OLADE METHODOLOGY FOR THE ELABORATION OF

ENERGY BALANCES IN TERMS OF USEFUL ENERGY (BEEU)

CEE OLADE ONU-DTCD

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S E C T O R A L A P P E N D I C E S

INTRODUCTION

The uneven development of energy planning instruments observed in Latin America led OLADE to propose the execution of a program of energy balances for the region, at the X Meeting of Ministers, held in Panama in December 1979.

The scope and significance of this program was widely accepted, and it constitutes an indispensable element for fostering energy planning in the Member Countries, thus facilitating their cooperation and integration.

Along this vein, and in order to comply with the ministerial mandate expressed in Panama, OLADE developed a methodology for the elaboration of energy balances in terms of final energy (BEEF) for the Latin American and Caribbean area, for the purpose of unifying criteria and facilitating, in addition, the work of technicians and researchers in the field of energy; this methodology has been developed fundamentally for use by the countries of the region and for the region itself, but it can obviously be applied at the subregional and continental levels.

Currently, 25 of the OLADE Member Countries have an historical time series of energy balances, which has been of great utility especially in those countries in which this tool of analysis and energy planning had not been available previously.

In the current state of development of the BEEF-OLADE, the sources of energy are converted into their energy equivalent from the primary level up through final energy consumption. In other words, they do not cover losses at the level of final consumers.

The OLADE methodology for elaboration of BEEF has been adequate for the requirements of information indispensable for analysis of the energy sector. However, given the need to broaden the energy picture and to delve into greater depth in certain aspects of importance for system management, the energy balance requires an evolution compatible with the infrastructure and basic requirements for information in the region.

The current matrix of the BEEF-OLADE has been enhanced due to the needs of economic and energy analyses at the national and regional levels. Recent trends in energy policy call for more detailed knowledge about the amount of energy actually used both in producing energy and in satisfying the needs of final consumers.

The concepts of rational use of energy, substitution among energy sources, and projection and analysis of energy demand merit in-depth accounting of the energy losses occurring during the processes of transformation and actual consumption, i.e., determination of the "useful energy" available in the processes of production of goods and services, as well as that destined for satisfying household needs.

Therefore, headway must be made in methodological efforts in order to broaden the current structure of the OLADE energy balance and to be able to satisfy the present requirements of more effective energy analysis through the calculation of useful energy as a function of the equipment used and the sources consumed in each one of the end-uses for which energy is required.

The methodology presented herein was the effort of a group of professionals from the Member Countries and from national and international organizations which have been developing a methodology for the incorporation of useful energy into the energy balance. It also includes the observations made during the International Seminar for the Presentation of the OLADE Methodology for Elaboration of Energy Balances in Terms of Useful Energy, held in Sao Paulo in August 1986. This has resulted in a method that not only considers the experience gained in past endeavors but which also goes further, to incorporate new definitions and treatments.

An attempt was made to develop a methodology for elaborating the energy balances in terms of useful energy (BEEU), these being an instrument which would serve as a basis for energy planning and its relations with rational use of energy and substitution among sources.

Energy balances constitute one of the instruments for organizing and presenting part of the information needed for energy planning. If the planning process is broken down into the stages of gathering and organization of information, energy assessment, preparation of projections and an effective planning process for the future system, energy balances are then found in the first and second stages.

Although BEEU have a broader scope than BEEF-- since, as will be seen, they disaggregate the sectoral consumption of the different energy sources by subsectors, energy uses and equipment-- they only provide part of the information required for energy planning, since the latter also calls for another type of information, on both the energy system and the socioeconomic system as a whole. Actually, from the standpoint of the energy system, for the analysis of demand, it may be necessary to have information on consumption indicators, information derived from case studies, information on the behavior of economic variables and information of an institutional nature.

In the assessment phase, an explicative analysis of the current situation and the past evolution of the energy system is done, as well as of its relations with the overall system. BEEU are an instrument which permits the detection of the principal bottlenecks and/or constraints in the energy system, the solutions for which may be based on special studies on demand (analysis of explicative variables, determining factors, homogeneous modules,...), supply, energy policies, the institutional system, the productive system and the decision-making process.

To arrive at BEEU, two stages must necessarily be completed: the first is the disaggregation of final consumption by subsectors and by uses and, the second, is the assignation of efficiencies to these aggregates. Without doubt, the first stage leads to more detailed knowledge about final energy consumption and, hence, is an instrument of great utility for demand projections.

The transformation of these aggregates into useful energy consumption and losses takes on importance when what is desired is to put in evidence the policy of substitution among sources, rational use of energy and the analysis and projection of demand. The effort to be made in preparing BEEU is thus intimately tied to the scope of the instruments of analysis and projection of needs which are available to a country. Therefore, an important amount of information contained in the BEEU will be indispensable, but there will also be another type of information, not contained in the BEEU (which has been compiled for their preparation), which is also indispensable. For the sake of illustration, mention can be made of any type of demand analysis done (whether aggregated or disaggregated), the consumption of the different branches of industry, by units of physical production, unit of value added, specific consumption in Kcal/inhabitant according to geographical regions, income levels, urban or rural zones, etc.

With respect to rational use of energy, the measures to be implemented at the level of sectors, subsectors or establishments require much more detailed information, which normally does not appear in the balance. However, this is the only instrument apt for detecting the demand aggregates most sensitive to programs of rational use and the impact that such programs would have at the national or regional level.

For the elaboration of policies such as those for pricing, substitution among sources, conservation and rational use, the BEEU facilitate analysis and permit a better definition of the spheres in which such policies would have an effect by providing more refined and homogeneous consumption aggregates.

In summary, although the BEEU in themselves do not constitute a direct instrument for the above-mentioned actions, the data needed for their elaboration, together with other information, provide the basis for analyses that will permit suitable actions. The advantage of energy balances, and particularly BEEU, is their organized presentation, which calls for controlled coherence in the data, thus permitting the relation with other systems for describing economic reality such as the national accounts; under certain conditions, international comparisons; and construction of a database or coherent information system with the objectives of the proposed analysis.

It is worthwhile to note that the methodology presented herewith, the consolidated format, and the common unit of aggregation do not intend to limit the field of action of the different countries in the elaboration of their national balances. Obviously, each country is free to adopt a greater or lesser degree of disaggregation than that proposed, or any other unit other than the one given.

What is desired is to provide a broad, common methodology for all of the countries of Latin America, permitting preparation of a "consolidated regional balance" and, thus, to facilitate the task of comparisons within the area and with other regions of the world, while formulating a methodology flexible enough to be applicable to the different characteristics and particularities of the energy systems of the Latin American countries.

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CHAPTER I

DEFINITIONS AND BASIC CONCEPTS

1. Definition of Useful Energy

The methodology to be used in preparing energy balances in terms of useful energy (BEEU) must necessarily begin by defining the concept of Useful Energy (UE) which will be adopted.

Although it is universally accepted that Final Energy (FE) is that which is put at the disposal of the consumer, the energy source in question must almost always undergo some transformation in order to attain the form of energy suitable for the use required by the consumer. It is also known that the end-uses of energy are to do work or obtain heat for given physical and chemical processes. Each one of the sources of energy apt for these end-uses is obtained by means of simple or complex transformations (*) of Final Energy.

The fact that there is no unique and universally accepted definition for useful energy led to the consideration of the different options which exist, before finally arriving at the one adopted by the present methodology.

One of the most widely accepted definitions of useful energy in the specialized literature is:

"the energy available to the consumer after its final conversion" (**).

For the concept of useful energy which will be used in the OLADE methodology, it was considered worthwhile to add to the foregoing definition other elements which should be taken into account:

(1) the existence of OTHER PROCESSES which occur between the last conversion and the useful energy available and which, although do not entail modifications in the physical state, do generate losses; and

(2) the existence of SYSTEMS OF USE for the different forms of intermediate energy.

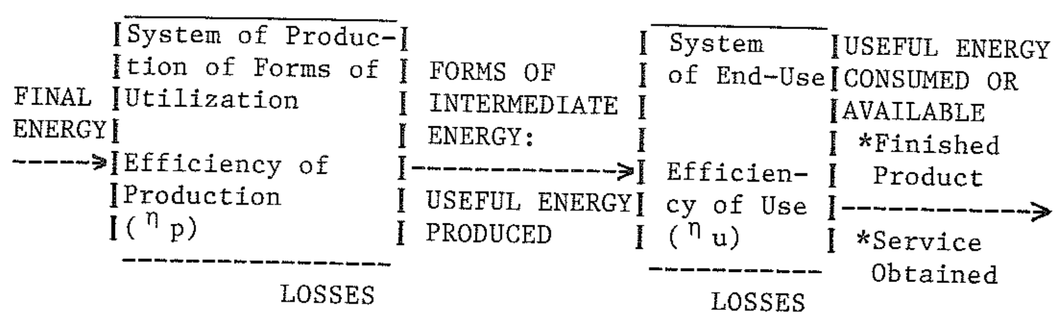
(*) Energy transformation or conversion is understood as "energy production with a modification of the physical state of the energy agent".

(**) "World Energy Conference Glossary of Energy Balances and Accounting," Pergamon Press, page 5. This definition can also be found in EUROSTAT, "Useful Energy Balance-Sheets 1975", Belgium 1979, page 22.

With the foregoing, an attempt is made to underline that, after the final conversion, useful energy (INTERMEDIATE ENERGY) is obtained; this form is not yet fully available for the production of goods or the satisfaction of needs (rendering of services), since the use of this Intermediate Energy will depend on the efficiency of other processes and on the greater or lesser efficiency of the available system of utilization.

Figure 1 schematically represents the proposal for evaluating available useful energy (AUE) as the energy available after the system of use, for the production of goods or the satisfaction of needs. As examples of systems of use, steam distribution pipes, mechanical energy transmission systems, or wall insulation in space conditioning, etc., may be cited.

FIGURE 1



This definition is to a certain extent implicit in the aforementioned glossary, which, in defining the useful-energy balance, reads as follows:

"Balance established on the basis of accounting for the different energy flows, according to their net calorific value, from the primary supply to the useful energy recovered by the final consumer at the outlet of his devices, making appear the losses suffered in the different phases of transformation and consumption. Since there is no effective measure of useful energy, this balance is in fact a balance derived from the final-energy balance since it actually accounts for consumption at the level of final energy, applying the average or estimated efficiencies of the last device in the transformation and assuming sound knowledge about the park and its efficiencies, which can vary in important proportions.

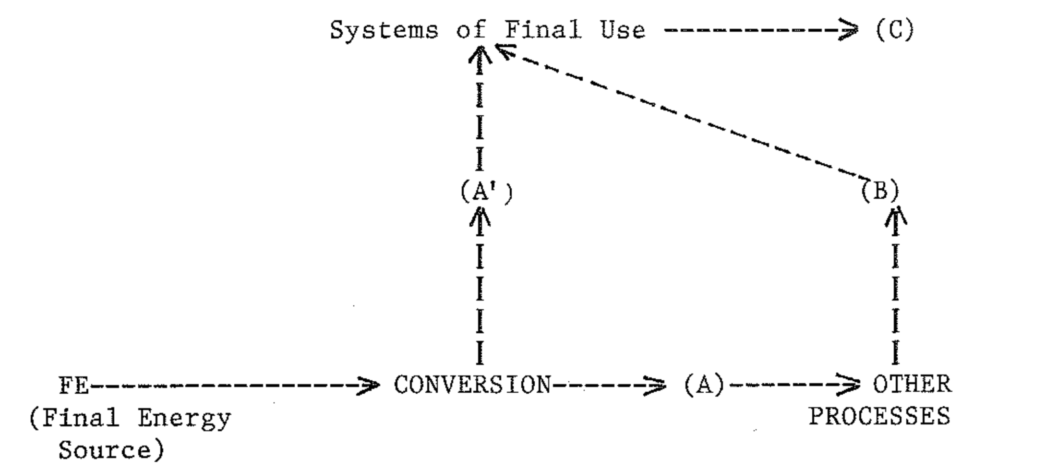
Note: Determination of useful energy could be considered as a function of technical procedures, of its uses or of economic sectors, but these breakdowns present such theoretical and practical difficulties that, currently, only the first solution is applied." (*)

(*) Glossary, op. cit., page 21.

