaggregates activities whose evolution can vary substantially depending on the types of policy that apply.

It is possible to collect direct data in order to set up the database and achieve a suitable sample design.

Obviously, each country can have variants of this disaggregation depending on the complexity of each subsector and its significance in the country's energy consumption, but we usually recommend these eight subsectors. The eighth is the most diverse, as it includes numerous activities, but fortunately its energy consumption is small compared to other subsectors.

5.2 DISAGGREGATING BY APPLICATION

The activities in each subsector have very different energy applications. For example, they can range from predominantly heating applications (cooking, water heating, etc.) for group 2 (hotels and restaurants), to a predominance of applications such as lighting and air conditioning for groups 1, 3, 4 (Trade, Financial Institutions and Public Administration, respectively). Other activities, such as public lighting, show one energy application and a single energy source.

When preparing the balance, we propose including the following applications:

- Heating
- Cooking
- Water heating
- Air conditioning and ventilation
- Refrigeration
- Lighting
- Mechanical force
- Other applications

These applications are similar to those in the residential sector, but the devices and use characteristics are different in the trade, service and public sector. They include industrial kitchens, boilers for hot water or steam, central heating systems, chillers to produce ice water in central air conditioning systems, and elevators or escalators in shopping malls.

However, they are similar to the residential sector in that the demand for utilizable energy depends on two factors:

- The level of comfort and/or mechanization
- The efficiency of equipment use

5.3 FINAL ENERGY, UTILIZABLE ENERGY AND EFFICIENCY

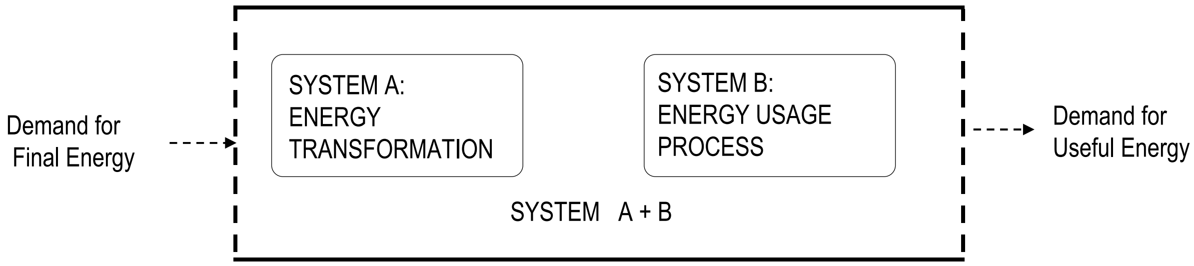
Final energy is consumed in establishments to meet specific needs such as lighting, food preservation, cooking, water heating, etc. It is usually possible to know the total monthly energy consumption of an establishment, because power and gas utilities install meters at the entrance to record consumption. The problem is that to know the energy consumption for each application, we would need a meter on each device, or at least a model to calculate the consumption of the device based on its technical features and time of use (use habits).

For example, in the case of electricity—the most used energy source in the trade, service and public sector—daily, weekly or monthly consumption can be calculated from data on the power demanded by each device and its hours in use. The power demand of some appliances is not constant, such as refrigerators, washing machines, etc., in which case you estimate the average power demand and usage time.

The same applies to other energy sources, particularly LPG or NG, which can be connected to feed more than one appliance (stove, water heater and oven) at the same time. It is easy to get the total monthly LPG consumption, but to disaggregate it by devices you need data on the variables that determine their consumption and lab measurements to know, for example, how much gas each burner consumes in an hour.

Conceptualizing utilizable energy involves two stages: production and use. The former relates to measuring the efficiency of energy transformation equipment, and the latter has to do with to how it is used. For example, in the case of storage water heaters, electricity or fuel is used to heat the water in a vessel, and when a faucet is opened, the heated water goes through pipes to the point of use. Thus one can think of a transformation efficiency of electricity or fuel to heat (sometimes called the production efficiency) and a use efficiency, which in the example is due to heat losses through the insulation in the walls of the vessel and the pipes.

Figure 20. Transforming final energy into utilizable energy



In refrigerators and chillers, the conversion efficiency includes not only compression motors but also the refrigeration cycle, refrigerant gas, and exchangers in the evaporator and condenser.

Including losses in utilization systems requires measuring appliance consumption under actual operating conditions. This second efficiency can be very important for some equipment such as stoves, refrigerators and air conditioners. As for cooking, combustion efficiency can be viewed as the conversion efficiency, while the efficiency of heat transfer between the burner and the vessel (including the ambient air if there is ventilation, for example) is the use efficiency. In the case of refrigeration and air conditioning, locating the appliance near a window where it receives sunlight, or near a stove where it receives heat, can affect its use efficiency.

To determine the utilizable energy in the trade, service and public sector, you need to know:

- The main types of equipment used by final energy consumers
- The final energy amounts actually consumed by these appliances
- The efficiencies of those devices under normal operating conditions

Appliance efficiency should be subject to specific research in each country, because experience has shown that the actual figures found in practice are often different from those given by manufacturers. Measurements should be taken in the establishments to find the actual numbers, but if this is not possible you should preferably use the data available from prior studies or, lacking these, in the technical literature from manufacturers.[6]

5.3.1 UEB Applied to a Unit of the Trade, Service and Public Sector

Energy entering an establishment is purchased or sometimes self-generated using fuel or renewable energy (solar, wind or other). This makes up the Net Energy Input (NEI), i.e., the energy entering a unit of the sector, disaggregated into various sources, and then transformed into useful forms. The NEI can be assumed to be equal to final consumption by source, since in most cases it is not inventories or is negligible in relation to the yearly energy consumption.

Final consumption by source may be related to final consumption by use. The electrical devices that account for the various energy applications in an establishment (refrigeration, air conditioning, lighting, driving force, etc.) will have their consumption aggregated and related to the final power consumption that appears in the establishment's electricity bill. Likewise, fuels should be considered according to their different applications and related to final consumption. For example, the power consumption of appliances is determined by direct measurement over a period of time, determining or estimating it using a combination of measurements and survey data.

The appliances available in a home include those whose power demand during operation has one of the following characteristics:

- Constant power demand
- Variable power demand

These features enable different methods for measuring the power demand and estimating power consumption, as follows:

Constant power demand: Examples of this type of equipment include light bulbs, CFLs, fluorescent lamps, radios, TVs, computers, and escalators. Power demand is determined from measurements or plate readings, and surveys determine the numbers of the same

6 Indicative values from studies of Brazil's labeling program at http://www.inmetro.gov.br/consumidor/tabelas.asp.

appliances and their daily use in hours/day. Next, the daily consumption of the devices is calculated. Extrapolating daily consumption to monthly consumption (kWh/month) requires determining daily or weekly use based on survey data. For example, if daily use on weekdays is different from weekends, this regime is determined and taken into account when calculating monthly consumption.

Variable power demand: Examples of this type of appliance include washing machines, refrigerators, chillers, and water pumps. In this case, either average out the power used by the device and use the calculation suggested above, or measure the electricity consumed by the equipment in a day and extrapolate it to a month. If it is operated on a different regime such as weekends, its consumption is also measured over the weekend. These consumption levels (weekday regime and weekend regime) are used to extrapolate the monthly consumption.

Table 56 illustrates a summary of the above observations.

Table 56. Methodology for estimating power consumption

ORIGIN OF THE INFORMATION					
Power demand	Estimate	Survey	Measurement	Survey	Regime
Constant Use Regime 1 - R1	E(kWh/month) = # of units x power(W/unit) x daily use@R1(hrs/day) x # of days@R1(days/month)				
Constant Use Regime 2 - R2	E(kWh/month) = # of units x power(W/unit) x daily use@R2(hrs/day) x # of days@R2(days/month)				
....					
Variable Use Regime 1 - R1	E(kWh/month) = E(Wh/day) x daily use@R1(hrs/day) x # of days@R1(days/month)				
Variable Use Regime 2 - R2	E(kWh/month) = E(Wh/day) x daily use@R2(hrs/day) x # of days@R2(days/month)				

Source: The Consultant

The monthly power consumption thus calculated for each appliance is grouped by end uses. Finally, total consumption is calculated by adding up all consumption levels by all end uses.

In the case of fuels, measuring consumption by use is more complex. For example, you know the monthly NG or LPG consumption, but need specific lab measurements in the establishments to determine what percentage is used for hot water, heating or cooking, and in some cases there is only one use, such as NG for the boiler.

Table 57 shows the analytical procedure for preparing the commercial balance. You start with final consumption per energy source, which should be consistent with the consumption disaggregated by application. At the bottom of the table, the final consumption totals are calculated by use and by useful consumption as the sum of all final consumption levels weighted by their production efficiencies.

Table 57. Energy Balance by Establishment of the Sector

COMMERCIAL SECTOR
ENERGY BALANCE APPLIED TO ONE COMMERCIAL UNIT

SOURCES	HEAT	AIR CONDITIONING / VENTILATION	COOKING	WATER HEATING	REFRIGERATION	SHAFT POWER	LIGHTING	TOTAL CONSUMPTION BY SOURCES AND AVERAGE EFFICIENCY
Crude Oil								
Natural Gas Liquids								
Natural Gas								
Coal								
Nuclear								
Hydro								
Geothermic								
Wind								
Solar								
Firewood								
Sugarcane products								
Other biomass								
Other primaries								
Electricity								
GLP								
Gasoline								
Kerosene and Jet Fuel								
Diesel Oil								
Fuel Oil								
Refinery gas								
Oil coke								
Other oil and gas products								
Coal coke								
Industrial gasses								
Other products from mineral sources								
Charcoal								
Ethanol								
Biodiesel								
Biogas								
Other Secondary Sources								
Non-energy								
Total								
Average efficiency per uses								
Useful Energy consumption								
Losses								

Finally, losses are calculated as the difference between final consumption and useful consumption. This procedure only considers the efficiency of the first transformation. To include use efficiency as well, measure or estimate the consumption under the actual operating conditions of the equipment.

5.4 THE UEB APPLIED TO THE TRADE, SERVICE AND PUBLIC SECTOR

The energy balance for the trade, service and public sector can be presented with the help of Table 58 and Table 59, which summarize the statistical findings of the surveys and/or measurements.

To make the calculation approach transparent, you should present a similar table to the above, including efficiencies by use and by source. This table should be the outcome of specific studies on the conversion efficiencies of appliances on the market and those found in establishments. These results will make it possible to monitor efficiency factors and technology improvements in the future. These tables represent the final output of the work done to prepare the UEB for the trade, service and public sector.

As seen for the other sectors, virtually all the data making up the UEB for an establishment can be conveyed in the form of a double-entry table. This sub-section shows how to present the UEB for the entire trade, service and public sector of a country or region. First of all, if you want to view all data making it up, the proposed disaggregation imposes a 4-entry table:

- By subsector (eight subsectors described)
- By use (space heating, air conditioning, cooling, water heating, driving force, lighting, and others)
- By source (according to the OLADE Balance, 31)
- By consumption type (4): final, useful, efficiency and losses

Following the OLADE balance format, i.e., the list of energy sources in the columns, you can present the UEB for the industrial sector in the two double-entry forms.

We propose a system with one main form and another auxiliary one. The main form contains the maximum detail for final consumption and a summary of useful data for consumption, as shown in Table 58.

Table 58. Main Form

	SELF PRODUCTION			FINAL CONSUMPTION (AND EFFICIENCY) BY SOURCES AND USES												
Sources	Energy Input	Fuels	Renewables	Final Consumption by sources	Heat		Air conditioning		Cooking		Cooling		Driving Force		Lighting	
					Unit	n%	Unit	n%	Unit	n%	Unit	n%	Unit	n%	Unit	n%
Crude Oil																
Natural Gas Liquids																
Natural Gas																
Coal																
Nuclear																
Hydro																
Geothermic																
Wind																
Solar																
Firewood																
Sugarcane products																
Other biomass																
Other primaries																
Electricity																
GLP																
Gasoline																
Kerosene and Jet Fuel																
Diesel Oil																
Fuel Oil																
Refinery gas																
Oil coke																
Other oil and gas products																
Coal coke																
Industrial gasses																
Other products from mineral sources																
Charcoal																
Ethanol																
Biodiesel																
Biogas																
Other Secondary Sources																
Non-energy																
Total																
Intermediate consumption (production of useful forms)																
Efficiency of use																
Useful Energy consumption																
Losses																

The auxiliary form is simply the same as the right-hand side of the table above (from the Final Consumption by Source column) for each subsector.

Table 59. Auxiliary Form

Presentation of energy balances disaggregated for the commercial, services and public sector			
Sources		Primary	Secondary
Final consumption			
Subsectors (8)	HEAT		
	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	OTHER USES		
Total final consumption	HEAT		
	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	OTHER USES		
Useful Consumption	HEAT		
	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	OTHER USES		
Average Efficiency	HEAT		
	AIR CONDITIONING / VENTILATION		
	COOKING		
	WATER HEATING		
	REFRIGERATION		
	SHAFT POWER		
	LIGHTING		
	OTHER USES		

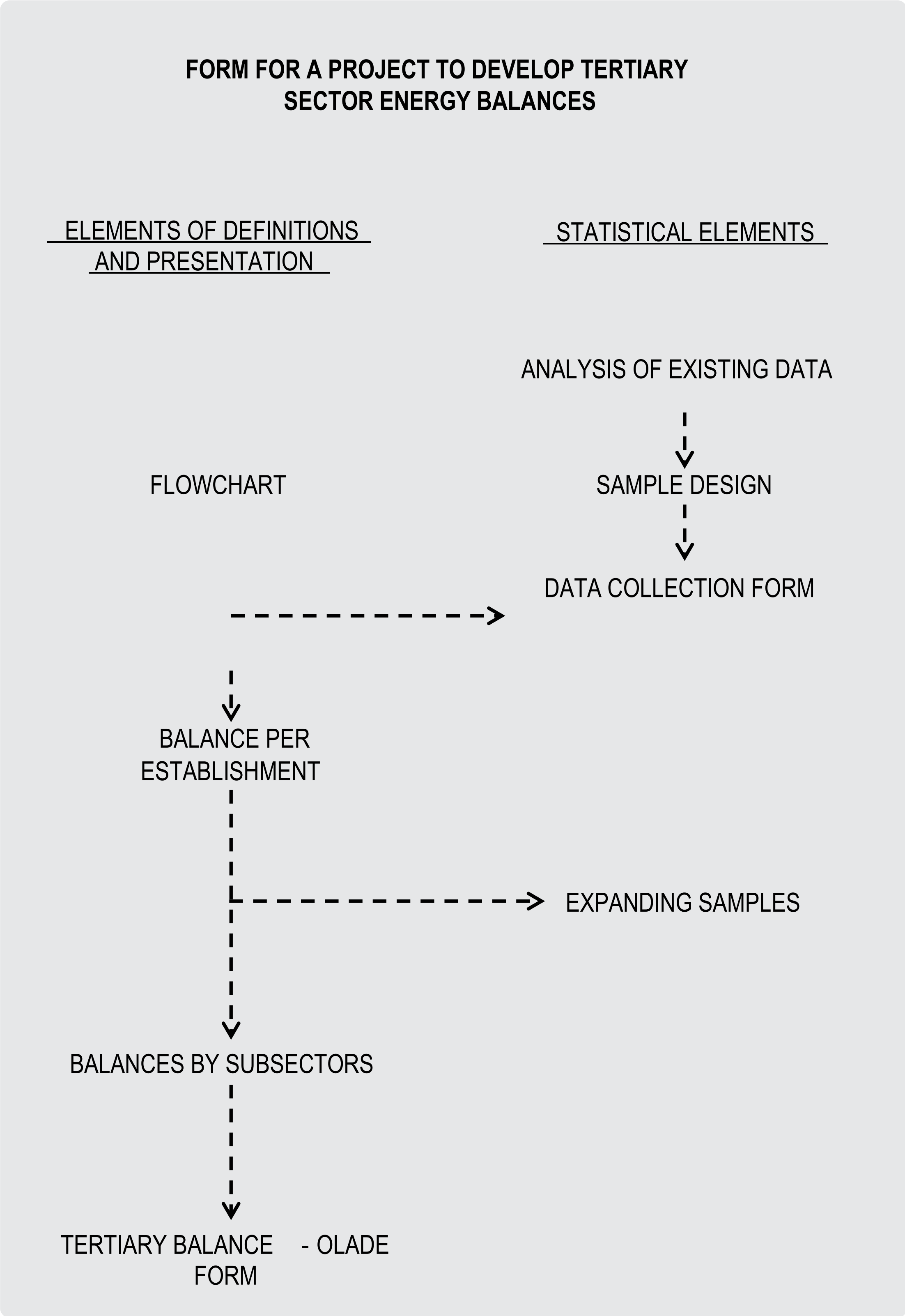
Thus, there will be 8 forms (subsectors) per country, which will be part of their own BUEs, but should not necessarily be included in the OLADE balance matrix, although they should be attached for its database.

The primary and secondary energy sources are:

Primary Energy Sources												
Primary Hydrocarbons			Mineral Sources		Direct energy				Biomass			Other primary sources
1	2	3	4	5	6	7	8	9	10	11	12	13
Crude Oil	Natural Liquids Gas	Natural Gas	Coal	Nuclear	Hydro	Geothermal	Wind	Solar	Firewood	Sugarcane, bagasse	Other biomass	

Secondary Energy Sources																	
	Oil and Natural Gas Products								Products from mineral sources			Biomass products					
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Electricity	GLP	Gasoline	Kerosene y Jet Fuel	Diesel oil	Fuel oil	Refinery Gas	Oil Coke	Other mineral products	Coal Coke	Industrial gases	Other mineral products	Charcoal	Ethanol	Biodiesel	Biogas	Other secondary sourcesras	Non - energy

The Figure below outlines the relationships between the main components of a project to build disaggregated BUEs for the tertiary sector.



5.5 DATA COLLECTION AND PROCESSING

Developing the proposed methodology that ends up with UEB development requires collecting data on the trade, service and public sector. In this regard, one must resort to the data-collection methods described in the base document, i.e., collecting secondary data, conducting surveys, preparing models, and taking measurements. Prior experience in several countries has shown that in this case, the best way to obtain the required data is using surveys and measurements. As described in section 4.4, measurements and lab work are needed to divide consumption by application for each source, in addition to information on the appliances owned and how they are used.

The measurements and other data require a sample design and survey, for which we have two important recommendations. The first is that to ensure the quality of the results, the project should have the help of a statistician, preferably with experience in the country under study, who should follow the methods and subsamples of other data surveying processes at the local official level. The second recommendation is the need for a preliminary study of the universe to be surveyed, analyzed or measured. Another feature of the sector is that the unit of study is establishments, in this case malls, schools, hospitals, government offices, etc., whose power consumption is variable, depending on the time of year or working days versus holidays.

The energy consumption of a facility is determined by the equipment inventory and its operating regime. Prior experience in several countries has shown that in this case, the best way to obtain the required data is through technical visits (with a tour of the different facilities) by experienced engineers able to interact with maintenance staff and fill out survey forms (more a personal interview than a survey), because companies keep inventories of goods rather than of equipment and power consumption profiles. So in cases where you lack have the data requested above, visiting engineers should be able to complete the inventories during the visit and request the consumption of fuels and other energy sources.

5.5.1 Prior Study of the Universe

Sources of knowledge on the universe vary from country to country and from region to region, but can be grouped into three distinct categories:

- General sources
- Energy data sources
- Equipment data sources

- ***General Sources***

The largest data source is the census of establishments in the trade, service and public sector, conducted every ten years in almost all countries. The census provides information on the number of establishments in each subsector, their sales, numbers of employees, assets and others. In addition to the census, there may be specific surveys for subsectors, hospitals, high schools, etc., which are essential to gaining a better understanding of the universe. Local sample surveys, usually conducted by local authorities, prefectures, regional bodies, and development organizations, can provide detailed information on specific regions.

- ***Sources of Energy Information***

For sources of commercial energy in general, annual BUEs are published by the appropriate ministries or departments (depending on the country, Mines and Energy, Energy, Industry and Trade, etc.). The data for this sector are usually available at varying levels of territorial aggregation or by sources, and in this case the most common is to aggregate them as residential, commercial and public. Therefore, to disaggregate them, we would have to know the separate consumption of the residential sector and subtract it.

Public and private distributors of electricity and oil products can provide consumption data by sector, and some countries may have them by subsector. Moreover, some subsectors, such as hospitals, public education and the financial sector, have special reports on sectoral features, including energy consumption.

- ***Equipment Data Sources***

Energy consumption in this sector depends heavily on the equipment used. Knowing the availability and quality of the equipment used in the country is essential to provide an initial overview of the country and complete the appropriate form. The search for data on the inventory of equipment utilized in the subsectors can be divided into two parts: number of devices and consumption characteristics.

From a quantitative viewpoint, you can review the production or importation statistics available from public bodies and commercial organizations. Trading companies also have market surveys and consumer profiles, which can help you develop profiles for establishments and establish inventories of air conditioning, heating, refrigeration, cold storage, and other commercial cooling equipment (refrigerated display cases, etc.), depending on the type of establishment, for each of the eight subsectors, to draw up hypotheses on their energy consumption.

In countries that implement energy labeling, consumption ranges are known for each category and for each electric or gas appliance on the market, as measured and certified in specialized labs.

In summary, an initial assessment in the sector may reveal three variants:

- Energy consumption is known for the sector, but not by subsector.
- Power consumption supplied by utilities is known, but not the consumption of fuel or other energy sources for each subsector.
- Energy consumption by subsector is known.

The most common cases in Latin American countries are the first and second. The second case involves having records of the electricity consumption invoiced in each subsector, together with data on fuel sales to certain establishments within the sector. This information is invaluable for sample design, especially in the case of electricity, which is the control element for expanding the sample on energy applications.

5.5.2 Guidelines for Sample Design

The sample design for consumption by application is based on the assumption that energy consumption by subsector is known and that you have the number of establishments per subsector, together with their economic variables, value added, number of employees, sales, etc. Since the sector has been disaggregated into 8 subsectors with fairly consistent consumption and a few large establishments that concentrate most consumption, we propose using a stratified sampling.

Forming the strata requires a variable that correlates with energy consumption, which for this sector could be the number of employees, the area of the establishment or its sales. The first variable seems the most suitable, being available and representing energy consumption fairly well. Other variables could be useful for expanding the findings, depending on the sector, such as the number of beds in a hospital, the number of rooms in a hotel, etc.

Once the correlated variable has been chosen, cut-off intervals should be defined to form the strata, i.e., the ranges for grouping establishments according to that variable. It is very difficult to suggest an overall mechanism for making these cut-offs, and it is better to treat each problem as a case study. For example, if some data shows that establishments with over 200 employees (400, 600, etc.) account for 60% or 70% of the sector’s added value or sales, then that group is defined as the UPPER STRATUM and must necessarily be included in the sample. The other strata are set more or less arbitrarily according to their implicit share of the variable, e.g., 200-150 employees, 150-100, 100-50, and less than 50.

It is advisable to define establishments as large, medium, small or micro, as the case may be, because the subdivision into 8 subsectors already results in 24-32 sub-populations. If the subsector consumption is unknown, you need to take simple random samples of 24 or 32 sub-populations to determine the average energy consumption and its variance. If these are unsatisfactory, then you need to increase the sample size or stratify it differently.

5.5.3 Survey Form

Since the data unit is establishments and the aim is to collect data on energy consumption per application, it is preferable to use the technique of developing a form by sections, in which each section is specialized in the record of the different energy applications in each establishment.

The contents of the form to be used in each country should be decided on once its particular situation is known. However, one can also identify referential contents, such as those shown in Tables 6 to 11 below, which cover sections A to J, thus:

- **Section A:** Specific data of the establishment (Table 60)
- **Section B:** Lighting (Table 61)
- **Section C:** Food preservation (refrigeration) (Table 62)
- **Section D:** Space conditioning (ventilation, air conditioning) (Table 62)
- **Section E:** Driving force (Table 63)
- **Section F:** Direct heat and process heat (Table 63)
- **Section G:** Office equipment (Table 64)
- **Section H:** Other equipment (Table 64)
- **Section I:** Fuels used (Table 64 and Table 65)
- **Section J:** Electricity bill (Table 65)

Table 60. Section A – Specific data of the establishment

NATIONAL SURVEY TO FINAL ENERGY CONSUMPTION SECTORS

COMMERCIAL, SERVICES, PUBLIC SECTOR SURVEY

A1. GEOGRAPHICAL IDENTIFICATION

COMMERCIAL NAME OF THE ENTITY
NUMBER OF THE ENTITY
PROVINCE ____________________
MUNICIPALITY ____________________
NEIGHBORHOOD ____________________
ADDRESS ____________________
NAME OF SURVEYED ____________________ TELEPHONE No. __________

A2. SAMPLE IDENTIFICATION

Wholesale and retail trade		
Hotels and restaurants		
Financial establishments, insurance, real estate, business services		
Public administration, defense and government		
Education		
Public Health and Social Assistance		
Water and waste, street lighting		
Other services, transport activities, communications, etc.		
Entertainment		
Government		
Other Specify		

Small (Between 1 and 9 Employees)		
Medium (Between 10 and 49 Employees)		
Large (Over 50 employees)		

Number of employees	

FINAL VISIT

DAY ....
MONTH................................
YEAR 2 0 1 6
RESULTS
01 COMPLETE INTERVIEW
02 ABSENT
03 PARTIALLY ANSWERED
04 REJECTED

NAME OF THE INTERVIEWER

CODE

RESULTS CODES:

	SUPERVISOR	CRITICAL / DIGITED IN THE FIELD BY:
NAME		
DATE		

Table 61. Section B – Lighting

SECTION E. LIGHTING

B1. What type of lighting do they use in your entity?

Type of lighting	Power Watts	Quantity	Hours of use per month
Traditional	60		
Traditional	100		
Halogen	50		
LFC (Low consumption)	15		
LFC (Low consumption)	20		
LFC (Low consumption)	35		
LFC (Low consumption)	45		
LF T12 (120 centimeters)	48		
LF T12 (200 centimeters)	96		
LF T8 (60 centimeters)	17		
LF T8 (120 centimeters)	32		
LF T5 (60 centimeters)	18		
LF T5 (120 centimeters)	54		
LED bulb	12		
LED Dicroica	7		
T8 LED (60 centimeters)	9		
T8 LED (120 centimeters)	18		
Micro LED	20		
Metal Halide	75		
Metal Halide	150		
High Pressure Sodium Lamps	50		
High Pressure Sodium Lamps	70		
High Pressure Sodium Lamps	100		
High Pressure Sodium Lamps	150		
Low Pressure Sodium Lamps	90		
Low Pressure Sodium Lamps	150		
Load spotlights	250		
Load spotlights	400		
Load spotlights	600		
Load spotlights	1000		
Load spotlights	Other		
Load spotlights	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		
Other (Specify)	Other		

Table 62. Sections C and D – Refrigeration and HVAC

C. COOLING		
C1. Do you have refrigeration equipment in your entity? Yes .... 1, ==> Continue No	Yes. Continue	
	No. Go to Question D1	

TYPE OF DEVICE	QUANTITY (No.)	Capacity (Cubic feet)	Antiquity
Fridge			
Horizontal Freezer 1 door			
Horizontal Freezer 2 doors			
Vertical Freezer 1 door			
Vertical Freezer 2 doors			
Bottle rack 1 door			
Bottle rack 2 doors			
Bottle rack 3 doors			
Cooling room			
Freezing cold room			
Refrigerated display case			
Refrigeration Racks			
LPG Refrigerator			
Water fountain (5 gallons)			
Other			
Other			
Other			
Other			

D. CONDITIONING OF SPACES		
D1. Do you have SPACE CONDITIONING equipment in your establishment?	Yes. Continue	
	No. Go to Question E1	

Type of equipment		Quantity	BTU / h capacity							Total hours of daily use
			9,000	12,000	18,000	24,000	36,000	60,000	Other (Specify)	
Fan	Pedestal									
	Ceiling									
	Table									
	Wall									
Air conditioner	Ventana									
	Traditional Split									
	Split Inverter									
	Central (Question D2)									

D2. If your entity has Central Air Conditioning System

Data of the central air system	Tons of Refrigeration Capacity	Cooled			Distribution		Antiquity	Total hours of daily use
		air	water	Other: specify	kW water pump	kW of the fan		
Equipment 1								
Equipment 2								
Equipment 3								

Table 63. Sections E and F – Driving force, direct heat and process heat

E. DRIVING FORCE

E1. Which Driving Force equipment do you USE EVERY DAY? If you do not use it go to question F1

TYPE OF DEVICE	Quantity	CAPACITY OR POWER		USE TIME in day hours
		Capacity	Unit	
Stairway				
Elevator				
Extractors				
Water pumps				
Engines				
Sewing machine				
Other (Specify)				
Other (Specify)				
Other (Specify)				
Other (Specify)				
Other (Specify)				
Other (Specify)				
Other (Specify)				
Other (Specify)				

F. DIRECT HEAT AND HEAT PROCESS

F1. What kind of direct and indirect heating equipment do you have in your entity?