Generally speaking, it can be said that the design of an appropriate methodology for calculating useful energy is based on the consideration of four elements: energy source, conversion system, other processes, and system of final use.

Graphically, these four elements can be diagrammed as they appear in Figure 2:

FIGURE 2



For the balances of Final Energy Consumption (whether primary or secondary sources), energy accounting can establish the amounts of each source consumed for each use. For that purpose, it is only necessary to disaggregate consumption by sectors of economic or social activity, according to consumption by end-uses.

To express the foregoing in terms of useful energy, in keeping with the definitions presented above, alternatives must be recognized.

Alternatives (A) and (A'), which take into account only the energy sources and conversion systems, provide knowledge about one stage of Intermediate Energy. For some methodologies (for example, that of the OECD), this option already constitutes Useful Energy.

Considering the section (A)--> (B), losses in the conversion systems would incorporate those originating in other processes, the respective efficiencies of which give rise to what in this methodology has been termed EFFICIENCY OF PRODUCTION.

It is considered that only the option which incorporates the four phases (FE)-(A)-(B)-(C) is appropriate for calculating the energy which is really incorporated into the final product or which provides the required service. Only by going through these four phases of the diagram would it be possible to arrive at knowledge about useful energy with the scope of the definition adopted in this methodology.

The implications of the definition of useful energy having been clarified, it proves equally important for the development of the methodology to define the efficiencies (η_p) of the equipment which takes part in each stage of the process of energy conversion, since, ultimately, the numerical values will be applied to Final Energy (FE) in order to determine the values of Intermediate Energy. Thus, it is necessary to bear in mind that the η_p depend on the operating conditions of the equipment.

Taking into account the multiplicity of situations and the diversity of systems of use, even for one same use, in this first stage of the methodology, the decision was made to extend the analysis only up to calculation of Intermediate Energy.

Consequently, in this first stage OLADE proposes to prepare BEEU taking into consideration only the efficiencies of the systems of production (η_p) and leaving the incorporation of the systems of use (η_u) for a second stage of the elaboration of energy balances.

The adopted definition may be clarified through the following example, which shows a diagram of the use of diesel for steam production in a boiler.

FIGURE 3

```
                  System of                           System of
                  Production                          Use
                  ---------                           -----------
Final Energy] Boiler     ]  Intermediate  ]Industrial]
Diesel      ]            ]     Energy     ]Process   ]    Useful
            ]            ]     (Steam)    ]Equipment ]    Energy
----------> ] ηp= 0.85]  ------------>    ] ηu= 0.80 ]  ------------>
  1 Kcal      ---------     0.85 Kcal       ----------    0.68 Kcal
```

In the preceding example, which considers only the first stage, there would be an 85% efficiency; however, if both stages are considered (system of production and system of use), the overall efficiency would be 68% (1 x 0.85 x0.80).

Figure 3-1 presents a general scheme for calculating the previous example.

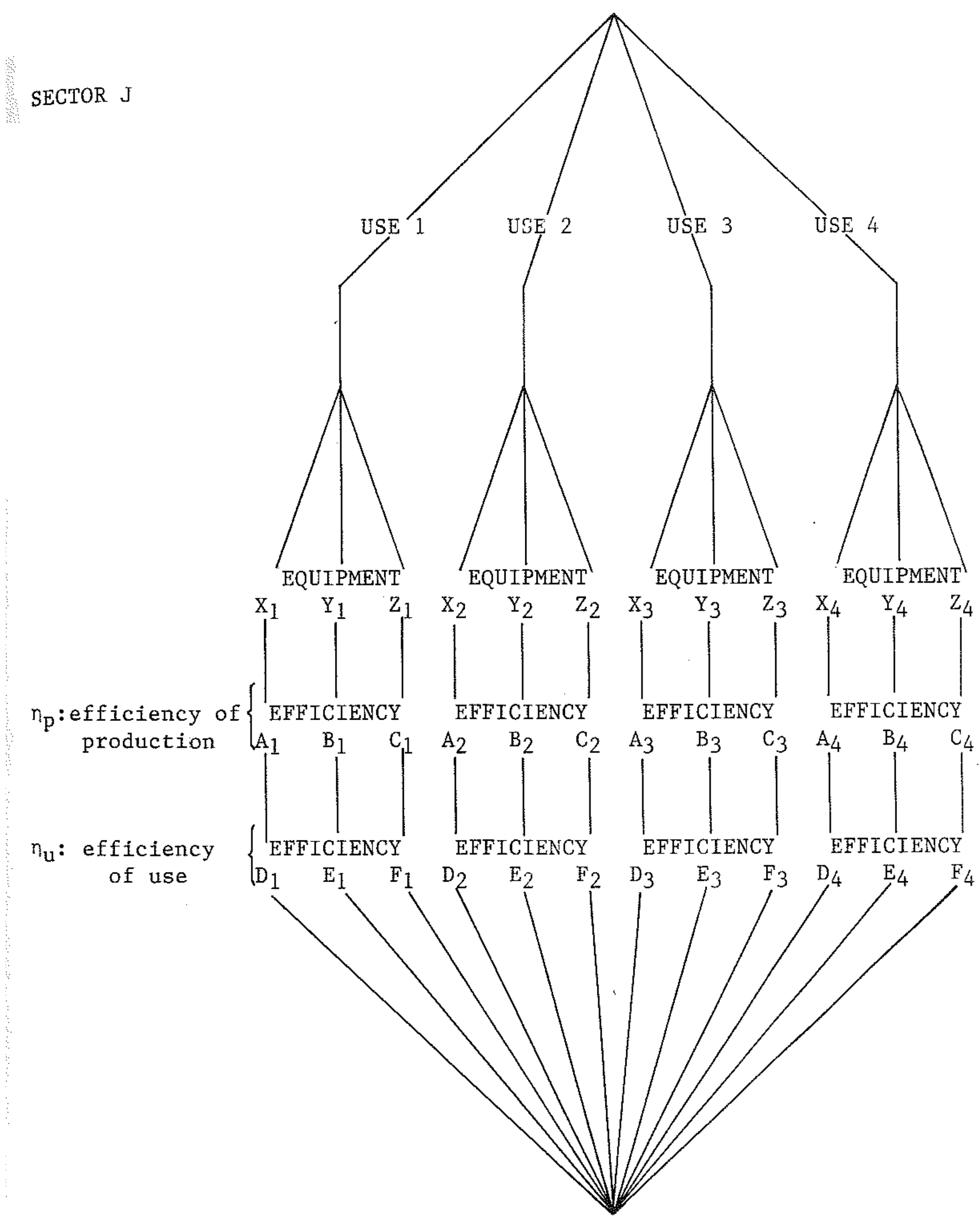
Thus, the first stage proposed by OLADE, i.e., calculation of the useful energy of production, will result from relating the final consumption of one source in one end-use in one sector, subsector, activity, etc., to the efficiency of the respective equipment.

To calculate useful energy, it is necessary to resolve two basic questions:

i) the determination of equipment efficiency and

FIGURE 3-1

FINAL CONSUMPTION
BY ENERGY SOURCE



CONSUMPTION OF THE USEFUL ENERGY OF AN ENERGY SOURCE X
IN A CONSUMPTION SECTOR J

ii) the definition of the equipment to be considered.

i) To determine efficiencies of production, two alternatives may be considered:

- Direct measurement, by means of energy audits, or

- Use of efficiencies provided by producers or competent authorities.

The quantification of efficiencies by means of ENERGY AUDITS stresses the thermodynamic parameters of the processes being measured. However, in some cases, it proves very difficult to generalize statistically the values determined for nume rous types of equipment existing in any one sector or subsector. Direct measurement of efficiencies is needed when it is desired to highlight the alternatives for energy CONSERVATION, which require energy audits.

In energy demand calculations which reach the level of useful energy, it is very common to work with ADOPTED EFFICIENCIES from manufacturers´catalogs; this practice has been establishing certain standard values which are applied with greater or lesser rigor in the different countries. This approximation can be clear enough when the projection of final energy demand is oriented to emphasizing the mechanisms for SUBSTITUTION of the different sources which compete in the price market to produce the same amounts of required energy. Under such circumstances, it is not so much the absolute value of the efficiencies which matters, but the relative value, in order to reflect the fact that one source is more, or less, efficient than another in the satisfaction of needs for a given technology.

This methodology proposes the use of a combination of the two types of efficiencies. Depending on the weight of some subsectors in energy consumption, it is possible to use adopted efficiencies, or audits may be carried out where necessary; however, the latter present the major drawback of high cost measurement procedures.

ii) As for consideration of the equipment in measuring the production efficiency, several cases may arise. Therefore, it is necessary for each end-use and source considered in each subsector or activity to have a clear definition of the respective equipment.

A simple case will be, for example, a waterwheel which generates mechanical energy which is then used in a mill. Here, the efficiency of production will lie in the efficiency of the waterwheel, and the efficiency of use, in the mill.

In the case of an automobile, whose purpose is to transport a person over a certain distance, the scheme would be as follows:

	Final Energy →	Motor →	Mechanical Energy EI →	Transmission System →	Movement →	Required Service
Stage	A		B		C	
Efficiency	η_1		η_2		η_3	

The internal combustion engine produces mechanical energy with a certain efficiency (η_1). The first and only conversion of chemical energy into mechanical energy occurs in A.

In B and C there is no energy conversion; however, losses occur and there are thus efficiencies to be taken into account in calculating useful energy. In this case, the automobile as a whole is adopted as the "equipment" (see Sectoral Appendix I), so that the efficiency of production will be $\eta_1 \times \eta_2$ (where η_1 is the efficiency of conversion and η_2 the efficiency of Other Processes); on the other hand, η_3 determines the efficiency of use.

From what can be seen in the two preceding cases, the mill and the automobile, for determination of the efficiencies of production, it is necessary to define clearly all the equipment for each end-use-source combination considered.

2. Disaggregation of Energy Consumption

A first disaggregation of total final energy consumption can be done at the level of:

- Final Non-Energy Consumption

  Including the volumes of energy products which are used for non-energy purposes in all of the consumption sectors.

- Final Energy Consumption

  Referring to the total amount of primary and secondary products used by all of the consumption sectors, for satisfying their energy needs.

As for the sectors and subsectors considered, these are detailed under points 2.1 and 2.2 which follow.

2.1 Disaggregation by Sectors

- Transportation Sector

  Includes the energy consumption of all transportation services, whether public or private, (state or privately owned) national or international (Bunkers) for the different means and modes of freight and passenger transportation (land, air, water).

- Industrial Sector

  Includes the energy consumption of all the industrial activities and end-uses except for transport of merchandise, which is included under the transportation sector. Small-, medium-, and large-scale industry should be included.

- Residential Sector

  Includes all of the energy consumed to cover domestic needs (cooking, lighting, refrigeration, etc.) for urban and rural families, with the exception of the energy consumed in transportation and other productive activities carried on in the household.

- Commercial-Services-Public Sector

  Includes the consumption of all commercial activities and services in the private sector, e.g., shops, hotels, restaurants, etc. Also includes energy consumption by the Government at every level (national, provincial, municipal); by public-service firms and institutions, whether State-owned and operated or private, e.g., the energy consumed by hospitals, schools, the armed forces and/or the police.