Type of EQUIPMENT	Number	Capacity	Quantity							
			Laundry		Kitchen		Bars and restaurants		Common areas	
			Number	Hours of average use	Number	Total hours of use	Number	Total hours of use	Number	Total hours of use
Water Heaters LPG		Gallons								
Electric water heater		kW								
Fuel Oil furnace		BHP								
LPG Furnace		BHP								
Solar heater		m^2								
Steam washing machine		Pounds								
LPG Dryer		Pounds								
Electric Dryer		Pounds								
Steam iron										
Coffee machine		kW								
Microwave ovens		kW								
Gas stove		#Burners								
Electric stove		#Burners								
LPG Oven										
LPG Oven										
Steam kettle										
Wood burning stoves										
Charcoal cooking equipment										
Cooking Equipment										
Cooking Equipment										
Cooking Equipment										
Cooking Equipment										

Table 64. Section G, H, I – Office equipment, other equipment and fuels used

G. OFFICE EQUIPMENT

G1. What office equipment do you use EVERY DAY in your entity? If you do not use any, go to question H1

TYPE OF DEVICE	Quantity	USE TIME in DAY HOURS
Computers		
Printers		
Cash registers		
Photocopiers		
Other: specify		
Other: specify		
Other: specify		
Other: specify		

H. OTHER EQUIPMENT

H1. What other equipment you use EVERY DAY in your entity?	Yes. Continue	
	No. Go to question I1	

TYPE OF DEVICE	Quantity	CAPACITY OR POWER		USE TIME in day hours
		Capacity	Unit	

SECTION I: USED FUELS

I1. DO NOT INCLUDE VEHICLE CONSUMPTION: Do you use LPG - GASOLINE - DIESEL OIL-NG?	Yes. Continue	
	No. Go to question I2	

Used fuel	How much do you buy?			How often do you buy it ?
	Quantity	Unit	$	
LPG				
GASOLINE				
DIESEL OIL				
NG				
ANOTHER? Which one?				

I2. How many hours of electricity do you ussually HAVE every day?	Hours

I3. Do you have your own power plant?	Yes (Continue)	
	NO Go to I5	

I4 Why do you have your own plant?

High Rate	Power outages	Variations of Voltage	Do not have electricity supply	Others

Table 65. Sections I (cont.) and J – Electricity bill

I5. Mention the characteristics of the plant.

TYPE OF FUEL USED	POWER (kW)	Frequency of use			Hours of use
		Weekly	Monthly	Seldom	
GASOLINE					
DIESEL OIL					
OTHER specify					

I6. Do you have solar panels for electricity generation?	Yes. Continue	
	No. Go to question I10	

Why do you have solar panels?			
High Rate	Power outages	Variations of Voltage	Others

I7. Mention the characteristics of your solar panel.

POWER (Watts)	Do you have an accumulation battery for your panel?				Battery Capacity (Amp-h)	Cost of acquisition
	Yes		No (Go to acquisition cost)			

I8. Do you have Investors for electricity generation?	Yes. Continue	
	NO Go to J1	

POWER (kw)	Frequency of use			Hours of use per week	Approximate acquisition cost
	Balance	Weekly	Monthly		

J. ELECTRICITY INVOICE

J1. Name the rate type

BT1			MTD 1	
BT2			MTD 2	
BTH			MTH	

J2. What is the electricity bill monthly consumption (kWh) of the year 2016.

MONTH	CONSUMPTION kWh / month			
	Meter 1		Meter 2	
	$	kWh	$	kWh
LOWEST amount paid year 2016				
HIGHEST amount paid year 2016				
Monthly average				

SECTION K: Mention the share in % for each one of the uses and the efficiencies in each one, if any

Applications	Lighting		Cooking		Cooling		Air conditioner		Heating		Hot water		Others	
Energy sources:	%	η %	%	η %	%	η %	%	η %	%	η %	%	η %	%	η %
Electric power														
LPG														
Natural gas														
Other fuels														

5.6 APPLICATION: THE PARAGUAYAN CASE

As an example of implementing the methodology, we will use the 2011 UEB for Paraguay. The 2011 National Economic Census (NEC) was used as the sampling framework for the Trade, Service and Public sector. For the public sector (education, health, public administration and defense), we used the list of hospitals and public health facilities provided by the Ministry of Public Health and Social Welfare, the record of public schools provided by the Ministry Education and Culture, and the ANDE power consumption databases.

The sampling framework associated with the fields that arose from the 2011 NEC was developed by first grouping the fields by ISIC activities, then regionalizing them geographically into Metropolitan Area (Asuncion and the entire Central department) and Rest of the Country, and finally stratifying them by size, as shown in Table 66.

Table 66. Subsectors used in Paraguay

Branch	Sub-sector	Comprehended CIIU Activities
1	Commerce	45, 46, 47
2	Hotels and Restaurants	55, 56
3	Teaching	85
4	Health and Social Assistance	86, 87, 88
5	Public Administration and Defense	Doesn't Apply
6	Mail, Telecom, Water, Waste	36, 37, 38, 53, 61
7	Other Services	Other between 52 and 96
8	Street Lighting	Doesn't Apply

Source: 2011 UEB for Paraguay

The variable used to approximate the energy consumption and to stratify by size was the number of persons employed per establishment. After defining the establishments associated with each subsector to be used, we stratified them by size following the DGEEC criteria and added a smaller module for micro-enterprises. The stratification by size included the following sections:

- Large: more than 50 employees
- Medium: more than 10 and less than or equal to 50
- Small: more than 3 and less than or equal to 10

We also separated the 100 largest establishments from the database when defining the sample framework to ensure they would be surveyed, regardless of the draw. The largest 100 establishments represent less than 0.05% of the total, but account for 7.5% of all employed personnel.

We set the error at 10% for the subsector level, but at 5% and 8% for subsectors 1 and 7, respectively, due to their significance in the total sectoral share. The total sample size for this portion of the trade, service and public sector was 1,195 surveys, to which we added public education, health institutions, public administration, and defense establishments.

Public schools and health facilities were treated with a different approach, as energy consumption was estimated based on registries by establishment and the number of beds, respectively. With these representation variables, the databases were stratified and the statistics were prepared to define the sample. The sample size for establishments was 55 for the public education subsector, 33 for public health and 75 for public administration and defense. A total of 1,358 surveys were conducted in the sector. No surveys were conducted for public lighting, but consumption was obtained from the ANDE records.

5.6.1 Findings for the Sector

Table 67 shows the net energy consumption by sources and applications for the 2011 UEB.

Table 67. Net energy consumption (Ktoe) by source and application – trade, service and public sector

USES	GL	MN	DO	LE	CV	EE	Total
Lighting						45010	45010
Cooking	4226			1813	2826	5006	13871
Water heating	358			286		11970	12614
Ambient heating				11		15760	15771
Food Preservation						43771	43771
Refrigeration / ventilation						65531	65531
Water pumping						9933	9933
Shaft power						4780	4780
Other appliances	25	46	3	264		26660	26998
Internal Transportation	79	19	277			17	392
TOTAL	4688	65	280	2374	2826	228438	238671
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay

Table 68 shows the utilizable energy consumption by source and application.

Table 68. Utilizable energy consumption by source and application – entire sector

USES	GL	MN	DO	LE	CV	EE	Total
Lighting						8445	8445
Cooking	1902			275	330	4073	6580
Water heating	168			188.6		9209	9565.6
Ambient heating				2		13125	13127
Food Preservation						33671	33671
Refrigeration / ventilation						52424	52424
Water pumping						8046	8046
Shaft power						3557	3557
Other appliances	12	8	0.8	79		22436	22535.8
Internal Transportation	14	3.4	66			12	95.4
TOTAL	2096	11.4	66.8	544.6	330	154998	158046.8
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay

The average performance in the sector was 66.2%. The performance rates adopted were standard values from manufacturers' tables and technical studies, taking into account the average numbers of each type of appliance. That is, these performance rates did not come from measurements or specific energy efficiency studies.

Table 69 shows the average performance by source and by use.

Table 69. Use performance percentages (%)

USES	GL	MN	DO	LE	CV	EE	Total
Lighting						18.8	18.8
Cooking	45.0			15.2	11.7	81.4	47.4
Water heating	46.9			65.9		76.9	75.8
Ambient heating				20.0		83.3	83.2
Food Preservation						76.9	76.9
Refrigeration / ventilation						80.0	80.0
Water pumping						81.0	81.0
Shaft power						74.4	74.4
Other appliances	47.9	18.0	24.0	30.0		84.2	83.5
Internal Transportation	18.0	18.0	24.0			75.0	24.7
TOTAL	44.7	18.0	24.0	23.0	11.7	67.9	66.2
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay

Net energy consumption by subsector is shown in Table 70.

Table 70. Net energy consumption by subsector

USES	GL	MN	DO	LE	CV	EE	Total
Wholesale and retail commerce	1506	15	226	920	447	98720	101834
Hotels and Restaurants	2556	13		755	2371	44226	49921
Education	110	10	24	1		13799	13944
Health and Social assistance	185	10	30	13		11903	12141
Public administration and defense	148	0		687		6764	7599
Water and sanitation	2					7040	7042
Other services	181	15			8	31391	31595
Street lighting						14596	14596
TOTAL	4688	65	280	2376	2826	228439	238674
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay

The two largest subsectors are trade and hotels/restaurants. Table 71 and Table 72 show the performance and net energy for each subsector.

Table 71. Net energy consumption (Ktoe) by source and by application in the wholesale and retail subsector

USES	GL	MN	DO	LE	CV	EE	Total
Lighting						14673	14673
Cooking	1323			656	447	1582	4008
Water heating	167					663	830
Ambient heating						5262	5262
Food Preservation						31305	31305
Refrigeration / ventilation						31577	31577
Water pumping						744	744
Shaft power						1903	1903
Other appliances				264		10995	11259
Internal Transportation	15	15	226			17	273
TOTAL	1505	15	226	920	447	98721	101834
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay

Table 72. Performance by sources and by application in the trade subsector

USES	GL	MN	DO	LE	CV	EE	Total
Lighting						19.8	19.8
Cooking	45.0			11.5	10.0	81.8	50.2
Water heating	45.0					82.8	75.2
Ambient heating						81.8	81.8
Food Preservation						77.1	77.1
Refrigeration / ventilation						81.0	81.0
Water pumping						81.0	81.0
Shaft power						72.0	72.0
Other appliances				30.0		84.4	83.1
Internal Transportation	18.0	18.0	24.0			75.0	26.4
TOTAL	44.7	18.0	24.0	16.8	10.0	70.9	69.7
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay

Table 73. Net energy consumption (Ktoe) by sources and by application in the hotel and restaurant subsector

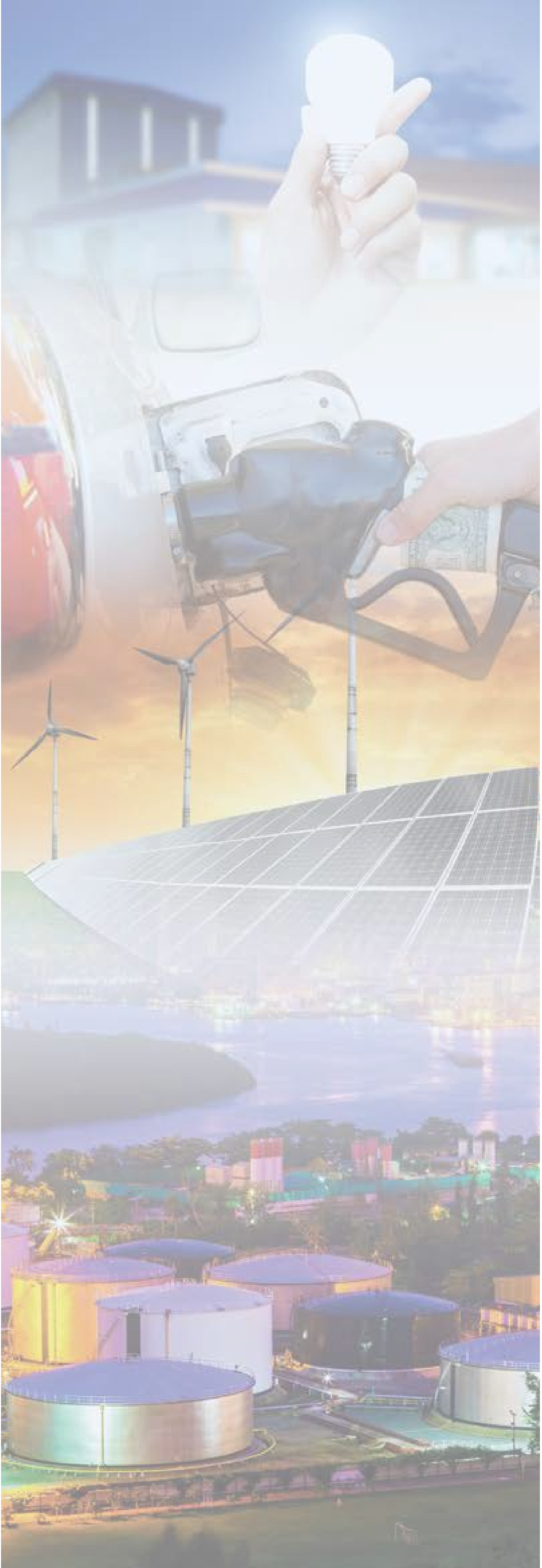
USES	GL	MN	DO	LE	CV	EE	Total
Lighting						3416	3416
Cooking	2460			703	2371	1652	7186
Water heating	97			40		8993	9130
Ambient heating				11		4491	4502
Food Preservation						9168	9168
Refrigeration / ventilation						11367	11367
Water pumping						306	306
Shaft power						863	863
Other appliances		13				3969	3982
Internal Transportation							0
TOTAL	2557	13	0	754	2371	44225	49920
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay

Table 74. Performance by source and application in the hotel/restaurant subsector

USES	GL	MN	DO	LE	CV	EE	Total
Lighting						15.1	15.1
Cooking	45.0			15.5	12.0	81.3	39.6
Water heating	45.0			10.0		75.5	74.9
Ambient heating				20.0		83.6	83.4
Food Preservation						76.0	76.0
Refrigeration / ventilation						78.8	78.8
Water pumping						81.0	81.0
Shaft power						80.0	80.0
Other appliances		18.0				81.1	80.9
Internal Transportation							
TOTAL	45.0	18.0		15.3	12.0	73.4	68.2
Legend	Liquefied Gas	Naphthas	Diesel	Firewood	Charcoal	Electricity	

Source: 2011 UEB for Paraguay



CHAPTER VI

The Farming, Mining and Fishing Sector

6. THE FARMING, MINING AND FISHING SECTOR

6.1 DISAGGREGATION BY SUBSECTOR

This sector comprises activities related to primary production using the general divisions of ISIC Code Rev. 4, Sections A and B, as follows:

- Section A: Agriculture, animal husbandry, forestry and fishing, codes 01, 02 and 03

- Section B: Extraction of metallic minerals, other mining and quarrying activities, and mining and quarrying support services, 07, 08 and 09. It excludes activities 05 and 06 of section B, pertaining to coal, oil and gas, which are included in the self-consumption sector.