- Agriculture-Fishing-Mining Sector

  Covers the energy consumption in activities related to obtention of raw materials, such as agricultural and livestock activities, fishing and extraction of minerals (not used as fuels).

- Auto-Consumption Sector

  Considers the consumption associated with the production, transformation and pipeline transport of energy sources.

- Others Sector

  Includes all of the energy consumption in the construction sector, civil structures and all other energy consumption that cannot be classified as belonging to any of the aforementioned sectors.

2.2 Disaggregation by Subsectors

The need to disaggregate final consumption by subsectors is widely justified and represents a necessary stage in the treatment of energy balances in terms of useful energy. One of the most important reasons is related to the elaboration of models for projection of energy demand; whether these are econometric models or process models, they will always be strongly determined by the relation between energy consumption and some value which will be characteristic of a product (industrial product, passenger-kilometers, etc.). Another reason is that consumption patterns-- and therefore the amounts consumed, the sources and the equipment used to satisfy production requirements or to provide energy services-- vary substantially according to the activity (if referring to a productive sector) or to the characteristics of the housing or level of income (in the case of the residential sector), implying different levels of consumption of both final energy and useful energy, as will be observed in the presentation of the corresponding sectoral appendices.

Thus, given the heterogeneity and different forms of use of energy sources in the different sectors, a sufficiently broad sectoral disaggregation arises, so that each Member Country will be able to work out a disaggregation process in keeping with its needs and energy profiles in the field of useful energy.

In light of the foregoing, the disaggregation of the sectors into subsectors to be considered would be as follows: (For more details, see the corresponding sectoral appendices.)

* SECTOR: TRANSPORTATION

Disaggregation:

```
                                                         I-Public
                                     I-Urban-----------I
                                     I                   I-Private
                I-Freight-----------I
                I                    I                   I-Public
                I                    I-Interurban------I
                I                    I                   I-Private
-Road-----------I                    I
                I                    I                   I-Public
                I                    I-Urban-----------I
                I                    I                   I-Private
                I-Passengers--------I
                                     I                   I-Public
                                     I-Interurban------I
                                                         I-Private
```

```
              I-Freight
-Rail---------I                    I-Urban Public
              I-Passengers---------I
                                   I-Interurban Public

              I-Freight
-Air----------I
              I-Passengers

                                     I-Passengers
              I-River----------------I
-Water--------I                      I-Freight
              I-Sea

-Pipelines1/-I-Freight
```

* SECTOR: INDUSTRIAL

The subsectors indicated below correspond to the conventional disaggregation for preparation of energy balances; every country or region should group these or further disaggregate them as a function of their economic importance, while always respecting the categories of the ISIC Classification.

- Food, Beverages and Tobacco
- Textiles, Clothing, Shoes and Leather
- Wood and Furniture
- Paper and Pulp
- Iron, Steel and Non-Ferrous Metals (except the coke plants of integrated steel mills, excluding the furnaces)
- Machinery and Equipment
- Chemicals (except petroleum refining)
- Cement
- Stone, Glass and Ceramics
- Other Industries

* SECTOR: RESIDENTIAL

Disaggregation

```
                       I-Urban
- Urban----------------I
                       I-Small Urban

- Rural
```

1/ It is worthwhile to note that the pipelines (oil pipelines, gas pipelines, poly-pipelines, etc.) used to transport energy products are accounted for under the auto-consumption sector.

* SECTOR: COMMERCIAL-SERVICES-PUBLIC

Disaggregation:

- Public Services
- Commerce, Transport, Storage and Communication
- Restaurants
- Hotels
- Financial Establishments, Insurance, Real Estate and Company Services
- Public Administration, Defense, Government
- Public Health
- Other Services

* SECTOR: AGRICULTURE-FISHING-MINING

Disaggregation:

- Agriculture
- Fishing
- Mining

* SECTOR: AUTO-CONSUMPTION

Disaggregation:

- Production
- Transformation
- Pipelines

* SECTOR: OTHERS

Disaggregation:

- Construction
- Broad Zero Grouping of the ISIC Code
- Unclassified Consumption

3. Disaggregation by End-Uses

Disaggregation of final consumption under the different end-uses is fundamental in determining energy consumption in terms of useful energy.

In different kinds of work in which energy consumption is broken down by end-uses, a group of quite different categories is used at the level of each sector and then these are grouped under large headings which, in one way or another, are related to the basic categories of physics in relation to energy in the form of heat and work.

In each one of these, different approaches are used to deal with the problem, many times generating different categories in different sectors, for end-uses which are intrinsically similar.

There are also different degrees of disaggregation of end-uses, according to the sector or activity under consideration, as can be seen under point 3.2 below.

It is for this reason that a first attempt at systematization has been made herein, simultaneously taking into account that these categories have to do not only with the end-uses themselves but also with the economic sectors associated with each end-use, with the energy sources which satisfy them, with the devices and equipment used, and with their efficiencies of end-use.

An effort has been made to synthesize the multiplicity of different end-uses in the different sectors in a small number of general categories; and, at a second, somewhat broader level, in specific categories.

In defining these categories, the need to be able to assign an efficiency of use to each one of them for each source has particularly been kept in mind, so as to permit an estimation of the corresponding useful energy.

Finally, disaggregation by end-uses makes it possible to consider the problems of substitution among sources and among devices and equipment.

3.1 Basic Categories

The basic end-uses can be grouped under four categories:

- Heat
- Mechanical Force
- Lighting
- Electronics and Electrochemistry (Electrolysis)

- The use of HEAT covers all of the range of energy end-uses whose specific purpose is to raise the temperature of a given space or product above the natural ambient temperature, either for productive purposes or reasons of comfort.

  In this case, there is a direct identification with the forms in which energy is manifested in the field of physics.

- The use of MECHANICAL FORCE refers to all of those energy end-uses in which the specific purpose is production of some type of movement or work, no matter what the type of device, equipment or energy source used to obtain it.

  In this case there is also a direct correlation to work, which is the other way in which energy manifests itself in the field of physics.

- The use of LIGHTING has been considered independently from the remaining caloric end-uses since, while all lighting devices dissipate heat to a greater or lesser extent, their specific end-use is to supply radiation within the spectrum of visible wavelengths.

  In addition, this end-use is discussed independently in all of the bibliography, even though many times, for practical reasons, it is associated with the use "Mechanical Force".

- ELECTRONIC and ELECTROCHEMICAL end-uses are identified as a general, independent category in order to take into account those cases in which energy has one of two specific purposes: operation of electronic devices or development of an electrochemical process. This type of process constitutes one of the few instances of a permanent specific use for electricity.

  In both cases, the only source apt for satisfying them is electricity and, for this reason, they have been considered jointly.

3.2 End-Uses Considered for Each Consumption Sector

The disaggregation adopted for each sector is justified in each sectoral appendix; however, it can be summarized as follows:

```
SECTOR: TRANSPORTATION

   - MECHANICAL FORCE-------|- Mechanical Force

SECTOR: INDUSTRIAL

                             |-Steam
   -HEAT---------------------|
                             |-Direct Heat

                             |-Mechanical Force
   -MECHANICAL FORCE---------|-Refrigeration
                             |-Transportation

   -LIGHTING

                             |-Feedstock
   -OTHERS-------------------|-Electrolysis
                             |-Other Uses
```

SECTORS: RESIDENTIAL AND COMMERCIAL-SERVICES-PUBLIC

- -HEAT
  - -Cooking
  - -Heating
  - -Water Heating and Steam
- -MECHANICAL FORCE
  - -Refrigeration (of food, etc.)
  - -Air Conditioning/Ventilation
  - -Water Pumping
  - -Mechanical Force
- -LIGHTING
- -OTHERS
  - -Electronics
  - -Other Uses (iron, etc.)

SECTOR: AGRICULTURE-FISHING-MINING

- -HEAT
  - -Direct Heat
  - -Steam
- -MECHANICAL FORCE
  - -Mechanical Force
  - -Irrigation
  - -Water Pumping
  - -Refrigeration
- -LIGHTING
- -OTHERS
  - -Electrolysis
  - -Other Uses

SECTOR: AUTO-CONSUMPTION

- -HEAT
  - -Direct Heat
  - -Steam
- -MECHANICAL FORCE
  - -Mechanical Force
  - -Transportation
  - -Refrigeration
- -LIGHTING
- -OTHERS

SECTOR: OTHERS

- -MECHANICAL FORCE
- -HEAT
- -LIGHTING

4. Transformation Centers and Sources Considered

4.1 Transformation Centers

Installations in which primary or secondary energy is subjected to processes which modify its properties or original nature, by means of physical, chemical and/or biochemical changes, thereby converting it into another form of energy more suitable for final consumption.

The transformation centers considered are:

a) Refineries

These are transformation centers in which petroleum is physically separated into its different components, and these components are chemically converted into others.

Such centers include a series of basic processes for obtaining the various petroleum derivatives and may be more or less complex, depending precisely on the conversion units which comprise them. The most commonly used units are:

a) Atmospheric distillation (the primary process of any refinery)
b) Vacuum distillation
c) Thermal cracking
d) Catalytic cracking
e) Coking
f) Catalytic reformation
g) Viscoreduction
h) Hydrocracking

This methodology will deal with the group of refining units as though they were one processing unit. Although this representation does not allow a complete description of the transformation center, in terms of refining, nor does it analyze the internal flexibility of each refinery, it is sufficient for the purpose of establishing input-output ratios for the balance proposed herein (see Figure 4).

b) Electric Power Plants

This includes all of the electric power generating centers, offering both public and private services.

In general, there are two types of electric power plants:

a) Hydroelectric stations, which utilize the water falling from one level to another to operate an electric generator.

b) Thermoelectric stations, which are divided according to the generating system used:

- Steam-run stations, which use the steam produced in a boiler, nuclear reactor or geothermal well to turn the shaft of a turbine coupled to an electric generator.

  The heat used to produce steam in the boilers may come from different sources: coal, natural gas, liquid petroleum derivatives (fuel oil), firewood, sugarcane, bagasse, etc.

- Gas turbines, whose operation is similar to that of steam turbines, only in this case the combustion gases are used directly to drive the turbine. This type of turbine normally uses diesel fuel and gas.

- Diesel engines.

Usually, a countrys electricity generation is based on a combination of the different kinds of stations described above.

A simplified scheme making it possible to establish clearly the efficiency of each system could be like the one presented in Figure 5.

c) Natural Gas Treatment Plants

In gas treatment plants, natural gas is processed for the principal purpose of recovering liquid hydrocarbon compounds such as gasoline and naphthas; pure hydrocarbons such as butane, propane and ethane, or a mixture of these; and non-energy products such as carbon.

In general, gases (wet gas) with an important amount of compounds having heavy molecular weights are used, in order to obtain (dry) gas, liquefied gas and gasoline.

The separation of gasoline may be done by means of absorption processes in mineral oil or gasoline at high temperatures; compression and refrigeration; absorption through charcoal in fixed or continuous beds; and more frequently, by means of a combination of these processes.

Figure 6 shows a simplified diagram of this process.

Operation of these plants requires consumption of fuels plus small amounts of electricity.