  As in the industrial sector, certain activities should be filtered out to include only direct energy contents. In other words, the energy content of inputs, equipment and materials used in exploitation units are not included, being recorded in the industrial sector. For example, the energy content of inorganic fertilizers for farming or of explosives for mining will be included.
  This sector is conflictive with regard to allocating energy consumption across sectors, because the data is not entirely separate, such as mining and smelting complexes, timber extraction combined with paper pulp mills, fishing and the fish processing industry. Depending on the type of activity, therefore, each establishment or unit in the sector should be categorized in the ISIC group that includes the goods or services making up most of its gross product. For example, a business that combines tree felling with a sawmill is classified as a sawmill, and clay pits combined with brickworks are categorized as brickworks.

According to this criterion, energy consumption associated with an establishment's activity cannot be separated in the following cases, but should be included under the relevant subsector of the industrial sector:

- Agriculture from agribusiness
- Fishing from the fishing industry
- Mining from metallurgy

In summary, Table 75 shows the activities of each subsector and compares them to ISIC Rev. 4.

Table 75. Subsectors and activities

Groups Balance	CIIU Rev 4 Correspondence	Denomination of the subsector
1	1, 2	Agriculture, livestock, hunting and related service activities, forestry and logging
2	3	Fishing and aquaculture
3	7, 8	Extraction of metal ores, exploitation of other mines and quarries and support services activities

Especially in the case of subsector 3 (Mining), the following observations should be taken into account:

- Mining and quarrying include mineral extraction, processing, beneficiation and complementary activities (crushing, screening, leaching, smelting, etc.) required to prepare and extract ores and other crude minerals, and to facilitate subsequent marketing.
- In the mining business, the extraction stage ends with ore production. Ore is treated in beneficiation plants to obtain concentrates, and the percentage of the mineral is increased to different concentrations by subsequent processing (metallurgy).

Moreover, there are various types of establishments, such as large ones with integrated extraction, beneficiation and metallurgy processes, and medium to small ones with only the first two processes. Therefore, in order to disaggregate energy consumption, in addition to subsector consumption, we propose:

- Including all the energy consumption of an integrated complex
- Excluding the steel industry
- Excluding metal refining, recovery and smelting, and the production of ingots, rods, bars, tubes, etc., which are included in the industrial sector.

6.2 DISAGGREGATING BY APPLICATION

The disaggregation of energy consumption into end uses has very different characteristics depending on the subsector, technology, equipment and energy source consumed. Therefore, applications are discriminated by subsector as follows:

- **Farming and Forestry Subsector**
  - Mobile mechanical force (tractors and farming machinery)
  - Fixed mechanical force (motors, power saws, etc.)
  - Irrigation and water pumping
  - Internal transport and spraying
  - Others:
    - Refrigeration
    - Direct heat (space heating, water heating, drying)
    - Lighting

- **Fishing Subsector**
  - Mechanical force (winches or cranes, mills, saws and other motors)
  - Transportation (travel to and from fishing sites)
  - Steam (sterilization)
  - Refrigeration
  - Direct heat (water heating, drying, cooking)

- **Mining Subsector**
  - Mechanical force (power drills, shovels, rakes, conveyors, etc.)
  - Internal transport
  - Pumping
  - Lighting
  - Ventilation
  - Direct heat (drying, water heating)

6.3 FINAL ENERGY, UTILIZABLE ENERGY AND EFFICIENCY

As mentioned for the previous sectoral approaches, for each application in the three subsectors, the matter of efficiency consists of observing energy consumption in its two stages:

- Producing steam, heat, mechanical force, etc. from energy supplies
- Using that steam, heat, mechanical force, etc. in the various processes of each subsector

Therefore, there is a PRODUCTION EFFICIENCY and a USE EFFICIENCY. The product of both will give the overall efficiency or simply the efficiency. Multiplying the energy per energy supply or final energy demand by that overall energy efficiency provides the utilizable energy demand, and the difference between the two will be losses.

If only the first of these efficiencies (production) is known, multiplying it by the final demand will give us the useful demand for production, i.e., the intermediate demand. One could say that final energy is measured at the beginning of the process, and utilizable energy at the end. Both can be disaggregated by subsector, by output and by use.

The problem with determining efficiencies is that usually you only know or can estimate the first—production efficiency—taken from manufacturers' catalogs, based on certain standard values that are applied with varying degrees of rigor in different countries. This approach is believed to be sufficient when demand forecasting is focused on emphasizing ways to SUBSTITUTE the various sources that compete in a price market to meet the same amounts of intermediate demand. Under these circumstances, we are interested not so much in absolute efficiency values, but in relative values, to reflect the fact that one source is more or less efficient than another in meeting the needs of a given technology.

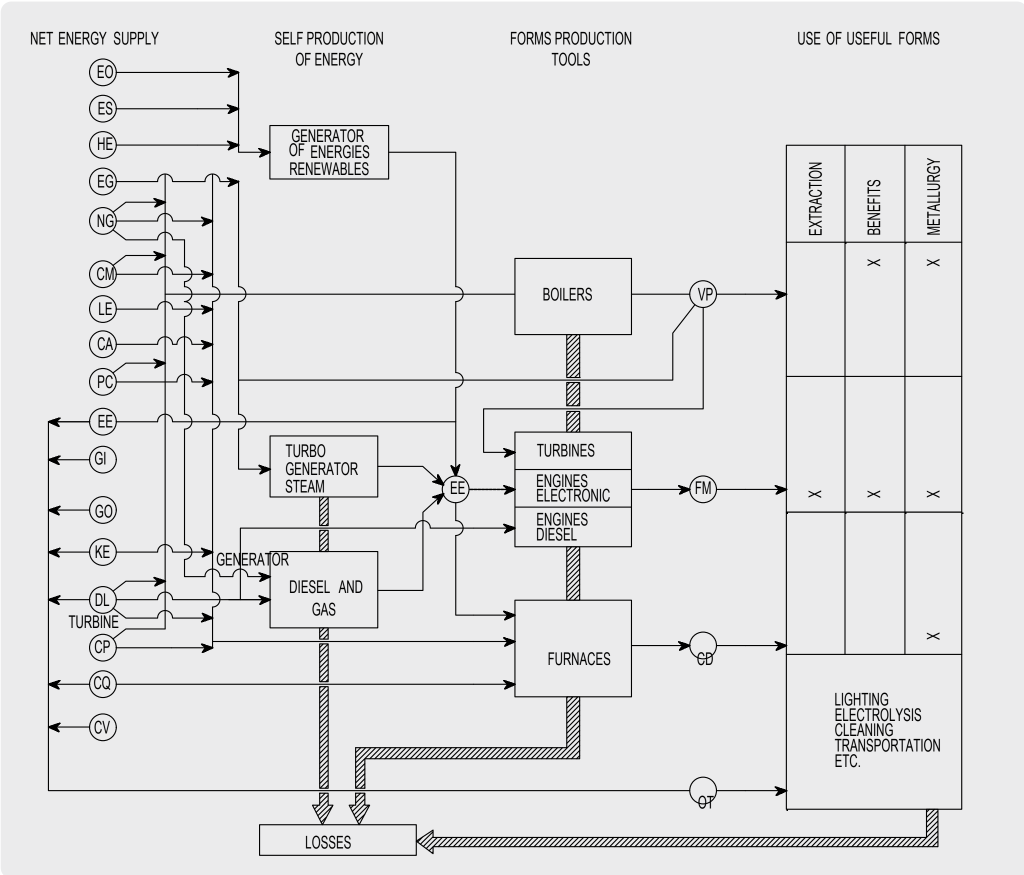
The second, use efficiency, can only be obtained through measurement, and the only way to measure use efficiency is through energy audits. Use efficiency in integrated mining-metallurgy or fishing-fish processing activities is determined by very similar energy audits to those conducted in the industrial sector. Lighting, direct heat, steam, cooling, and force applications in the three subsectors merit a similar treatment to the industrial sector.

In the farming and forestry sector, the main direct energy consumers are tractors and other farming equipment, and we know their production efficiency factors from the manufacturers and their conditions of age and maintenance. Use efficiency is complex and depends on many factors such as soil conditions (hardness, water content, density, etc.) terrain features (flat, sloping, uneven, etc.), the type of plowing or process to be performed, the depth to which the tool is inserted into the ground, the tire size and tread, etc. Therefore, use efficiencies should be studied for each type of terrain and machinery. Nevertheless, it is possible to establish certain indicators for each task, such as liters of fuel per hectare worked, and typify them according to the terrain and area, in order to establish standards for comparison.

6.4 THE UEB APPLIED TO A UNIT OF THE SECTOR

Of the three sectors analyzed, the mining subsector is the most difficult in terms of allocating consumption for transfer to the UEB. Both this subsector and the fishing/fish processing subsector can be treated similarly to industrial plants, i.e., by applying the FLOWCHART technique to the respective units following the energy conservation principle (see Figure 12). We will use the mining sector as a reference.

Figure 21. Energy balances in the mining subsector



Source: OLADE's UEB 1984 Methodology, updated

EO	Wind	CA	Sucarcane products	FO	Fuel Oil
ES	Solar	OB	Other Biomass	CC	Coke Coal
HE	Hydro energy	EE	Electric Energy	CV	Charcoal
EG	Geothermal Energy	LPG	Liquified Petrolium Gas	RC	Heat Residues
GN	Natural Gas	GM	Engine Gasoline	VP	Steam
CM	Coal	KJ	Kerosene, Jet Fuel	FM	Shaft power
LE	Firewood	DO	Diesel Oil	CD	Direct Heat
				OT	Other

Generally speaking, a metal extraction-beneficiation unit serves the dual function of purchasing and producing energy in the form of primary and secondary sources, which are then turned into useful forms as defined above (steam, direct heat, mechanical force, and other applications). PURCHASED ENERGY is disaggregated by energy source, according to those on the energy balance matrix of the net energy FEB.

NET ENERGY INPUT (NEI) is defined as the energy entering the unit, disaggregated by source, with no duplications. In many cases, the NEI will be equal to purchased energy, but to make treatment fully general, consider whether the unit sells energy, usually as electricity but sometimes as steam. These sales should be deducted from purchases. When calculating the NEI in the specific case of electricity, you can get a negative input when sales to other plants or to the public utility grid are based on self-production.

Some units may have generators with renewable energy sources such as hydro, solar, geothermal, wind, or biomass. Although these energies are not purchased, they should be included as inputs to avoid an imbalance. Some establishments produce substances with energy content as byproducts of the production process, e.g., LD (Linz Donawitz process) gas from ferro-metallurgy.

Once the NEI has been identified, its flows for each of the sources must be determined (see Figure 12). The energy input can be used primarily for DIRECT SELF-GENERATION of electricity through the renewable energy systems mentioned above or with diesel generator sets, gas turbines, or any other fuel. These fuels will be deducted, and the electricity produced added to purchases.

The second use for the input is INDIRECT SELF-PRODUCTION of electricity using steam. The situation is a bit more complicated than that, because steam is recycled from the boiler to feed the steam turbo-generators. Therefore, first you need to prepare the balance for the boiler that appears later in this flow, and then state that steam in terms of the fuels producing it, deduct the latter from the respective NEI and calculate the self-produced electricity as an input. A third use of purchased fuels (gasoline, diesel, LPG, etc.) is transport, which can be internal (forklifts and others) or external, for trucks carrying merchandise. In the latter case, this consumption does not pertain to industry but rather to transport, and must be deducted and recorded separately.

FINAL CONSUMPTION BY SOURCE is obtained by taking the NEI and adding or subtracting—as appropriate—direct and indirect self-production flows and external transport. This consumption by source can then be compared with FINAL CONSUMPTION BY APPLICATION. In the case of electricity, this can feed:

- Motors, mills, crushers, fans, compressed air, lighting or others
- Resistance ovens and other heaters

In the case of fuel, they can be used in:

- Diesel, LPG, NG or other engines
- Furnaces
- Boilers and the resulting steam can be recycled in steam turbines or centrifugal pumps for use as mechanical force.

Final consumption by source and the sum of final consumption by application should be balanced and consistent, although not equal, due to inventory variations or statistical error. An overview of these ideas is shown in a single form (Table 76)).

Table 76. Summary Form

					Final consumption and efficiency by source and usage								
Sources	Energy Input	Direct self-production through vapor	Use in transportation	Final consumption per source	Net vapor	Efficiency %	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Crude Oil												
Natural Gas Liquids		(-)										
Natural Gas		(-)										
Coal		(-)										
Nuclear												
Hydro												
Geothermal												
Wind												
Solar												
Firewood		(-)										
Sugarcane products		(-)										
Other biomass												
Other primaries												
Electricity		(+)										
LPG												
Gasoline												
Kerosene and Jet Fuel												
Diesel Oil												
Fuel Oil												
Refinery gas												
Oil coke												

					Final consumption and efficiency by source and usage							
Sources	Energy Input	Direct self-production through vapor	Use in transportation	Final consumption per source	Net vapor	Efficiency %	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Other oil and gas products												
Coal coke		(+)										
Industrial gasses												
Other products from mineral sources												
Charcoal												
Ethanol												
Biodiesel												
Biogas												
Other Secondary Sources												
Non-energy												
Total												
Intermediate consumption (production of useful sources)												
Usage efficiency												
Useful consumption												
Losses												

We start with the net energy input, which gives final consumption after subtracting or adding the self-production and transportation flows. This is disaggregated by application, and production efficiency is also given. The intermediate utilizable energy consumption is calculated at the bottom as the result of adding up the useful consumptions weighted by their respective production efficiencies. The use efficiencies (if known or calculable) are then entered, and useful consumption is calculated by multiplying the intermediate useful consumption by these efficiencies. Finally, losses are calculated as the difference between final consumption and useful consumption.

6.5 THE UEB APPLIED TO THE FARMING, FISHING AND MINING SECTOR

As seen above, virtually all the data making up the UEB for a unit can be placed in the form of a double-entry table. This sub-section shows how to present the UEB for the entire sector of a country or region. First of all, if you want to view all data making it up, the proposed disaggregation imposes a 4-entry table:

- By subsectors
- By application
- By source
- By consumption type: final, useful, efficiency and losses

Following the OLADE balance format, i.e., the list of energy sources in the columns, you can present the UEB for the industrial sector in the two double-entry forms: a main one and an auxiliary one (see Table 77 and 78). On the main form you record final consumption in the greatest detail and a summary of the useful consumption data. The auxiliary form is simply the same as the right-hand side of the table above (from the Final consumption by Source column) for each subsector.

Table 77. The main form

Self - Production					Final consumption and efficiency by source and usage							
Sources	Energy Input	Direct + COQ	"Direct	Final consumption per source	Net vapor	Efficiency %	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
self-production through vapor"	Use in trans- portation	Final con- sumption per source	Net vapor	Efficiency %	Direct heat	Efficien- cy %	Shaft power	Efficien- cy %	Other uses	Effi- ciency %		
Crude Oil												
Natural Gas Liquids												
Natural Gas												
Coal												
Nuclear												
Hydro												
Geothermic												
Wind												
Solar												
Firewood												
Sugarcane products												
Other biomass												
Other primaries												
Electricity												
GLP												
Gasoline												
Kerosene and Jet Fuel												
Diesel Oil												
Fuel Oil												
Refinery gas												
Oil coke												
Other oil and gas products												
Coal coke												
Industrial gasses												
Other products from mineral sources												
Charcoal												
Ethanol												
Biodiesel												
Biogas												
Other Secondary Sources												
Non-energy												
Total												
Intermediate consumption (production of useful sources)												
Usage efficiency												
Useful consumption												
Losses												

Table 78. The Auxiliary Form

Presentation of energy balances disaggregated for the agro, fishing and mining sector			
Sources		Primary	Secondary
Final consumption			
Subsectors (3)	Steam		
	Direct heat		
	Shaft power		
	Other uses		
Total final consumption	Steam		
	Direct heat		
	Shaft power		
	Other uses		
Useful Con-sumption	Steam		
	Direct heat		
	Shaft power		
	Other uses		
Average Efficiency	Steam		
	Direct heat		
	Shaft power		
	Other uses		

These auxiliary forms represent the final stage of data processing for the sectorial survey. The primary and secondary energy sources are:

Primary Energy Sources												
Primary Hydrocarbons			Mineral Sources		Direct energy				Biomass			Other primary sources
1	2	3	4	5	6	7	8	9	10	11	12	13
Crude Oil	Natural Liquids Gas	Natural Gas	Coal	Nuclear	Hydro	Geothermal	Wind	Solar	Firewood	Sugarcane, bagasse	Other biomass	

Secondary Energy Sources																	
	Oil and Natural Gas Products								Products from mineral sources			Biomass products					
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Electricity	GLP	Gasoline	Kerosene y Jet Fuel	Diesel oil	Fuel oil	Refinery Gas	Oil Coke	Other mineral products	Coal Coke	Industrial gases	Other mineral products	Charcoal	Ethanol	Biodiesel	Biogas	Other secondary sourcesras	Non - energy

6.6 DATA COLLECTION AND PROCESSING

Developing the proposed methodology that ends with UEB development requires collecting data on the farming, mining and fishing sector. Accordingly, you will need to use the data collection methods described in Figure 2 (p. 76), i.e., collecting secondary data, conducting surveys, developing models and taking measurements.

Prior experience in several countries shows that, in this case, the best way to obtain the needed data is through technical visits (with a tour of the appropriate units) by experienced engineers who are able to interact with maintenance staff and fill out the survey forms (more a personal interview than a survey), because companies keep inventories of goods rather than of equipment and power consumption profiles. So in cases where the data requested above is not available, visiting engineers should be able to complete the inventories during the visit and request the consumption of fuels and other energy sources.

6.6.1 Survey Forms

- *o Farming Subsector:*

Table 79. Module I. Farm Development (Part I)

MODULE I. AGRICULTURAL EXPLOITATION (Part I)

1. VOLUME OF AGRICULTURAL PRODUCTION

A) Last Agricultural Period (Year)

____

B) It was normal since the last agricultural period Yes ☐ No ☐

C) If it was not normal (drought, excessive rains, lack of labor, etc.), indicate the normal agricultural period (Year)

____

D) Mention the sown, cultivated and harvested area, for the last agricultural period, or the normal agricultural period, if the last agricultural period was not normal.

Details of the table below:

* Last Period ____________ * Normal Period ____________

Agricultural Period	Culture	Sown Area		Cultivated area		Harvested area		Production Volumen	
		Uni.	Amount.	Uni.	Amount.	Uni.	Amount.	Uni.	Amount.
Year of the survey _______ (*)									
Total									
Normal year _______ (*)									
Total									

Table 80. Module II. Farm Development (Part II)

MODULE I. AGRICULTURAL EXPLOITATION (Part II)

2. LIVESTOCK ACTIVITY

A) Is there a livestock activity on the farm? Yes ☐ No ☐

(Continue with the survey only if the answer is yes)

B) Mention whether the last year was normal or not, from the point of view of livestock production

Last year normal _________ Last year not normal _________

Year: ____________

C) What was the extension for livestock activities last year?

____

____

C) What was the livestock production?

Details of the table below regarding each year _________

Type of Livestock	EXISTENCE No. heads of cattle		AVERAGE WEIGHT Live Animal (KG)	
Breed	Year Survey ________	Normal year _______	Year Survey ________	Normal year _______
CATTLE () ( )				
SWINE () ( )				

3. WORKFORCE

	Contract workers	Days per week	Week per month	Months per year
AGRICULTURAL				
LIVESTOCK				

Shifts worked: Explain _________________

Table 81. Module II: Energy Consumption for Production (Part I)

MODULE II. ENERGY CONSUMPTION FOR PRODUCTION (Part I)

1. FARM EQUIPMENT

	Quantity	Mode. (Year) and brand.	Power (HP)	HS. Work per year	Activit. (*)		Cons. of fuel		
					Agric%	Livest%	Kind	Unit	Quantity
Tractor 1									
Tractor 2									
Harvester 1									
Harvester 2									

(*) For agricultural products indicate% of the time for each product

2. IRRIGATION

EQUIPMENT	QUANTITY	POWER		FLOW PUMP (m^3 / h)	ANNUAL HOURS OF USE	ENERGY CONSUMPTION		
		HP	KW			KIND	UNIT	QUANTITY

3. WATER PUMP FOR OTHER USES DIFFERENT FROM IRRIGATION

EQUIPMENT	QUANTITY	POWER			ANNUAL HOURS OF USE	ENERGY CONSUMPTION		
		HP	KW			KIND	UNIT	QUANTITY

Table 82. Module II: Energy Consumption for Production (Part II)

MODULE II. ENERGY CONSUMPTION FOR PRODUCTION (Part II)

4. GRAIN DRYING AND STORAGE

4.1. Part of the production for drying and storage, culture 1, culture 2, culture n.
4.2. Operating capacity of dryers or silos (m3).
4.3. Months of operation.
4.4. Energy Consumption

EQUIPMENT	POWER		ANNUAL HOURS OF USE	CONSUMPTION ESP. / hour	ENERGY CONSUMPTION		
	HP	KW			KIND	UNIT	QUANTITY

5. OTHER USES

EQUIPMENT DESCRIPTION	POWER		ANNUAL HOURS OF USE	ENERGY CONSUMPTION			TYPE OF USES Desript
	HP	KW		KIND	UNIT	QUANTITY	

6. TOTAL ENERGY PURCHASED

KIND	UNIT	QUANTITY

o Mining Subsector

Table 83. Module I. Mine Equipment and Beneficiation Plant

MODULE I. MINE EQUIPMENT AND BENEFIT PLANT

1. EQUIPMENT OF THE MINE AND PLANT OF BENEFIT

TYPE OF EQUIPMENT	QUANTITY	POWER		CAP OF PROD.		REGIME OF USE			COMB. E. ELEC.		
		HP	KW	UNIT	Amount.	DAY (HS)	MONTH (Week)	YEAR (Month)	KIND	CONSUMPTION	
										UNIT	Amount.

2. PURCHASED AND SELF-DEVELOPED ENERGY

FUELS	UNIT	QUANTITY	PAID IN THE YEAR
Natural gas			
Mineral coal			
Firewood			
EE. Purchased			
EE. Self-produced			
EE. Sold			
TOTAL EE			
Liquified gas			
Diesel Oil			
Fuel Oil			

3. FUELS USED IN SELF-PRODUCTION

EQUIPMENT	QUANTITY	INSTALLED POWER	E. PRODUCED ELECTRICITY	FUEL CONSUMPTION		
				KIND	UNIT	QUANTITY
Diesel Engine						
Gas Turbines						
Turbo Vapor						
Others						

Table 84. Module II: Integrated Complexes (Part I)

MODULE II. INTEGRATED COMPLEXES (Part I)

1. Fuels Used to Produce Steam and Steam Produced.

FUELS	UNIT	QUANTITY
Natural gas		
Mineral coal		
Other biomass		
Diesel Oil		
Fuel Oil		
Others		

	QUANTITY	PRESSURE	TEMPERATURE
High			
Average			
Low			
TOTAL STEAM IN Kcal			

EQUIPMENT IN BOILERS	KIND	CAPACITY	EFFICIENCY

Table 85. Module II: Integrated Complexes (Part II)

MODULE II. INTEGRATED COMPLEXES (Part II)

2. Direct Heat

FUELS	UNIT	QUANTITY
Natural gas		
Mineral coal		
Firewood		
Other biomass		
Electricity		
Kerosene		
Diesel Oil		

EQUIPMENT IN TYPICAL OVENS	CAPACITY	EFFICIENCY

Table 86. Module II: Integrated Complexes (Part III)

3. Driving Force

FUELS	UNIT	QUANTITY
Electricity		
Diesel Oil		
Steam		

EQUIPMENT IN ENGINES AND TURBINES	INSTALLED CAPACITY	EFFICIENCY	HOURS IN USE
Electric motors			
Diesel Engines			
Steam Turbines			

4. Other uses

FUELS (UNIT)	LIGHTING TRANSPORTATION	ELECTROLYSIS RAW MATERIAL	OTHERS (DETAIL)
Natural Gas (__________)			
Electricity (__________)			
Liquified Gas (__________)			
Gasoline (__________)			
kerosene (__________)			
Diesel Oil (__________)			
Coke (__________)			
Charcoal (__________)			

6.7 ANALYSIS OF SECONDARY DATA

An initial assessment of existing data is obviously the first step in any sample design. It should be based on a review of data from the farming census, the overall economic activity census (including the fishing and mining sectors), and special studies (sometimes partial) of the sector. The situation in each country varies according to the significance of the three subsectors analyzed here for the national economy and the modes of production detected in each subsector.

The baseline information is the total energy consumption of each subsector, the number of production facilities, and the fishing and factory ship fleet. As for total energy consumption for these subsectors, three different assessments can be presented:

- Subsector consumptions are aggregated and usually included under the industrial sector.
- Energy consumption is only known for one of the subsectors.
- Energy consumption is known for the three subsectors under review.

In the latter case, design the survey based on this referential universe to disaggregate these overall consumption rates by energy source and by application. In either of the other two cases (whether the first case where the aggregate consumption is known from the FEB but sometimes you have data to disaggregate it, or the second case where some countries only have details on one of the subsectors, such as Peru's fishing industry and Chile's mining industry), before preparing the UEB, you should invariably disaggregate it to apply a use survey and quantify the share of each energy source in each application for each subsector.

6.7.1 Guidelines for Sample Design

The guidelines for sample design proposed below for the use survey are valid if there is data on energy consumption by subsector, in addition to non-energy data on each subsector to characterize levels of economic activity. The above is also usually valid for the industrial sector due to the "law of asymmetric proportions", according to which very few establishments account for a large percentage of consumption.

On this basis, we suggest stratified sampling, taking each subsector separately and stratifying it according to its characteristics. This will clearly differentiate the makeup of the strata in the three subsectors:

- Mining Subsector: Two strata can be considered, depending on whether they are integrated establishments. That is, small and medium-size mining is separated from large-scale mining, since including the latter is obligatory and will surely concentrate a large percentage of total consumption. The two subgroups are expected to have different applications. Small-scale mining establishments that only use human and animal energy are discarded.
- Fishing Subsector: This can include two modes of production: centralized (a company with dedicated boats) and small-scale (where the only consumption is fuel for transport). In the first case, conduct a survey of the companies that must be included, and in the second, take a sample according to the number of vessels at each port.
- Farming Subsector: Most countries have disaggregated data from farm censuses, specialized surveys and data from international organizations such as the FAO.

This information refers to the following:

- Personnel employed in agricultural, livestock and forestry
- For agricultural produce, the number of farms by size
- For each crop, the number of farms and the area of irrigated and rainfed land cultivated, the physical production per crop, and the yield
- The amount of livestock by type and farm size
- The number and horsepower of tractors and agricultural machinery per farm

We suggest double stratification of this subsector into two categories: the first referring to the type of activity and the second referring to farm size. The subsector can be grouped into three activities:

- o Annual crops such as cotton, rice, corn, beans, potatoes, tobacco, wheat, barley, etc.
- o Perennial crops such as sugar cane, oil palm, coffee, fruit trees, etc.
- o Livestock production, animal husbandry and animal products such as eggs, milk, etc.

The relative importance of each of these categories depends on each country's production structure.

The second level of stratification is set according to farm size. It is difficult to determine the number of strata *a priori*, because it will depend on the specific conditions of each country. We suggest having at least three categories: large (obligatory), medium and small.

Once the share matrices have been established, to calculate utilizable energy, consider whether you have use efficiencies or only production efficiencies, whether measured or adopted. In any case, when reporting the shares of each source in each application, the efficiency and consumption of each stratum will be obtained from the utilizable energy consumption.

6.8 APPLICATION: THE BRAZILIAN CASE

To illustrate the proposed methodology, we will take the Brazilian UEB from 2004, first the farming subsector and then the mining and pelletizing subsector.

6.8.1 The Farming Subsector:

Tables 13 to 17 show the findings of the study on this subsector in Brazil.