FIGURE 4

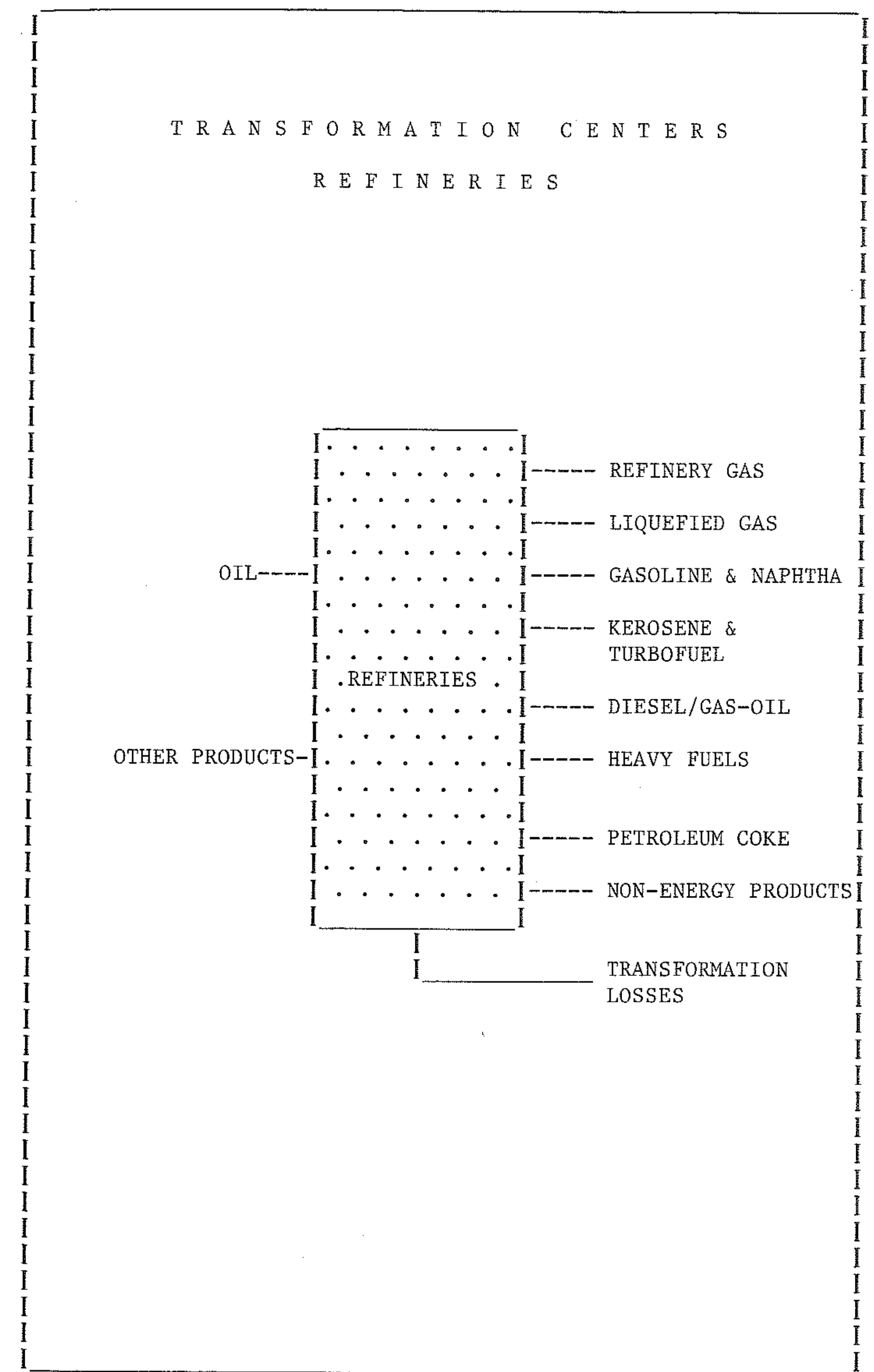


FIGURE 5

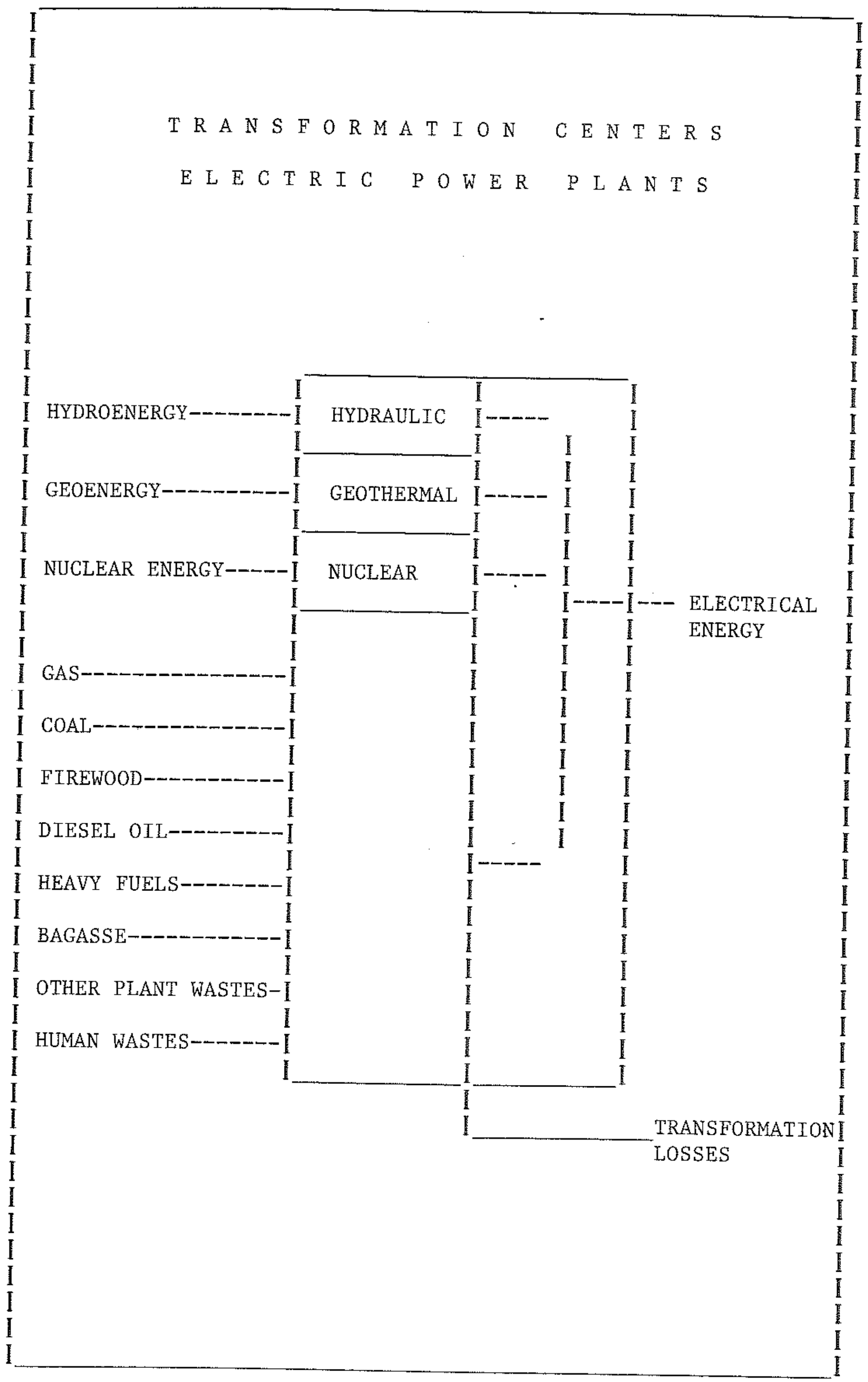


FIGURE 6

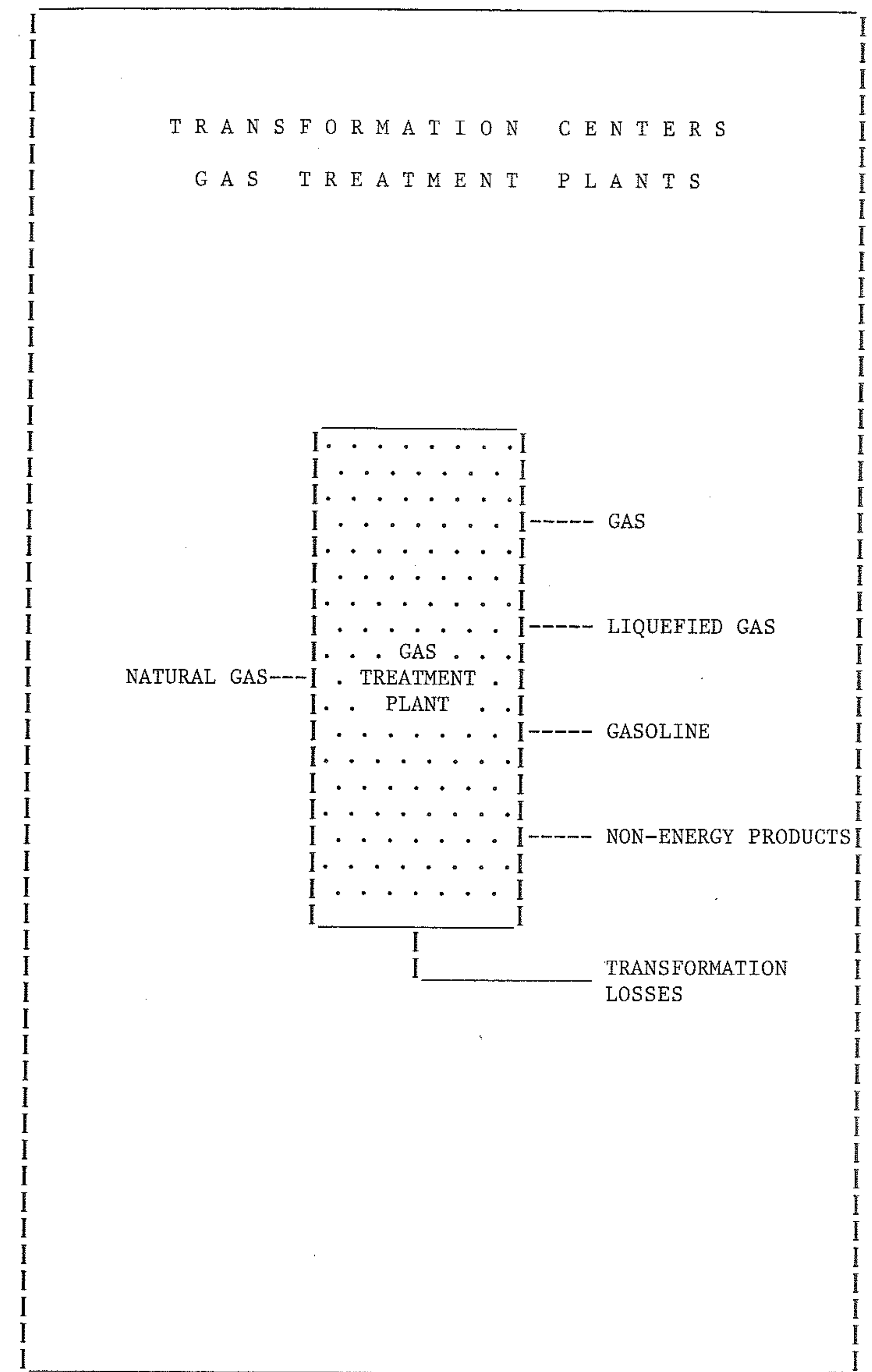


FIGURE 7

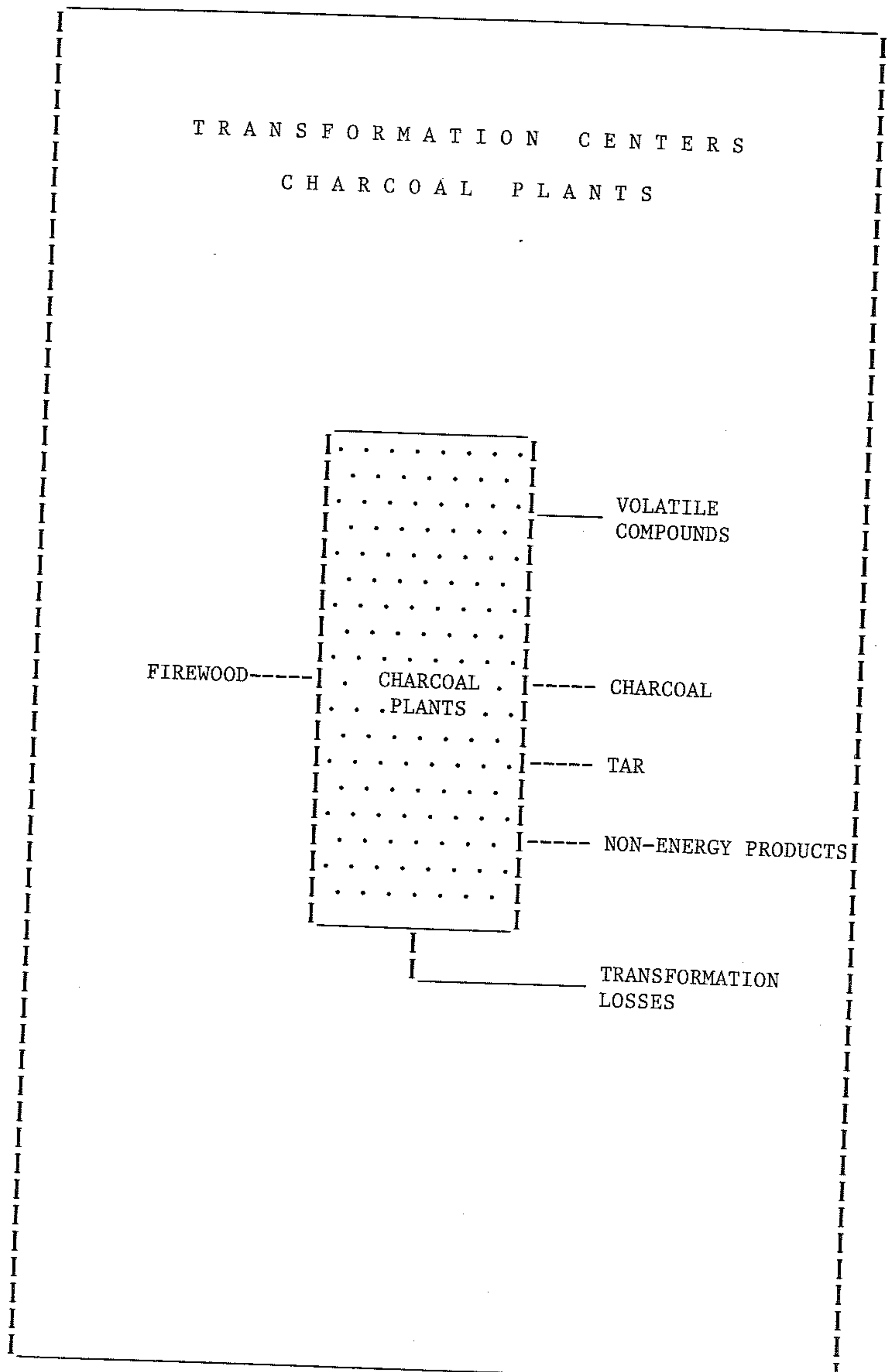
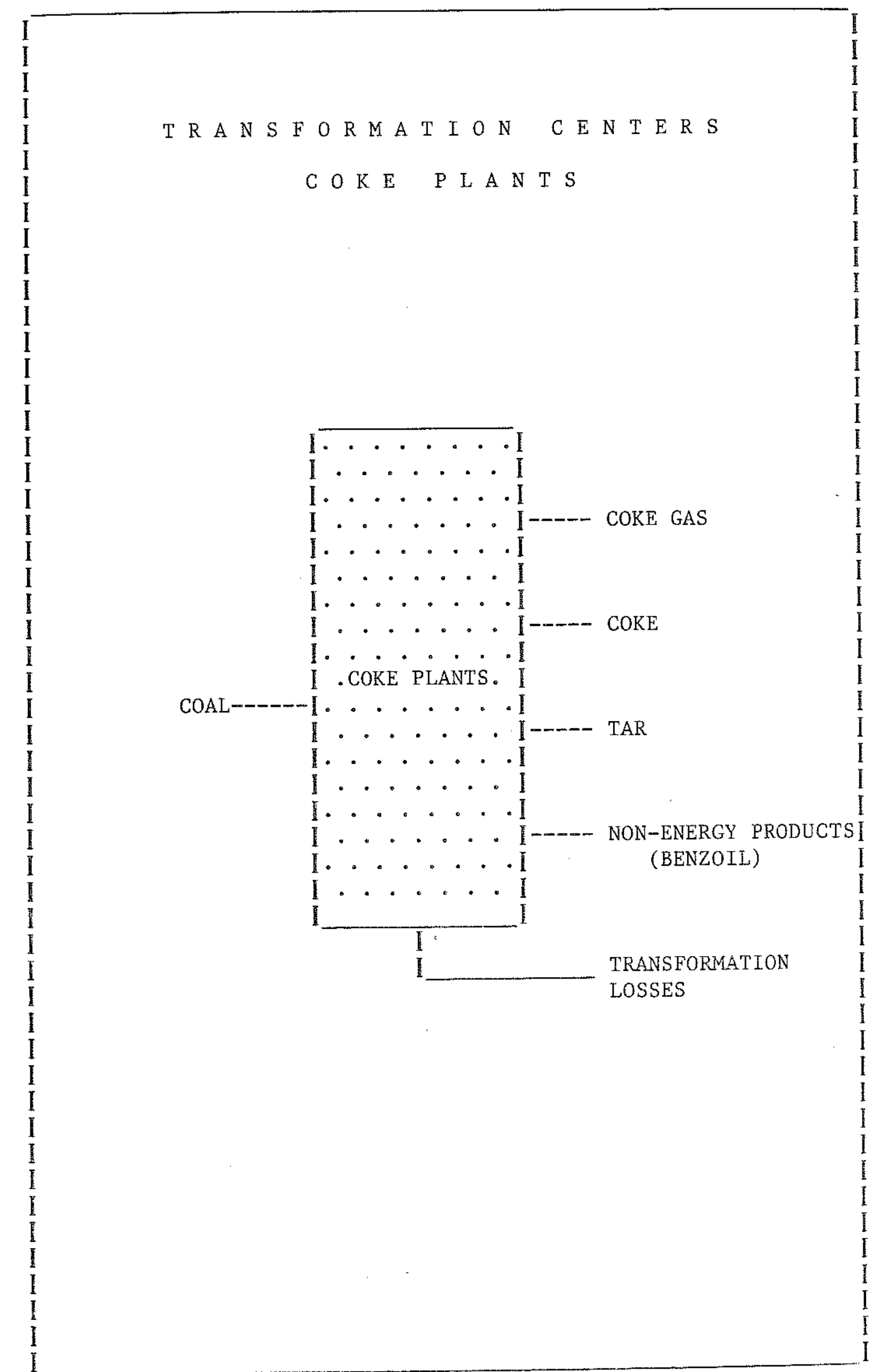


FIGURE 8



d) Charcoal Plants

These are biomass transformation centers which are treated separately due to the relative importance of the products which participate in this process within the energy balance of most of the Latin American countries.

These are ovens and furnaces where the incomplete combustion of firewood takes place to produce charcoal, volatile products and non-energy products; the latter two are not usually utilized.

These units (see Figure 7) are seldom very efficient since, precisely because combustion is incomplete, a great deal of heat is lost, leaving charcoal in the ash. Heat recovery in these centers varies between 25 and 40% of the heat fed into the production unit.

e) Coke Plants

The mechanism for coking based on carbonization of coal is complex and includes a series of chemical and physical phenomena. In coke plants, from the coal which enters the transformation center, coke, coke gas, tars and non-energy products (benzols, etc.) are produced. A good part of the coke produced in this center usually goes to furnaces; and much of the tar produced is consumed in the process itself, although most times its production is not recorded and its value is included in the losses or as part of the non-energy output.

This type of center may also consume small amounts of electricity.

Figure 8 shows a simplified diagram of this transformation center.

f) Alcohol Distilleries