Table 87. Final energy and share ratios by energy source and by application

Energy sources	Final Energy	Destination coefficients							
	1000 Toe	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other	Total
NATURAL GAS	1.80		0.50	0.50					1.00
STEAM COAL			1.00						1.00
METALLURGICAL COAL				1.00					1.00
FIREWOOD	2,129.50		0.45	0.55					1.00
SUGARCANE PRODUCTS			1.00						1.00
OTHER PRIMARY SOURCES			0.50	0.50					1.00
DIESEL	4,766.60	0.99	0.00	0.01					1.00
FUEL OIL	71.00		0.80	0.20					1.00
GASOLINE		1.00							1.00
LPG	20.20			1.00					1.00
KEROSENE		1.00							1.00
GAS				1.00					1.00
COKE FROM COAL				1.00					1.00
ELECTRICITY	1,281.00	0.85	0.00	0.01	1.00	0.04		0.00	1.00
CARCOAL	5.80		0.20	0.80					1.00
ETHANOL		1.00							1.00
OTHER OIL PRODUCTS			0.50	0.50					1.00
TAR			0.50	0.50					1.00

Source: UEB Brazil 2004

Table 88. Performance by energy source and by application

Energy sources	Energy Efficiency Coefficients						
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other
NATURAL GAS	0.330	0.720	0.520				
STEAM COAL							
METALLURGICAL COAL							
FIREWOOD		0.620	0.320				
SUGARCANE PRODUCTS		0.620	0.320				
OTHER PRIMARY SOURCES		0.650	0.320				
DIESEL	0.430	0.720	0.520				
FUEL OIL		0.720	0.520				
GASOLINE	0.280						
LPG	0.280	0.720	0.520		0.002		
KEROSENE	0.280	0.720	0.520		0.002		
GAS	0.330	0.720	0.520				
COKE FROM COAL							

Energy sources	Energy Efficiency Coefficients						
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other
ELECTRICITY	0.890	0.940	0.550	0.650	0.090		1.000
CARCOAL		0.620	0.320				
ETHANOL	0.34						
OTHER OIL PRODUCTS							
TAR		0.72	0.52				

Source: UEB Brazil 2004

Table 89. Utilizable energy consumption by energy source and application

Energy sources	Useful Energy Distribution								Losses
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other	Total	1000 Toe
NATURAL GAS		0.6	0.5					1.1	0.7
STEAM COAL								0.0	
METALLURGICAL COAL								0.0	
FIREWOOD		588.9	377.5					966.4	1163.1
SUGARCANE PRODUCTS								0.0	
OTHER PRIMARY SOURCES								0.0	
DIESEL	2,029.1	13.7	14.9					2,057.7	2,708.9
FUEL OIL		40.9	7.4					48.3	22.7
GASOLINE								0.0	
LPG			10.5					10.5	9.7
KEROSENE								0.0	
GAS								0.0	
COKE FROM COAL								0.0	
ELECTRICITY	970.2	2.4	5.6	83.3	4.3		2.6	1,068.4	212.6
CARCOAL		0.7	1.5					2.2	3.6
ETHANOL								0.0	
OTHER OIL PRODUCTS								0.0	
TAR								0.0	
Total	2,999.3	647.2	417.9	83.3	4.3	0.0	2.6	4,154.6	4121.3

Source: UEB Brazil 2004

In summary, the following tables are presented:

Table 90. Distribution by energy source

ARGROPECUARY SECTOR: DISTRUBUTION OF ENERGETICS			
Energy source	**Final Energy**	**Useful Energy**	**Efficiency**
DIESEL	4766.6	2057.7	0.43
FIREWOOD	2129.5	966.4	0.45
ELECTRICITY	1281	1068.3	0.83
FUEL OIL	71	48.3	0.68
OTHER	27.7	13.8	0.5

Source: UEB Brazil 2004

Table 91. Distribution by application

ARGROPECUARY SECTOR: DISTRUBUTION BY USES			
Use	**Final Energy**	**Useful Energy**	**Efficiency**
SHAFT POWER	5809	2999.3	0.52
DIRECT HEAT	1258.5	417.8	0.33
PROCESS HEAT	1030.2	647.2	0.63
OTHER	178.1	90.1	0.51

Source: UEB Brazil 2004

6.8.2 The Mining and Pelletizing Subsector

Tables 18 - 22 show the findings of the study on this subsector in Brazil.

Table 92. Final energy and share ratios by energy source and by application

Energy sources	Final Energy	Destination coefficients							
	1000 Toe	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other	Total
NATURAL GAS	228.8		0.375	0.625					1.000
STEAM COAL			0.064	0.936					1.000
METALLURGICAL COAL	602.4			1.000					1.000
FIREWOOD			0.125	0.875					1.000
SUGARCANE PRODUCTS			1.000						1.000
OTHER PRIMARY SOURCES			0.500	0.500					1.000
DIESEL	215.4	0.873	0.125	0.002					1.000
FUEL OIL	529.4		0.063	0.937					1.000
GASOLINE		0.100							1.000
LPG	28.7			1.000					1.000
KEROSENE	2.5	0.250	0.750						1.000
GAS				1.000					1.000
COKE FROM COAL				1.000					1.000
ELECTRICITY	799.1	0.924	0.015	0.040		0.020		0.001	1.000
CARCOAL				1.000					1.000
ETHANOL		1.000							1.000
OTHER OIL PRODUCTS	235.7		0.375	0.625					1.000
TAR			0.375	0.625					1.000

Source: UEB Brazil 2004

Table 93. Performance by energy source and by application

Energy sources	Energy Efficiency Coefficients						
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other
NATURAL GAS	0.330	0.780	0.550				
STEAM COAL		0.680	0.550				
METALLURGICAL COAL			0.550				
FIREWOOD		0.680	0.550				
SUGARCANE PRODUCTS		0.680	0.550				
OTHER PRIMARY SOURCES		0.680	0.550				
DIESEL	0.430	0.780	0.550				
FUEL OIL		0.780	0.550				
GASOLINE	0.280						
LPG	0.280	0.780	0.550		0.002		
KEROSENE	0.280	0.780	0.550		0.002		
GAS	0.330	0.780	0.550				
COKE FROM COAL			0.550				
ELECTRICITY	0.900	0.950	0.550	0.600	0.245	0.570	1.000
CARCOAL		0.680	0.550				
ETHANOL	0.34						
OTHER OIL PRODUCTS		0.780	0.550				
TAR		0.780	0.550				

Source: UEB Brazil 2004

Table 94. Utilizable energy consumption by energy source and application

Energy sources	Useful Energy Distribution								Losses
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other	Total	1000 Toe
NATURAL GAS		66.9	78.7					145.6	83.2
STEAM COAL								0.0	
METALLURGICAL COAL			331.3					331.3	271.1
FIREWOOD								0.0	
SUGARCANE PRODUCTS								0.0	
OTHER PRIMARY SOURCES								0.0	
DIESEL	80.8	21.1	0.2					102.1	113.3
FUEL OIL		26.0	272.9					298.9	230.6
GASOLINE								0.0	
LPG			15.8					15.8	12.9
KEROSENE	0.2	1.4						1.6	0.9
GAS								0.0	
COKE FROM COAL								0.0	
ELECTRICITY	664.5	11.4	17.6		4.0		0.6	698.1	101.0
CARCOAL								0.0	
ETHANOL								0.0	
OTHER OIL PRODUCTS		68.9	81					149.9	85.7
TAR								0.0	
Total	745.5	195.7	797.5		4.0		0.6	1,743.3	898.7

Source: UEB Brazil 2004

In summary, the following tables are presented:

Table 95 Distribution by energy source

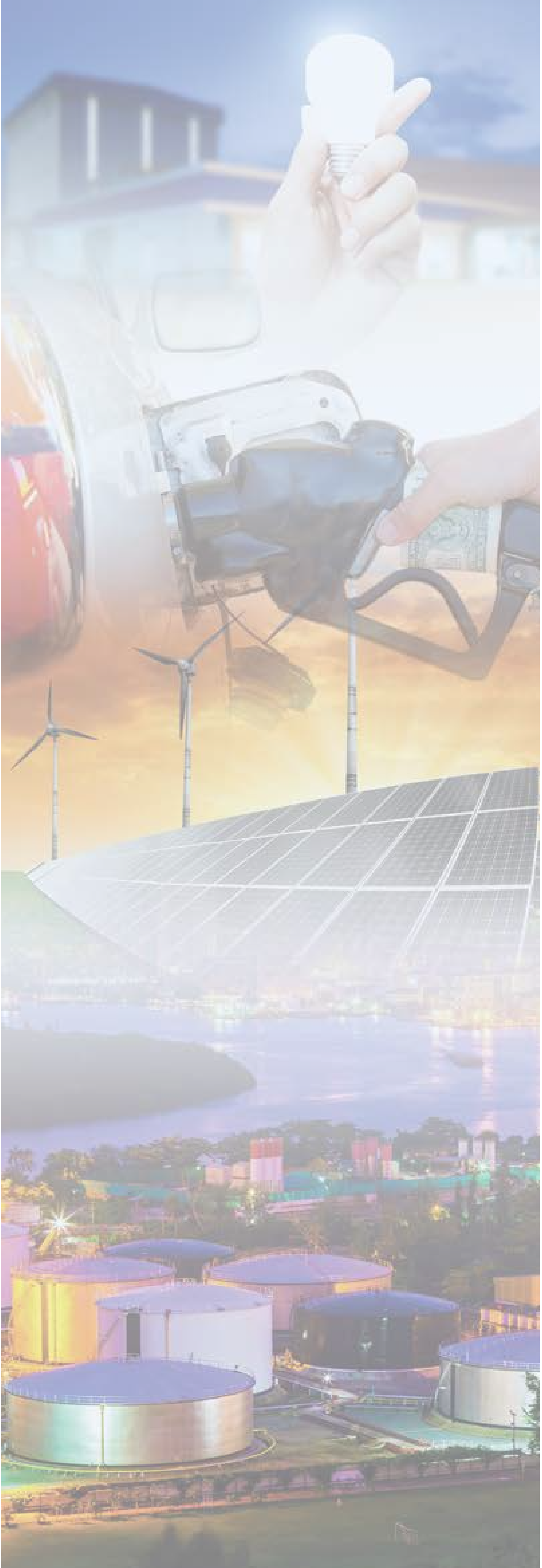
MINING AND PELETIZATION SECTOR: DISTRUBUTION OF ENERGETICS			
Energy source	**Final Energy**	**Useful Energy**	**Efficiency**
ELECTRICITY	799.1	698.1	0.87
FUEL OIL	529.4	298.8	0.56
DIESEL	215.4	102.1	0.47
OTHER	1098.1	644.3	0.59

Source: UEB Brazil 2004

Table 96 Distribution by application

MINING AND PELETIZATION SECTOR: DISTRUBUTION BY USES			
Use	**Final Energy**	**Useful Energy**	**Efficiency**
SHAFT POWER	927	745.5	0.80
DIRECT HEAT	1,449.9	797.4	0.55
PROCESS HEAT	248.3	195.7	0.79
OTHER	16.8	4.6	0.27

Source: UEB Brazil 2004



CHAPTER VII

The Self Consumption Sector

7. THE SELF-CONSUMPTION SECTOR

Unlike the previous sectors, this one addresses supply but not demand in the UEB. To facilitate data processing, it distinguishes between the two subsectors of transformation and self-consumption.

Transformation centers are traditionally treated as a balance of input and output flows, from which transformation efficiencies and losses arise automatically. This subsector does not use the concept of utilizable energy, but can achieve a better disaggregation of efficiencies and an improved database to better estimate the performance ratios associated with the technologies used.

Self-consumption pertains to supply, since forecasting techniques relate to supply models. When designing a refinery or developing oil or gas wells, self-consumption is the result of selecting conversion and production technologies, and has little or nothing to do with final demand forecasts. Nevertheless, from a UEB viewpoint, the energy sector is a major energy consumer, and its usage patterns are no different from the mining and industrial sectors. It has a dual nature, and the concept of utilizable energy is applicable to it as a consumer sector, which it is considered in OLADE's final energy balance methodology.

Finally, we should point out that inflows to conversion units are deemed raw materials and **are what is transformed**, while self-consumption is considered **what is consumed,** which can be treated like utilizable energy with its own losses in terms of use practices.

7.1 DISAGGREGATION BY SUBSECTOR

In the energy sector, self-consumption takes place at different stages, one of which is transformation and another production of primary sources and transport, although only internal transportation is considered in production or processing units. Transport via pipelines and their pumping/heating units are also included in this sector. Thus, the subsectors to be considered are:

- Transformation
- Production
- Pipelines

Self-consumption can be disaggregated by type of transformation plant:

- Oil refineries
- Public power stations
- Self-production power stations
- Gas treatment plants
- Coal plants
- Coking plants
- Alcohol distilleries
- Biodiesel plants
- Other transformation centers

Public and self-generation power stations can be divided into various types:

- Hydroelectric
- Conventional thermoelectric
  - Turbo steam
  - Turbo gas
  - Combined cycle
  - Internal combustion engines
- Co-generation plants
- Geothermal stations
- Wind farms
- Photovoltaic and solar thermal stations
- Nuclear power plants

Opening the balance by plant type is essential when developing the UEB, which should show the conversion technologies in homogenous groups. Efficiencies range from 90% for hydroelectric stations to 10%-15% for photovoltaic or solar thermal plants. We propose developing a power sector sub-balance to see the flows clearly and place the countries on an equal standing for comparison purposes. The production subsector, including pipeline transportation, can be disaggregated by energy sources, as can self-consumption:

- Oil and gas
- Coal
- Biodiesel
- Nuclear fuels
- Electricity
- Others

7.2 DISAGGREGATING BY APPLICATION

Disaggregating by application is only for the self-consumption subsector, not for the raw materials used in processing.

In the production subsector, application technologies are similar to those used in mining, with a predominance of shaft power. Higher consumption levels are recorded for natural gas, coal and oil development, related to motors and pumping equipment used for extraction, transportation and storage of those sources.

In the processing subsector, the largest consumption centers are oil refineries, distilleries and biodiesel plants, which use process heat, direct heat and mechanical force.

Transport by pipelines, as well as special cranes and trucks, conveyor belts or vehicles that are mobilized exclusively within the energy establishment, within fields, mines or within processing complexes. As long as it is only internal, it will be considered as mechanical force. In the case of consumption of fuels for external transport, it must be deducted from the own consumption in order to transfer it to the transport sector.

We propose including the following applications within the self-production sector:

- Steam or process heat
- Direct heat
- Mechanical force
- Other applications (cooling, lighting and others)

The utilizable energy demand of production centers for primary sources and energy transformation is expressed in terms of these applications or services.

7.3 FINAL ENERGY, UTILIZABLE ENERGY AND EFFICIENCY

The best way to visualize the efficiency problem in the energy sector is to see the energy consumption process as having two stages:

- Producing steam, heat, mechanical force, etc., from energy supplies
- Using that steam, heat, mechanical force, etc. in the processes of production or transformation of primary sources

Therefore, there is a PRODUCTION EFFICIENCY and a USE EFFICIENCY. The product of both will give the overall efficiency or simply the efficiency. Multiplying the energy per energy supply or final energy demand by that overall energy efficiency provides the utilizable energy demand, and the difference between the two will be losses.

If only the first of these efficiencies (production) is known, multiplying it by the final demand will give us the useful demand at the production level, i.e. the intermediate demand. One could say that final energy is measured at the beginning of the process, and utilizable energy at the end thereof. Both can be disaggregated into the two subsectors and by application.

The second (use efficiency) can only be obtained using measurements, and the only way to measure efficiency is through ENERGY AUDITS to reveal the thermodynamic parameters of the processes of transformation or transmission/transportation in extraction and mining.

Transformation has no utilizable energy, but only primary energy or inputs and secondary energy or outputs, and transformation efficiencies are the result of relating production rates to their respective feeds. Traditionally, overall efficiencies were used, but disaggregating power stations by types with their different efficiencies, and disaggregating thermal stations further by components depending on the technologies used (boilers, turbines, engines, etc.), provides a power sub-balance on an auxiliary form to identify equipment types and their performance.

7.4 THE UEB APPLIED TO A SELF-CONSUMPTION UNIT

The data units for the self-consumption sector are transformation plants and deposits, the former being comparable to industrial plants and the latter to mining facilities.