These are transformation centers where sugarcane products are treated to produce bagasse and alcohol (ethane). They should also include the alcohol distilleries which process other feedstock such as beet, cassava or other products having a high starch or cellulose content.

In general, the obtention of alcohol requires three important steps:

- Preparation of the fermentable solution: when dealing with solutions having a high sugar content, a solution is prepared with a given concentration and clarified by sedimentation and/or centrifugation; this solution should be sterilized in order to reduce the fermentation risk. For materials rich in starch, the feedstock should be peeled, washed and ground in order later to extract the starch, which will undergo enzymatic hydrolysis to obtain soluble fermentable sugars. For cellulosic compounds, acid hydrolysis is required previously.

- Fermentation: this consists of microbiological conversion of the hexoses in alcohol and carbon gas with heat release.

- Distillation and Dehydration: this consists of the separation of alcohol from the fermented mass, its purification and dehydration.

This is the stage which consumes the largest amount of energy required for alcohol production.

A more generalized diagram of this center is presented in Figure 9.

g) Other Transformation Centers

Those processing centers which yield producer gas from wood-burning gasogenes and biogas from other vegetable and animal fuels are included here.

h) Other Transformations

The energy recycling related to some sources of energy such as furnace gas, liquefied gas, naphthas, etc., is included here; detailed treatment is given this topic in Chapter II point 2.

4.2 Energy Sources

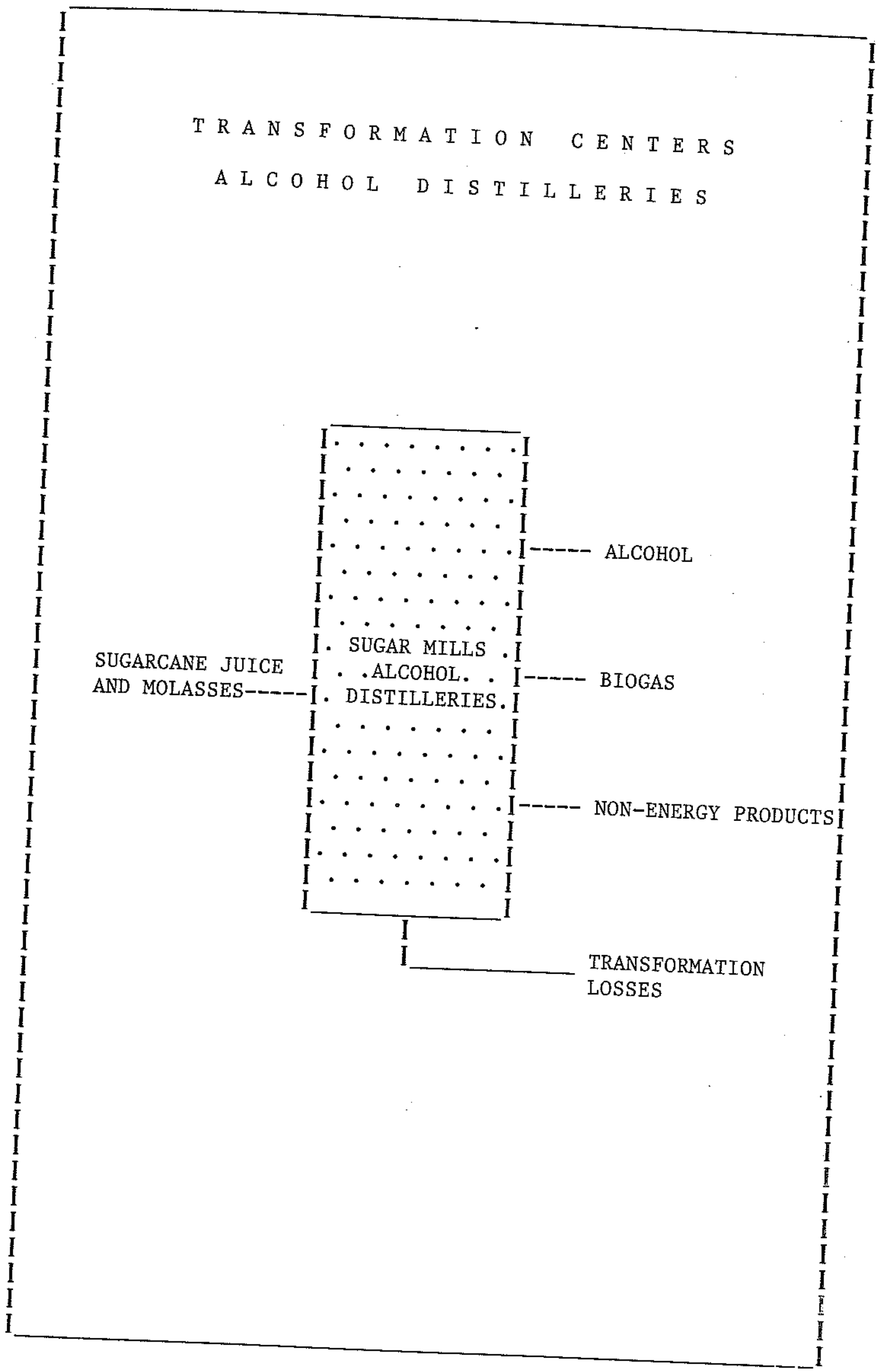
i) Primary Energy

Primary energy is understood as the different sources of energy as they are obtained in nature, whether directly as in the case of hydro or solar energy; following a process of extraction, as in the case of petroluem, coal, geothermal energy, etc.; or through photosynthesis, as in the case of firewood and other vegetable or plant fuels.

The primary energy sources considered in this methodology are listed below and defined in the glossary.

- Crude Oil
- Natural Gas (Free and Associated)
- Hydroenergy
- Geoenergy
- Fission Fuels
- Coal
- Firewood

FIGURE 9



- Sugarcane Products (molasses, juice, and bagasse for energy purposes)
- Other Primary Sources (animal waste and other vegetable waste, recovered energy, etc.)

ii) Secondary Energy

Secondary energy refers to the different energy products whose origin is the different transformation centers, after undergoing a physical, chemical or biochemical process, and whose destination is the diverse consumption sectors and/or other transformation centers.

The secondary energy sources considered are listed below and defined in the glossary.

- Liquefied Gas
- Gasoline and Naphthas (aviation gasoline, motor gasoline, natural gasoline and naphthas)
- Kerosene and Turbofuels
- Diesel Oil (also including gas oil)
- Heavy Fuels
- Coke
- Electricity
- Charcoal
- Alcohol
- Gases (biogas, coke gas, furnace gas, refinery gas)
- Other Energy Fuels
- Non-Energy Products

FIGURE 10

ENERGY BALANCE OF ______OLADE____

UNIT OF MEASURE: ________

YEAR FACTOR DATE	PETRO-LEUM	NATURAL GAS	HYDRO-ENERGY	GEO-ENERGY	FIS-SION FUELS	FIRE-WOOD	CANE PROD.	COAL	OTHER SOUR-CES	TOTAL PRIMARY ENERGY	LIQUE-FIED GAS	GASO-LINE, NAPHTHA	KERO-SENE, TURBO	DIESEL & GAS-OIL	HEAVY FUELS	COKE	ELEC-TRI-CITY	CHAR-COAL	ALCOHOL	GASES	OTHER ENERGY PROD.	NON-ENERGY PROD.	TOTAL SECOND. ENERGY	CONSO-LIDA-TION
s PRODUCTION																								
u p IMPORTATION																								
p EXPORTATION																								
y VARIATION STOCKS			P R I M A R Y E N E R G Y													S E C O N D A R Y E N E R G Y								
INTERNAL SUPPLY																								
REFINERY																								
PUBLIC POWER PL.																								
t r AUTO-PROD.POWER																								
a n GAS TREAT. PLANT																								
s f CHARCOAL PLANT		T R A N S F O R M A T I O N C E N T E R S																						
o r COKE PLANT, FURN.																								
m BIOMASS PLANT																								
TOTAL TRANSFORM.																								
LOSSES																								
UNUTILIZED																								
ADJUSTMENTS																								
TRANSPORTATION																								
INDUSTRIAL																								
c RESIDENTIAL o COMM & PUBLIC																								
n s AGRIC/LIVESTOCK																								
u m AUTO-CONSUMPTION	T O T A L F I N A L C O N S U M P T I O N																							
p UNIDENTIFIED																								
ENERGY CONSUMP.																								
NON-ENERGY CONS.																								

CONSOLIDATED OLADE ENERGY BALANCE

	PETRO-LEUM	NATURAL GAS	COAL	HYDRO-ENERGY	GEO-ENERGY	FISSION FUELS	FIRE-WOOD	SUGAR CANE PROD.	OTHER ENERGY PROD.	TOTAL PRIMARY ENERGY	LIQUE-FIED GAS	GASOLINE AND NAPHTHA	KEROSENE & TURBO FUELS	DIESEL & GAS OIL	HEAVY FUELS	COKE	ELEC-TRICITY	CHAR-COAL	ALCOHOL	GASES	OTHER ENERGY FUELS	NON-ENERGY PROD.	TOTAL SECOND. ENERGY	TOTAL
S Production																								
U Importation																								
P Exportation										S U P P L Y														
P Variation in Stocks																								
L Unutilized																								
Y INTERNAL SUPPLY																								
T Refineries																								
R Public Power Plants																								
A Auto-Prod.Power Plants																								
N Gas Treatment Plants																								
S Charcoal Plants																								
F Coke Plants					T R A N S F O R M A T I O N																			
O Alcohol Distilleries																								
R Other Transf. Centers																								
M Other Transformations																								
A T TOTAL TRANSFORMATION																								
LOSSES (TRSP/STR/DIST)																								
ADJUSTMENTS																								
F Transportation																								
I Industrial																								
N Residential																								
A Comm/Serv/Pub																								
L Agro/Fishing/Mining				F I N A L C O N S U M P T I O N																				
Auto-Consumption																								
C Others																								
O N Final Energy Consump.																								
S Final Non-Energy Cons.																								
TOTAL FINAL CONSUMP.																								
U Transportation																								
S Industrial																								
E Residential																								
F Comm/Serv/Pub				U S E F U L C O N S U M P T I O N																				
U Agro/Fishing/Mining																								
L Auto-Consumption																								
Others																								
C Useful Energy Consump.																								
O Non-Energy Useful Cons.																								
N S TOTAL USEFUL CONSUMP.																								

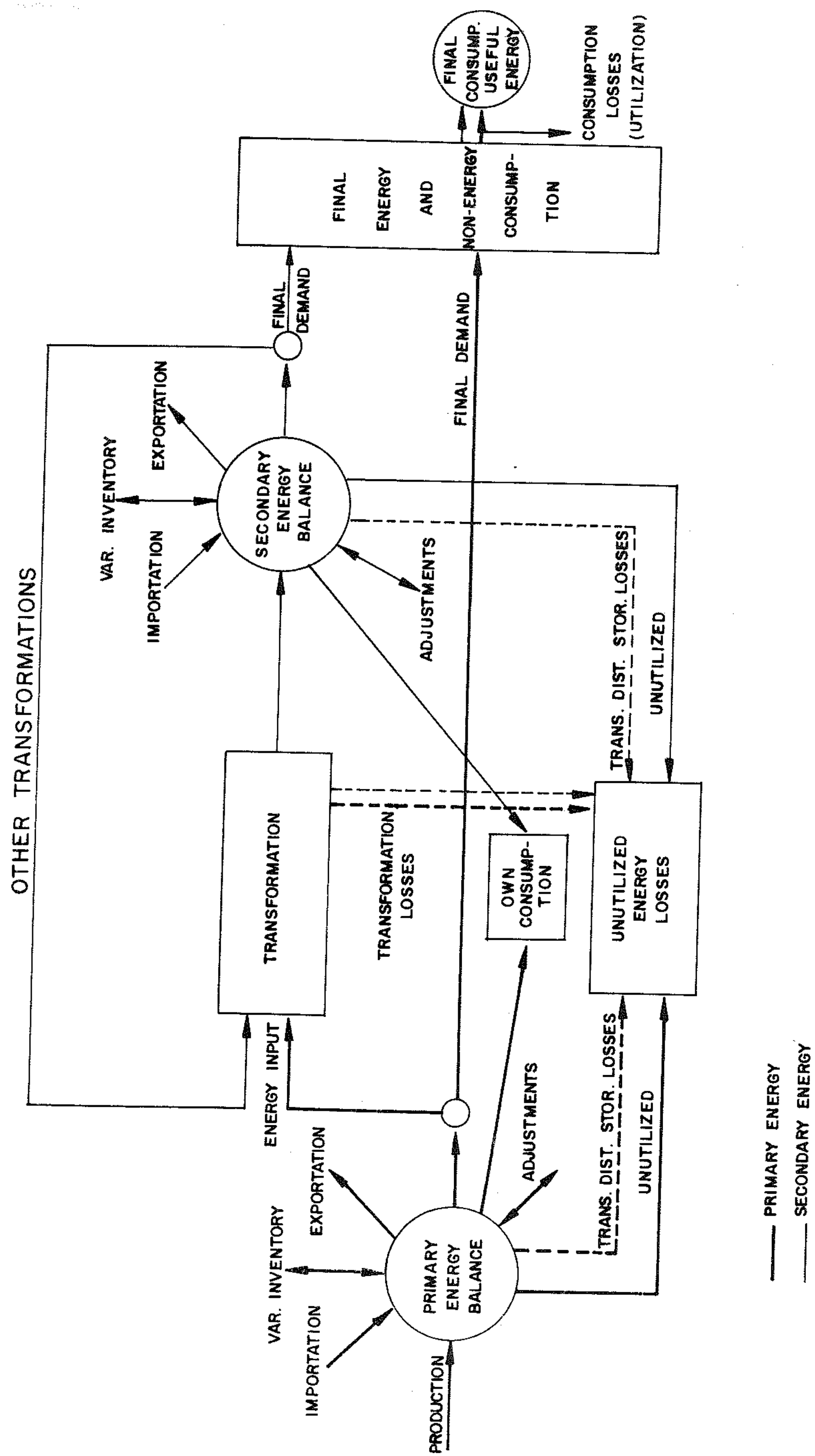


FIG. 12. ENERGY BALANCE FLOW UNTIL USEFUL ENERGY

CHAPTER II

GENERAL STRUCTURE OF THE BALANCE AND METHOD OF CALCULATION

1. General Structure of the Balance

The presentation of the current energy balance of OLADE in terms of final energy (BEEF) (see Figure 10) is comprised by a double-entry matrix where the columns indicate the sources of energy and the rows correspond to the operations (activities) which form part of the energy system.

The unit of presentation is the barrel of oil equivalent (BOE), the utility of which should be considered in the presentation of data within the balance.

BEEF have three parts:

- Supply
- Transformation
- Total Final Consumption

In order to present the energy balance in terms of useful energy (BEEU), the final consumption part of the balance must be expanded. Useful energy is calculated by disaggregating final consumption into end-uses and, within these, the participation of the sources of energy and kinds of equipment used.