To develop the self-consumption UEB for each unit, first define the NET ENERGY INPUT (NEI) as energy entering the unit, disaggregated by source and discounting all outputs and stock variations.

This sector rarely purchases energy, but rather uses its own products, which is why it is self-consumption. However, some purchase electricity from the grid and fuel from other refineries or deposits. They may also sell self-produced power or fuel, usually for self-consumption, such as refinery gas, heavy residuum and coke.

You need to be very careful to avoid double accounting, so once you have identified the NEI, you should deduct the following:

- The fuel equivalent of the self-produced electricity
- Fuel consumption for external transport

This will give you the FINAL CONSUMPTION PER ENERGY SOURCE for each unit, disaggregated by application, and the sum of all uses should be balanced with the final consumption by source.

An overview of these ideas should be transferred to a single form (Table 97), used to record the production efficiency for each application and energy source. The total consumption by application and by energy source, multiplied by these efficiencies, enables you to calculate the so-called intermediate demand that, multiplied by the use efficiency (for each application) gives you the useful consumption and losses.

Table 97. Summary Form

					Final consumption and efficiency by source and usage							
Sources	Energy Input	Direct self-production through vapor	Use in transporta-tion	Final con-sumption per source	Net vapor	Efficiency %	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Crude Oil		(-)										
Natural Gas Liquids		(-)										
Natural Gas		(-)										
Coal		(-)										
Nuclear												
Hydro												
Geothermic												
Wind												
Solar												
Firewood		(-)										
Sugarcane products		(-)										
Other biomass												
Other primaries												
Electricity		(+)										
GLP		(-)										

					Final consumption and efficiency by source and usage								
Sources	Energy Input	Direct self-production through vapor	Use in transporta-tion	Final con-sumption per source	Net vapor	Efficiency %	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Gasoline		(-)										
Kerosene and Jet Fuel												
Diesel Oil		(-)										
Fuel Oil		(-)										
Refinery gas												
Oil coke												
Other oil and gas products												
Coal coke		(+)										
Industrial gasses												
Other products from mineral sources												
Charcoal												
Ethanol												
Biodiesel												
Biogas												
Other Secondary Sources												
Non-energy												
Total												
Intermediate consumption (production of useful sources)												
Usage efficiency												
Useful consumption												
Losses												

FINAL CONSUMPTION (AND EFFICIENCY) BY SOURCES AND USES

In special cases, where oil refineries or gas processing plants are joined to petrochemical plants, no matter how complicated it may be, you should try to prepare one form for the refinery and another for the industrial plant. In the case of coke ovens, bear in mind that the methodology for the industrial sector considers blast furnaces as part of the industry, so blast furnace gas is not considered self-consumption.

7.5 DATA COLLECTION AND PROCESSING

In order to arrive at the BEEU of the sector own consumption according to the proposed methodology, given the diversity of the sector, depending on the sector, whether private or public, it is necessary to carry out a general survey or census, or to resort to transparency mechanisms of information.

It is recommended to group the specific topics as follows:

A. Efficiencies of commercial energy transformation plants:

For transformation centers, develop per-plant material balances and calculate their efficiencies as mass performance and then as heat-flow performance. Losses in these units are mass losses expressed in calorific terms to provide the efficiency. When the facilities are very large, such as oil refineries, adjust the flow accounting methods to avoid double accounting.

For hydropower stations, efficiency is the result of relating dam potential energy to the electricity produced by generator busbars, both expressed in the same units of energy. For thermoelectric stations, an enthalpy balance is advisable, assigning electricity an enthalpic content of 860 kcal per kWh and cutting off enthalpic flows at the outlets of boilers, turbines and generators to obtain overall efficiencies.

B. Power transmission losses:

The UEB must determine precise transmission and distribution loss levels. The more exact the recorded values are, the better we can reduce them before addressing production and use efficiencies in the consumption sectors. We should also mention clandestine connections, confused with losses, but which in practice are an under-invoicing problem. In countries where loss levels are above the acceptable limits, try to improve the data and apply modern tele-measurement techniques to detect them.

C. Efficiencies of non-commercial energy transformation plants:

Non-commercial transformation plants include small-scale charcoal and coke facilities. As with other transformation plants, we recommend estimating the efficiencies by developing material balances and calorific measurements in some of the units. However, the greatest difficulty is finding the installed capacity and, consequently, the amount of primary energy consumed and secondary energy produced, since the universe is unknown. The UEB can help solve this problem, insofar as we can know the charcoal and metallurgical coke consumed, and with good efficiency data we can estimate the primary sources that feed this production.

D. Self-consumption:

Overall self-consumption amounts by source and by subsector can be obtained from production, processing and pipeline transport plants, as power companies almost always have this data.

E. Disaggregating self-consumption by application:

This disaggregation only requires applying the appropriate survey of industrial and mining applications. When surveying the industrial or mining sector, we recommend including the power sector as a required additional layer. Since self-consumption is concentrated in a few large consumers, no sampling techniques are required, as all units will be included in the sample.

7.6 APPLICATION: THE BRAZILIAN CASE

The concept of energy efficiency, as used in the Brazilian UEB, refers only to the performance of utilizable energy production. This simplification makes it easier to determine the energy efficiency of equipment used in the different sectors, but distorts the meaning of loss, since not all losses are in the production process. Losses will always be greater than the estimates, so the savings potential will be underestimated.

In 1990-1991, energy characterizations were conducted in all sectors by the FDTE (*Fundação para o Desenvolvimento Tecnológico da Engenharia*), sponsored by the PROCEL. More than 1200 large, medium and small-size companies were assessed. The version brought over from 2005 took the following studies into account:

- The 2001-2002 Uso Racional da Energia Elétrica em Pequenas e Médias Empresas do Estado de São Paulo, conducted by the Instituto de Eletrotécnica e Energia of the Universidade de São Paulo (IEE/USP), and sponsored by the SEBRAE/SP, which included field measurements.
- In 2003, through the FDTE, the Programa SEBRAE de Eficiência Energética, also with the support of the SEBRAE/SP, included an assessment of 30,000 micro-enterprises, designed to determine their energy consumption and identify the equipment used and possible measures for rational energy use.
- Data was also collected through the Secretariat of Energy Planning at the Ministry of Mines and Energy on applications in the industrial sector and others.

The findings shown below are part of Brazil's 2005 UEB. The energy sector had a final consumption of 8.6% of the overall final consumption.

Table 98, Table 99, Table 100 and Table 101 show the share of energy sources and applications in the sector's energy consumption. This refers to primary energy consumption by the production, transformation and pipeline transportation sectors.

Table 98. Energy sources used and share percentages for each use

Energy sources	Final Energy	Destination coefficients							
	1000 Toe	Shaft Power	Process Heat	Direct Heat	Refrigera-tion	Lighting	Electro-Chemical	Other	Total
NATURAL GAS	2,947.85			1.00					1.00
STEAM COAL			1.00						1.00
METALLURGICAL COAL			1.00						1.00
FIREWOOD			1.00						1.00
SUGARCANE PRODUCTS	7,460.80		1.00						1.00
OTHER PRIMARY SOURCES			1.00						1.00
DIESEL	147.55	0.95	0.05						1.00
FUEL OIL	1,039.56	0.60	0.30	0.10					1.00
GASOLINE		1.00							1.00
LPG	45.83	0.50	0.02	0.49					1.00
KEROSENE			0.50	0.50					1.00
GAS	304.44		0.80	0.20					1.00
COKE FROM COAL				1.00					1.00
ELECTRICITY	1,102.35	0.93	-			0.07		0.00	1.00
CARCOAL			0.20	0.80					1.00
ETHANOL		1.00							1.00
OTHER OIL PRODUCTS	3,360.81	0.60	0.30	0.10		0.00			1.00
TAR			0.50	0.50					1.00

Table 99. Energy performance rates for each use

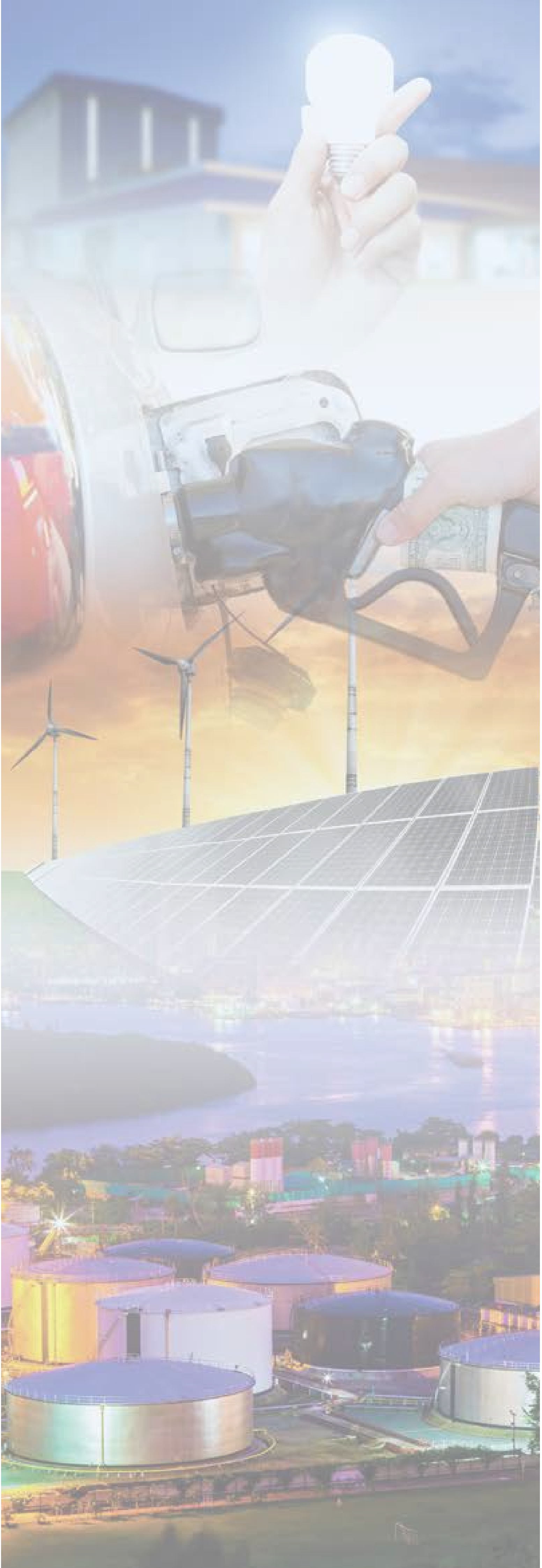
Energy sources	Energy Efficiency Coefficients						
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other
NATURAL GAS	0.480	0.880	0.900				
STEAM COAL		0.770	0.320				
METALLURGICAL COAL		0.77	0.32				
FIREWOOD		0.770	0.320				
SUGARCANE PRODUCTS		0.770	0.320				
OTHER PRIMARY SOURCES		0.770	0.320				
DIESEL	0.480	0.880	0.520				
FUEL OIL	0.480	0.880	0.520				
GASOLINE	0.280						
LPG	0.280	0.880	0.520		0.002		
KEROSENE	0.330	0.880	0.520		0.002		
GAS	0.480	0.880	0.520				
COKE FROM COAL							
ELECTRICITY	0.900	0.970	0.550	0.600	0.245		1.000
CARCOAL		0.770	0.320				
ETHANOL	0.39						
OTHER OIL PRODUCTS	0.48	0.88	0.52				
TAR		0.88	0.52				

Table 100. Utilizable energy distribution by energy source and by use

Energy sources	Useful Energy Distribution								Losses
	Shaft Power	Process Heat	Direct Heat	Refrigeration	Lighting	Electro-Chemical	Other	Total	1000 Toe
NATURAL GAS	2,947.85			1.00					1.00
STEAM COAL			1.00						1.00
METALLURGICAL COAL			1.00						1.00
FIREWOOD			1.00						1.00
SUGARCANE PRODUCTS	7,460.80		1.00						1.00
OTHER PRIMARY SOURCES			1.00						1.00
DIESEL	147.55	0.95	0.05						1.00
FUEL OIL	1,039.56	0.60	0.30	0.10					1.00
GASOLINE		1.00							1.00
LPG	45.83	0.50	0.02	0.49					1.00
KEROSENE			0.50	0.50					1.00
GAS	304.44		0.80	0.20					1.00
COKE FROM COAL				1.00					1.00
ELECTRICITY	1,102.35	0.93	-			0.07		0.00	1.00
CARCOAL			0.20	0.80					1.00
ETHANOL		1.00							1.00
OTHER OIL PRODUCTS	3,360.81	0.60	0.30	0.10		0.00			1.00
TAR			0.50	0.50					1.00
Total	2254.9	7131.3	2925.3		18.4		3.3	12333.2	4076.3

Table 101. Energy sector, energy source distribution and efficiencies

Energy source	Final Energy	Useful Energy	Efficiency
SUGARCANE PRODUCTS	7,460.80	5,744.80	0.77
OTHER OIL PRODUCTS	3,360.80	2,025.10	0.60
FUEL OIL	1,039.60	627.90	0.60
NATURAL GAS	2,947.80	2,653.10	0.90
OTHER	1,600.20	1,282.00	0.80



CHAPTER VIII

The Construction Sector

8. THE CONSTRUCTION SECTOR

8.1 DISAGGREGATION BY SUBSECTOR

This sector groups activities related to construction and civil works under the major divisions in Section F of the ISIC Code, as follows:

- Code 41: General construction activities, including the construction of entire dwellings, office buildings, stores and other local public and utility buildings, farm buildings, etc.
- Code 42: General construction of civil engineering objects such as motorways, streets, bridges, tunnels, railways, airfields, harbors and other water projects, irrigation systems, sewerage systems, industrial facilities, pipelines and electric lines, outdoor sports facilities, etc.
- Code 43: Specialized construction activities (special trades), i.e. construction of parts of buildings and civil engineering works without responsibility for entire projects. These activities usually require the use of specialized skills or equipment, such as pile driving, foundation work, carcass work, concrete work, brick laying, stone setting, scaffolding, roof covering, etc.

Due to their energy consumption and the specificity of their activities, we suggest two subsectors.

- Buildings, which includes the activities of ISIC 41, Rev. 4
- Civil engineering projects, including the activities of ISIC 42 and 43, Rev. 4

In summary, Table 102 shows the activities of each subsector and compares them to ISIC Rev. 4.