The new energy balance matrix developed by OLADE, in terms of useful energy, reflects the relations among all of the stages of the energy process. (See Figure 11).

In the complete energy flow of this balance (see Figure 12), four functions can be distinguished:

- Supply — Energy supply through the combination of production, importation, exportation and variation in stocks.
- Transformation — Physical, chemical and/or biochemical modification of one energy source to form another, in a transformation center.
- Final Consumption — Consumption of energy sources by final consumers in the different sectors, prior to some chemical or physical conversion of energy.
- Utilization — Transformation of final energy into intermediate energy by means of equipment and a system of end-use whose efficiency determines useful energy.

It should be pointed out that in the BEEF final consumption has been modified by replacing the Agricultural/Livestock Sector with the Agriculture-Fishing-Mining Sector, and by replacing "Unidentified" with "Others". Auto-Consumption of the energy sector has also been added.

All of the final consumption sectors have been disaggregated into subsectors and uses, the breakdown of which is detailed in the corresponding appendices.

The primary and secondary energy sources have included new energy sources:

- Under primary sources was added "Other Primary Energy Sources," which includes the products of the productive processes which have an energy content and which are not considered in any other part of the balance, e.g., black liquor, stillage, plant and animal fuels, wind energy, solar energy, etc.

- Under secondary sources, "Alcohol" and "Other Fuels" were included. These cover secondary energy products not considered under other previous definitions.

Preparation of BEEU depends on compliance with the following steps:

- preparation of BEEF;

- disaggregation of final consumption by subsectors and by end-uses;

- application of the efficiencies of the different types of equipment for each end-use in each subsector.

Before attempting the aforementioned steps, it must be kept in mind that preliminary data-gathering is necessary for construction of BEEU; this consists of collecting all of the information published on the topic, whether systematically or not, in the original formats.

It is useful to organize the collected data so as to facilitate final preparation of the balance. For the final consumption sectors as well as the auto-consumption sector (all of the transformation centers), it is suggested that the sectoral balance sheets presented in the corresponding appendices be used.

It should be taken into account that the format in which the balances will ultimately be presented can never be completed directly, but rather through certain intermediate steps.

It is suggested that the information be grouped by energy source and by sector in the so-called main sectoral data sheets, as shown in Tables 1 to 6.

In preparing the useful-energy balance or the main data sheets in terms of useful energy, it is necessary to be aware of the following basic principles:

- To observe the first law of thermodynamics, which states that the energy in a closed system is constant, i.e.: input = product + losses. Since the balance is a closed system, the consumer cannot obtain more energy than what is available to him.

- To treat all the energy sources with the same criteria. This calls for uniform application of precise equivalencies, conversion factors, and the balance (accounting) system itself.

- To use a common unit of measure, which will be general and applicable to all sources of energy and all forms of energy use (heat, radiation, etc.) in order to be able to tabulate the columns and rows of the balance. In this case, the barrel of oil equivalent (BOE) may be used, or any caloric unit (Teracalorie).

- To treat the energy flows, from production up through end-use, explicitly indicating the intermediate operations (transformation, transportation, consumption).

- To consider operations only at the national level, in the event that there is a transfer of energy products over the borders of neighboring countries. Any loss occurring on either side of the border is not considered in the balance of the country under study.

- To obtain a set of statistics which can be computer-processed. This implies consistency in the rows and columns of the balance matrix.

2. <u>Treatment of Other Transformations</u>

In the new summary matrix of OLADE, there is a row in the TRANSFORMATION submatrix termed "OTHER TRANSFORMATIONS," which serves to account for secondary energy sources which are products of a primary transformation and which are used in other secondary transformation processes, as in the cases of gas production in furnaces and reformed products in the petrochemical industry.

For the purpose of illustration, an attempt is made below to demonstrate the treatment that should be given these.

ENERGY FLOW IN A FURNACE

```
                   -----------
                  I           I GAS PRODUCED  I20 FURNACE CONSUMP.
COKE              I FURNACE   I IN FURNACE    I10 ELEC. AUTO-PROD.
------------------I           I --------------I40 FINAL CONSUMPTION
 (100)             -----------       70       I   IN OTHER IRON AND
                        I                     I   STEEL ACTIVITIES
                        I
                        ----------------------I30 FURNACE CONSUMP.
```

From the coke burned in the furnace (100), furnace gas (70) is produced. The energy difference between the coke that enters and the gas that is consumed (30) is considered as the furnace consumption and, therefore, as the final consumption of the iron and steel activities.

As for the furnace gas produced (70), one part is consumed in the furnace itself (20) and another part in other iron and steel activities (50), which could include direct uses (40) or indirect uses, in electricity generation (10).

As shown below, in the accounting procedure of the energy balance matrix, furnace gas production falls under the row corresponding to "Other Transformations" and the energy equivalent of the furnace gas produced is subtracted from the coke, so that the losses will be zero.

ACTIVITIES \ SOURCES	CQ	GH	EE	TRANSFORMATION LOSSES
Auto-Producing Power Plants		-10	3	-7
Other Transformations	-70	70		0
C5 Industry (Iron and Steel) Final Consumption	30	(20+40)		

CQ = Coke GH = Furnace Gas EE = Electricity

ENERGY FLOW OF NAPHTHA PROCESSED IN THE PETROCHEMICAL INDUSTRY

```
                   -----------
                  I PETRO-    I                I15 LIQUEFIED GAS
NAPHTHA           I CHEMICAL  I       30       I10 GASOLINE
------------------I PLANT     I ---------------I 5 OTHER ENERGY
 (100)             -----------                 I   PRODUCTS (*)
                        I
                        I             70
                        ------------------------I PETROCHEMICAL
                                                  PRODUCTS
```

(*) Returned to refineries for distribution as energy products.

From the naphtha processed in the petrochemical industry, there is a return or recycling of energy products known as petrochemical effluents, which are classified according to the final products of liquefied gas, gasoline and others. As can be seen below, in the energy balance matrix these effluents are recorded in the row corresponding to "Other Transformations", and the energy equivalent of the effluents produced is subtracted from the naphtha, so that the transformation losses will be zero.

For the other products processed in the petrochemical industry (natural gas, refinery gas, etc.), the same line of reasoning can be followed. It is important to note that in the final non-energy consumption of naphtha, not all of the naphtha processed in the petrochemical industry is accounted for: the recycled effluents are deducted, in order to avoid duplications.

ACTIVITIES \ SOURCES	NAPHTHA	LIQUEFIED GAS	GASOLINE	OTHER ENERGY	TRANSFORM. LOSSES
Other Transformations	-30	15	10	5	0
Final Non-Energy Consumption	70				

3. <u>Equilibrium Equations</u>

For each one of the four parts comprising the energy balance and the basic functions defined in the OLADE Methodology for Elaboration of BEEF, equilibrium equations are provided to permit verification of the consistency of the information presented. The following equilibrium equations have been defined:

3.1 Total Internal Supply

3.1.1 Primary Energy (FP)

In the supply balance of primary energy sources, the following equations must be met:

Production

$$O_1\ (FP) = \sum_{j=1}^{9} (FP_j)\ O_1 \qquad (1)$$

Importation

$$O_2\ (FP) \quad \sum_{j=1}^{9} (FP_j)\ O_2 \qquad (2)$$

Exportation

$$O_3\ (FP) \quad \sum_{j=1}^{9} (FP_j)\ O_3 \qquad (3)$$

Variation in Stocks

$$O_4\ (FP) = \sum_{j=1}^{9} (FP_j)\ O_4 \qquad (4)$$

Unutilized

$$O_5\ (FP) = \sum_{j=1}^{9} (FP_j)\ O_5 \qquad (5)$$

Total Internal Supply of Primary Energy

$$O\ (FPj) = O_1\ (FP_j) + O_2\ (FP_j) - O_3\ (FP_j) - O_4\ (FP_j) - O_5\ (FP_j) \qquad (6)$$

$$O\ (TEP) = \sum_{j=1}^{9} O\ (FP_j) \qquad (7)$$

3.1.2 Secondary Energy (FS)

Production

$$O_1\ (FS) \quad \sum_{j=1}^{12} O_1\ (FS_j) \qquad (8)$$

Importation

$$O_2\ (FS) = \sum_{j=1}^{12} O_2\ (FS_j) \qquad (9)$$

Exportation

$$O_3\ (FS) \quad \sum_{j=1}^{12} O_3\ (FS_j) \qquad (10)$$

Variation in Stocks

$$O_4\ (FS) = \sum_{j=1}^{12} O_4\ (FS_j) \qquad (11)$$

Unutilized

$$O_4\ (FS) = \sum_{j=1}^{12} O_4\ (FS_j) \qquad (12)$$

Total Internal Supply of Secondary Energy

$$O\ (FSj) = O_1\ (FS_j) + O_2\ (FS_j) - O_3\ (FS_j) - O_4\ (FS_j) - O_5\ (FS_j) \qquad (13)$$

$$O\ (TES) = \sum_{j=1}^{12} O\ (FS_j) \qquad (14)$$

As for accounting for the totals (last column TOT) in the supply submatrix of the energy balance, the following equations should be fulfilled:

a) The box corresponding to O_1 (TOT) should be equivalent to the box corresponding to O_1 (FP), total energy production so as to avoid duplication.

b) To determine total energy supply (primary plus secondary), the following equation must be solved:

$$O\ (TOT) = O\ (TEP) + O\ (TES) - O_1\ (TES) \quad (15)$$

In other words, total secondary energy production must be subtracted from the sum of primary and secondary energy supply.

c) Once the primary energy supply has been tabulated, the following must hold true for every primary source:

$$O\ (FP_j) = T\ (FP_j) + PT\ (FP_j) + NA\ (FP_j) + CT\ (FP_j) \quad (16)$$

Equation (16) indicates that the destination of the primary energy supply may be a transformation center and/or a final consumption sector, plus unutilized energy (NA) and transmission, distribution and storage losses (PT).

d) Furthermore, by obtaining secondary energy supply and using the same equation (14) the following must be true for every secondary source:

$$O\ (FS_j) = T\ (FS_j) + PT\ (FS_j) + NA\ (FS_j) + CT\ (FS_j) \quad (17)$$

3.2 Transformation Centers

This part is constituted by the transformation centers in which the energy which enters is transformed into one or more secondary forms of energy, with the corresponding transformation losses. The following equations must be met in this part:

- For the total:

$$T\ (TOT) = T\ (TEP) + T\ (TES) \quad (18)$$

- For primary energy:

$$T\ (TEP) = \sum_{j=1}^{9} T(FP_j) \quad (19)$$

For every primary source j, it is also true that:

$$T\ (FP_j) = \sum_{i=1}^{9} T_i\ (FP_j) \quad (20)$$

If there is a difference in Equations (14) and (15), between energy supply and its distribution, it should be interpreted as the Statistical Adjustment (A).

- For secondary energy:

This part of the matrix should be balanced horizontally, to meet the following equation:

$$T\ (TES) = \sum_{j=1}^{12} T\ (FS_j) \quad (21)$$

In tabulating this part of the matrix vertically, for every secondary source (j = 1 to 12), the following must be true:

$$T\ (FS_j) = \sum_{i=1}^{9} Ti\ (FS_j) \quad \text{taking a negative value for every (i,j)} \quad (22)$$

In other words, when accounting for the transformed secondary energy (row T, FS), only the negative values corresponding to the input of secondary energy to the transformation centers should be added up. Thus, there would be no duplication of secondary energy production (outputs of the transformation centers), which is already accounted for under the row of secondary energy production ($O_i\ FS_j$).

- The transformation losses in each center are the difference between $T_i\ FP_j$ or $T_i\ FS_j$ and the corresponding production $O_1\ FS_j$.