Table 102. Subsectors and activities

Groups Balance	CIIU Rev 4 Correspondence	Denomination of the subsector
1	41	Construction of houses, office buildings, warehouse premises and other public and service buildings
2	42, 43	Civil engineering works such as roads, streets, bridges, tunnels, railway lines, airports, ports and other projects. Specialized construction activities

8.2 DISAGGREGATING BY APPLICATION

From an energy standpoint, the activities included in the construction subsectors have very similar applications, with a predominance of mechanical force in both cases. Other applications, such as lighting and direct heat, participate in the two subsectors differently. For the UEB, we propose the following applications in this sector:

- Mechanical force
- Direct heat
- Lighting

In the case of the civil works subsector, driving force relates to specialized machinery, graders, bulldozers, power shovels, bulldozers, mixers, etc. In the case of housing and building construction, it is associated with smaller equipment such as mixers and tower cranes with horizontal or collapsible jibs. The use of lighting will depend on the project type and the working conditions, and will be more intense when building tunnels and underground railway lines than for other works. Direct heat is used to heat and prepare tar or asphalt for paving roads or other works. Other equipment, such as compressors for pressure filling or concreting and integrated mixer trucks, will be deemed driving force.

8.3 FINAL ENERGY, UTILIZABLE ENERGY AND EFFICIENCY

As mentioned for previous sectoral approaches, for each use in the three subsectors, the efficiency matter consists of observing the energy consumption process as having two stages:

- Producing mechanical force, heat, light, etc. from energy sources
- Using mechanical force, heating, lighting, etc. in the different processes of each subsector

Therefore, there is a PRODUCTION EFFICIENCY and a USE EFFICIENCY. The product of both will give the overall efficiency or simply the efficiency. Multiplying the energy per energy supply or final energy demand by that overall energy efficiency provides the utilizable energy demand, and the difference between the two will be losses. If only the first of these efficiencies (production) is known, multiplying it by the final demand will give us the useful demand at a production level, i.e. the intermediate demand. One could say that final energy is measured at the beginning of the process, and utilizable energy at the end thereof. Both can be disaggregated by subsector, by output and by use.

8.4 THE UEB APPLIED TO A UNIT OF THE SECTOR

The energy balance study applied to a large construction project is of particular significance, because the company can purchase and produce primary or secondary energy, which will then be transformed into useful forms. These energy sources can be disaggregated according to the matrix suggested in
Table 103.

NET ENERGY INPUT (NEI) is defined as the energy entering the unit, disaggregated by source, with no duplications. In many cases, the NEI will be equal to the purchased energy, but to generalize the treatment, consider cases where the company generates its own electricity. Unlike other sectors, here we do not consider the alternative that the company sells energy to third parties.

In this sector, self-production is direct through sets of diesel or gas turbines, in which case fuel purchases for self-production should be discounted, and self-produced electricity added to what is taken from the public utility grid. Energy sources used in transport (to move materials) outside of the works will be included in the transportation sector. Only fuels used for internal transport or to move construction machinery will be included under driving force in the sector.

FINAL CONSUMPTION BY SOURCE is obtained by taking the NEI and adding or subtracting—as appropriate—direct self-production flows and external transport. This can then be compared to FINAL CONSUMPTION BY APPLICATION. Final consumption by source and the sum of final consumption by application should be balanced and consistent, although not equal due to inventory variations or statistical error.

An overview of these concepts is summarized in a single form (Table 103).

Table 103. Summary Form

			Final consumption and efficiency by source and usage							
Sources	Energy Input	Direct self-pro-duction	Use in internal transpor-tation	Final consump-tion per source	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Crude Oil										
Natural Gas Liquids		(-)								
Natural Gas		(-)								
Coal		(-)								
Nuclear										
Hydro										
Geothermic										
Wind										
Solar										
Firewood		(-)								
Sugarcane products		(-)								
Other biomass		(-)								
Other primaries										
Electricity		(+)								
GLP										
Gasoline										
Kerosene and Jet Fuel										
Diesel Oil		(-)								
Fuel Oil		(-)								
Refinery gas										
Oil coke										
Other oil and gas products										
Coal coke										
Industrial gasses										
Other products from mineral sources										
Charcoal										
Ethanol										
Biodiesel										
Biogas										
Other Secondary Sources										
Non-energy										
Intermediate consumption (production of useful sources)										
Usage efficiency										
Useful consumption										
Losses										

It starts with the net energy input, which gives final consumption after subtracting or adding the self-production and transportation flows. This is disaggregated by application, and production efficiency is also given. The intermediate utilizable energy consumption is calculated at the bottom as the result of adding up the useful consumptions weighted by their respective production efficiencies. The use efficiencies (if known or calculable) are then entered, and useful consumption is calculated by multiplying the intermediate useful consumption by these efficiencies. Finally, losses are calculated as the difference between final consumption and useful consumption.

8.5 THE UEB APPLIED TO THE CONSTRUCTION SECTOR

As seen above, virtually all the data making up the UEB for a unit can be placed in the form of a double-entry table. This sub-section shows how to present the UEB for the entire sector of a country or region. First of all, to view all the data making it up, the proposed disaggregation imposes a 4-entry table:

- By subsectors
- By application
- By source
- By consumption type: final, useful, efficiency and losses

Following the OLADE balance format, i.e., the list of energy sources in the columns, you can present the UEB for the industrial sector in two double-entry forms: a main one and an auxiliary one.

On the main form you record final consumption in the greatest detail and a summary of the data on useful consumption. The auxiliary form is simply the same as the right-hand side of the table above (from the Final consumption by Source column) for each subsector.

Table 104. Main Form

			Final consumption and efficiency by source and usage							
Sources	Energy Input	Direct self-pro-duction	Use in internal transpor-tation	Final consump-tion per source	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Crude Oil										
Natural Gas Liquids										
Natural Gas										
Coal										
Nuclear										
Hydro										
Geothermic										
Wind										
Solar										
Firewood										
Sugarcane products										
Other biomass										
Other primaries										
Electricity										
GLP										
Gasoline										
Kerosene and Jet Fuel										
Diesel Oil										

			Final consumption and efficiency by source and usage								
Sources	Energy Input	Direct self-production	Use in internal transportation	Final consumption per source	Direct heat	Efficiency %	Shaft power	Efficiency %	Other uses	Efficiency %
Fuel Oil										
Refinery gas										
Oil coke										
Other oil and gas products										
Coal coke										
Industrial gasses										
Other products from mineral sources										
Charcoal										
Ethanol										
Biodiesel										
Biogas										
Other Secondary Sources										
Non-energy										
Intermediate consumption (production of useful sources)										
Usage efficiency										
Useful consumption										
Losses										

Thus, there will be 2 forms per country, which will form part of their own BUEs, but should not necessarily be part of the OLADE balance matrix, although they should be attached for the OLADE database.

Table 105. Auxiliary Form

Presentation of energy balances disaggregated for the construction sector			
Sources		**Primary**	**Secondary**
Subsectors (2)	Direct heat		
	Shaft power		
	Lighting		
Total final consumption	Direct heat		
	Shaft power		
	Lighting		
Useful Consumption	Direct heat		
	Shaft power		
	Lighting		
Average Efficiency	Direct heat		
	Shaft power		
	Lighting		

These auxiliary forms are the final stage of data processing for the sectoral survey. The primary and secondary energy sources are:

Primary Energy Sources												
Primary Hydrocarbons			Mineral Sources		Direct energy				Biomass			Other primary sources
1	2	3	4	5	6	7	8	9	10	11	12	13
Crude Oil	Natural Liquids Gas	Natural Gas	Coal	Nuclear	Hydro	Geothermal	Wind	Solar	Firewood	Sugarcane, bagasse	Other biomass	

Secondary Energy Sources																	
	Oil and Natural Gas Products								Products from mineral sources			Biomass products					
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Electricity	GLP	Gasoline	Kerosene y Jet Fuel	Diesel oil	Fuel oil	Refinery Gas	Oil Coke	Other mineral products	Coal Coke	Industrial gases	Other mineral products	Charcoal	Ethanol	Biodiesel	Biogas	Other secondary sourcesras	Non - energy

8.6 DATA COLLECTION AND PROCESSING

Developing the proposed methodology that ends with UEB development requires collecting data on the construction sector. In this regard, one must resort to the data-collection methods described in the base document, i.e., collecting secondary data, conducting surveys, preparing models, and taking measurements.

This sector has special features, being made up of companies operating discontinuously and with differing intensities over time. Therefore, a field study is needed to characterize some of the specific energy consumption indicators, such as kWh/m^2 of construction or gal/m^2 of fuel, or others that will give us consumption. These indicators can be specified by type of construction: dwellings (houses, apartments, etc.), office buildings, business establishments, etc. In the case of civil works, there will be other indicators per km of track and by road type, project type, etc., which can be developed from surveys and on-site measurements (energy audits) in companies of the sector.

8.6.1 Survey Forms

The contents of the form to be used in each country should be decided on after understanding its particular situation, but it is possible to determine a reference content such as that shown in
Table 106 to Table 109 that include four different modules.

Module I shows general company data, such as number of projects implemented, square meters built, number of employees, hours worked in the year, etc.

Table 106. Module I. Characteristics of the construction company

MODULE I. CHARACTERISTICS OF THE CONSTRUCTION COMPANY

In 2016, what were the main projects carried out?

Nº	Types of project	Location City	Number of units	Square meters built
I	Construction of houses (houses)			
2	Construction of houses (buildings)			
3	Building Construction			
4				
5				
6				
7				
8				
9				
10				
11				
12				

Hours worked per day	Days worked per month	Months worked											
		Jan	Feb	March	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Average number of employees in 2016	

Module II records the movements of energy purchases and self-production, which makes it possible to calculate the net energy input (NEI).

Table 107. Module II. Purchased and self-produced energy

MODULE II. TOTAL PURCHASED AND SELF-DEVELOPED ENERGY
FUELS

What were the total purchases of fuels in 2015?

FUEL TYPE	UNIT OF MEASURE	AMOUNT PURCHASED OR OBTAINED	VARIATION OF STOCK 1 /	ORIGIN OF THE PURCHASE OR OBTAINMENT OF FUEL			
				EDS Purchase		Purchase to the Distributor	Purchase to others. To who?
Gasolines	(Kgal / year)						
Kerosene	(Kgal / year)						
Diesel Oil	(Kgal / year)						
Fuel Oil	(Kgal / year)						
Petroleum liquid gas	(Kgal / year)						
Charcoal	(Tm / year)						
Firewood	(Tm / year)						
Cane products	(Tm / year)						
Natural gas	(m3/ year)						
ANOTHER? Which one?							

1/ It is the existence of the fuel as of December 31, 2014, deducted from the existence, as of December 31 of the previous year.

SELF-GENERATION

A1. Does the company have Autogeneration	Yes. (Go to question A2.)	
	No. (Go to question A3.)	

A2. Frequency of self-generation	Average hours per week
SCHEDULED	
CONTINUOUS	
EMERGENCY	

A3. Indicate the following characteristics of the self-generating plants

PLANT	Used fuel								Installed power	Yield. Average kWh per gallon	Operation time
	LPG	Gasoline	Kerosene and Jet Fuel	Diesel	Fuel Oil	Coke	Coal	Other biomass			
Floor 1											
Floor 2											
Floor 3											
Floor 4											
Floor 5											

Module III includes power and transport equipment using electricity or fuel, as well as electricity or fuel consumption.

Table 108. Module III. Power equipment used

MODULE III: FORCE EQUIPMENT USED

B1. MOTOR POWER FORCE EQUIPMENT

Electric power equipment	Active Amount	Power (weighted average)		Hours of average use per week	EFFICIENCY %	Fuel consumption
		kW	HP			Gal / hour
Fixed tower cranes						
Mobile tower cranes						
Mixer						
Engines						
Bulldozers						
Motor Graders						
Mechanical shovels						
Another? which one?						

TRANSPORTATION WITHIN THE PROJECT

Specify the fuel consumption of the Transport Vehicles for mobility within the Project

No	FUELS	UNITS 1 /	TOTAL CONSUMPTION IN 2015
1	Gasolines	(gal/year)	
2	Diesel		
3	LPG		
4	Natural gas		
5	Other*		

* 1 / If the unit is different,please mention it; 2 / If it is Batteries, ask Number per year and Voltage.

Modules IV and V record other applications (lighting and direct heat) and electricity consumption from the public grid.

Table 109. Modules IV and V. Other applications and electricity consumption

MODULE IV: OTHER USES

C1. LIGHTING EQUIPMENT

Type of lighting	Active Amount	Installed Power kW	Hours of average use per week
Spotlights			
Incandescent lights			
LEDs			
LFCs			
Another? which one?			

C2. DIRECT HEAT EQUIPMENT

Type of lighting	Active Amount	Installed Power kW	Hours of average use per week	Fuel Consumption (Gallons - hour)
Furnaces				
Burners				
Stove				
Another? which one?				

MODULE V: ELECTRICITY CONSUMPTION

How many hours of electricity do you ussually HAVE every day?	Hours

Determine the Electric Power and Power Billings in the previous year	TOTAL BILLED ELECTRIC ENERGY		kWh/o $
	MAXIMUM POWER (If applicable)		kW
	MAXIMUM AVERAGE POWER		kW

Distributor Company, Generator, Industrial Park or Other Supplier		Other	

Name the type of customer	
Not regulated	
Regulated	

Name the rate type	
BTS-1 = Low Simple Voltage 1	
BTD = Low Demand Voltage	
BTH = Low Voltage with Time Demand	
MTD-1 = Medium Voltage with Demand 1	
MTH = Medium Voltage with Time Demand	

8.7 ANALYSIS OF SECONDARY DATA

An initial review of existing data is obviously the first step in any sample design. This assessment should be based on analyzing data from chambers of construction on total square meters built for each type of building. Public works offices of (Ministry of Works, municipalities, etc.) may also have data on completed and ongoing projects. The baseline information is the total energy consumption of each subsector and the number of construction companies.

As for total energy consumption for the subsectors, three different assessments can be presented:

- Subsector consumption is aggregated and usually included under the construction sector.
- Energy consumption is known for only one of the subsectors.
- Energy consumption is known for the two subsectors under review.

In the latter case, design the survey from this referential universe to disaggregate these overall consumption rates by energy source and by application. In either of the other two cases (whether the first case where the aggregate consumption is known from the FEB but sometimes you have data to disaggregate it, or the second case where some countries only know one of the subsectors in detail), before preparing the UEB, you should invariably disaggregate it in order to apply a use survey and quantify the share of each source in each application for each subsector.

8.7.1 Guidelines for Sample Design

The guidelines for sample design proposed below for the use survey are valid if you have data on energy consumption by subsector in addition to non-energy data for each subsector to characterize the levels of economic activity. The above is usually also valid for the industrial sector due to the “law of asymmetric proportions”, according to which very few companies account for a large percentage of consumption.

On this basis, we suggest stratified sampling, taking each subsector separately and stratifying it by its characteristics. This will clearly differentiate the makeup of the strata in the two subsectors. As in the other sectors studied, the stratification variable may be the number of employees, the total m^2 built or the total sales for past year.

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
Uruguay
Venezuela
Algeria (Participant Country)

Energy unites us

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