As for the input of data into the TRANSFORMATION submatrix of the summary matrix of the energy balance, it should be pointed out that:

- The value of the primary sources entering the transformation centers (T_1-T_9) should be indicated with a minus (-) sign.

- On the right-hand side of the transformation sector, which represents the secondary energy production or output, based on the primary energy input in the corresponding centers, figures should be indicated with a plus (+) sign.

- The values for the secondary sources which enter the transformation centers (e.g., diesel to the electric power plants) should be indicated with a minus (-) sign.

3.3 Total Final Consumption

This refers to the relations among the energy flows in the seven consumption sectors. Here, for every column the following must hold true:

$$CT = C + CN \quad (23)$$

In other words, total final consumption is equal to final energy consumption plus final non-energy consumption.

As for treatment of energy consumption by non-energy end-uses, it is worthwhile to stress that the presentation of this source is the same one used in the summary matrix; however, in the data-gathering of each country, an effort must be made to disaggregate this source under the corresponding sectors, in order to have greater knowledge about the sectoral shares of the source.

The energy consumption submatrix simultaneously considers the primary and secondary sources whose sub-totals appear in the columns TEP and TES, respectively, whereas the sum of the two appear in the last column (TOT) of the matrix. The following equation must also be met:

$$CF = C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 \qquad (24)$$

3.4 Useful Consumption

This refers to the relations between final energy consumption and the efficiencies of the equipment for final transformation to useful forms of energy. As in energy consumption, this last part of the general matrix also simultaneously considers the primary and secondary sources whose sectoral sub-totals appear in the columns TEP and TES, respectively, whereas the sum of the two appears in the last column (TOT) of the matrix.

The following equations must be met in this sub-matrix:

$$UE = U_1 + U_2 + U_3 + U_4 + U_5 + U_6 + U_7 \qquad (25)$$

That is to say, the useful energy consumption by column is equal to the sum of useful energy by sector.

The average efficiency will result from relating Equations (25) and (24).

Finally, the vector of utilization losses for each source PU (FP_j) or PU (FS_j) arises from the difference between the final consumption C (FP_j) or C (FS_j) and the useful consumption U (FP_j) or U (FS_j), so that:

$$PU\ (TEP) = \sum_{j=1}^{9} PU\ (FP_j) \qquad (26)$$

$$PU\ (TES) = \sum_{j=1}^{12} PU\ (FS_j) \qquad (27)$$

$$PU\ (TOT) = PU\ (TEP) + PU\ (TES) \qquad (28)$$

TABLE 1

YEAR:
SECTOR:

UNIT:

SOURCES	FINAL ENERGY CONSUMPTION (1)	%	USEFUL ENERGY CONSUMPTION (2)	%	EFFICIENCY (2)/(1)
$SOURCE_1$					
$SOURCE_2$					
$SOURCE_n$					
TOTAL					

TABLE 2

YEAR:
SECTOR:

UNIT:

USES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2)/(1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
USE_1					
USE_2					
USE_n					
TOTAL		100.0		100.0	

TABLE 3

YEAR:
SECTOR:

UNIT:

SUBSECTORS	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2)/(1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
$SUBSECTOR_1$					
$SUBSECTOR_2$					
$SUBSECTOR_n$					
TOTAL		100.0		100.0	

TABLE 4

YEAR:
SECTOR:
SOURCE:

UNIT:

USES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2)/(1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
USE_1					
USE_2					
USE_n					
TOTAL					

TABLE 5

YEAR:
SECTOR:
SUBSECTOR:
SOURCE:

UNIT:

USES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY (2)/(1)
	CONSUMPTION (1)	%	CONSUMPTION (2)	%	
USE_1					
USE_2					
USE_n					
TOTAL		100.0		100.0	

TABLE 6

CONSUMPTION OF NON-ENERGY PRODUCTS BY SECTOR

YEAR:

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

TABLE 7

SYMBOLS USED

SYMBOL	CODE	TERM
Primary Energy		
FP_1	PT	Crude Oil
FP_2	GN	Free and Associated Natural Gas
FP_3	CM	Coal
FP_4	HE	Hydroenergy
FP_5	GE	Geoenergy
FP_6	CF	Fission Fuels
FP_7	PE	Firewood
FP_8	PC	Sugarcane Products
FP_9	OF	Other Primary Sources
FP	TEP	Total Primary Energy
Secondary Energy		
FS_1	GL	Liquefied Gas
FS_2	GO	Gasoline and Naphthas
FS_3	KE	Kerosene and Turbofuels
FS_4	DL	Diesel and Gas Oil
FS_5	CP	Heavy Fuels
FS_6	CQ	Coke
FS_7	EE	Electricity
FS_8	CV	Charcoal
FS_9	AL	Alcohol
FS_{10}	GS	Process Gases
FS_{11}	OE	Other Energy Fuels
FS_{12}	NE	Non-Energy Products

SYMBOL	CODE	TERM
FS	TES	Total Secondary Energy
FT	TOT	Total
Supply		
O_1	PR	Production
O_2	IM	Importation
O_3	EX	Exportation
O_4	VI	Variation in Stocks
O_5	NA	Unutilized
O	OI	Supply
Transformation		
T_1	REF	Refineries
T_2	CEP	Public Power Plants
T_3	CEA	Auto-Producing Power Plants
T_4	PLG	Gas Plants
T_5	CAR	Charcoal Plants
T_6	COQ	Coke Plants
T_7	DEA	Alcohol Distilleries
T_8	OCT	Other Transformation Centers
T_9	OTR	Other Transformations
T	TRT	Total Transformation
PT	PET	Transmission, Distribution and Storage Losses
NA	NA	Unutilized Energy
A	AJ	Adjustments
Final Energy Consumption		
C_1	TRS	Transportation
C_2	IND	Industrial

SYMBOL	CODE	TERM
C_3	RES	Residential
C_4	CSP	Commercial-Services-Public
C_5	APM	Agriculture-Fishing-Mining
C_6	CFP	Auto-Consumption
C_7	OTR	Others
CF	CFE	Final Energy Consumption
CN	CFN	Final Non-Energy Consumption
CT	CFT	Total Final Consumption
Useful Energy Consumption		
U_1	TRS	Useful Transportation
U_2	IND	Useful Industrial
U_3	RES	Useful Residential
U_4	CSP	Useful Commercial-Services-Public
U_5	APM	Useful Agriculture-Fishing-Mining
U_6	CFU	Useful Auto-Consumption
U_7	OTR	Useful Others
UE	CEU	Useful Energy Consumption
UN	CNU	Useful Non-Energy Consumption
U	CUT	Total Useful Consumption
PU	PUT	Utilization Losses

CHAPTER III

INFORMATION AND DATA PROCESSING

Preparation of an energy balance in terms of useful energy (BEEU), on the basis of a methodology such as the one proposed herein, requires a series of both energy and non-energy information, the availability of which varies according to the type of data and the country being studied.

The experience in development of balances methodologies and their consequent application (as in the case of the OLADE balances) has not been accompanied by a similar systematic development of energy information systems, permitting refinement of consumption at the subsectoral level and, within each subsector, by uses and sources.

1. Organization and Treatment of Information

The first stage in construction of BEEU is preliminary data collection, which consists of gathering all of the data published on the subject of useful energy, whether systematic or not, and in the original formats.

The important thing in this phase is to be certain that all written data have been detected, so that the collected information is really what exists.

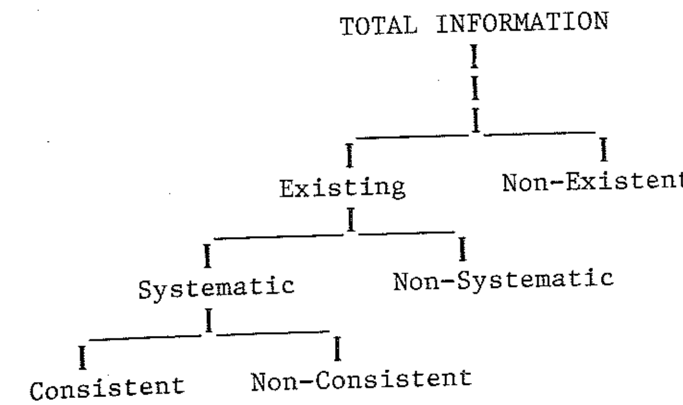
It is convenient to organize the collected data so as to facilitate final preparation of the balance for the final consumption sectors, as well as for the auto-consumption sector. This is a fundamentally qualitative stage, where the compiled information is transcribed into special formats, respecting certain rules of compilation.

It should be stressed that the format in which the balances are ultimately presented can never be completed directly but rather through certain intermediate steps.

It is suggested that the information be grouped by energy source and by sector in the so-called main sectoral data sheets, such as those shown in Chapter II (Tables 1 through 6).

1.1 Information Assessment

In the task of compiling the main data sheets, it is very useful to assess the information and to classify it according to the following scheme:



If percentages are assigned to the foregoing scheme, in keeping with the first effort at completing the sheets, this defines the initial stage. For example, initially a country may have only 20-30% of the existing information in systematic and consistent form, but at the end of the exercise should have at least 90% that way. To accomplish this, it will be necessary to establish certain criteria for consistency and to subject the information to these.

1.2 Historical Linkages

For each series, there should be logical historical behavior, so that there will be no discontinuities. This will make it possible to handle those cases in which there have been unspecified changes in the criteria for compiling the existing information.

Once all of the independently consistent statistical series on primary and secondary energy are available, it should be verified that the efficiencies of the transformation centers (energy sector) and those of the transformation equipment in final consumption (final consumption sectors) fall within the technical limits which correspond to the respective installations and transformation equipment.

By applying these criteria and processing the non-consistent information, the latter can become consistent.

As for the non-systematic information, the years that are missing can be completed by estimates, at least up to final energy; then consistency is verified. Non-existent information is still lacking and should be worked out with appropriate statistical methods.

1.3 Polls and Surveys

The non-existent information should be generated through polls and surveys.

In this case, a poll is a method consisting of interviews with persons or institutions that can provide insights as to adequate estimators (efficiencies, audits, etc.). Polls are characterized by the fact that they are done in a fairly indiscriminate way and without a previous design.

If the foregoing does not obtain results, a statistical design is made both for sampling and for analysis of the results, and surveys are taken; these are treated by sector in the sectoral appendices.

The information assessment can render account of what exists and is consistent; it can be affirmed that, on the basis of the systematic publication of the OLADE balances, the consumption of final energy by sector, as well as the information referring to the supply sector of the balance, forms part of this classification.

Nonetheless, the quantification of useful energy consumption requires a greater disaggregation of sectoral consumption, as well as consumption by end-uses, types of equipment, sources and efficiencies; in most of the countries of the region, this information can be classified as non-existent.

Thus, given the lack of such systems, it is necessary to present the different alternatives which, for each sector, will permit quantification of useful energy consumption. This quantification, as can be observed in the corresponding appendices, differs according to the subsectors, end-uses and sources considered, generating in each case, and in light of the different possibilities for knowledge about energy consumption, different methods of information-gathering, census and samples, and in these, different types of designs.

Thus arises the need to CREATE INFORMATION which, under the title DATABASE FORMATION, is included in Chapter II of each sector presented, with the sole aim of providing a frame of reference or general guidelines for its formulation.

2. Formation of Databases and Processing of Information

Given the heterogeneity presented by the consumption sectors, the guidelines for forming a database show uneven development, proper to each sector, with different alternatives, according to the previous knowledge available on sectoral energy consumption. Different is the case of the auto-consumption sector which, owing to its nature, entails census-taking in all of the activities which comprise the sector, except for the charcoal plants, for quantification of the useful auto-consumption and the transformation losses.

It is worthwhile to point out here that the guidelines presented in each sector for formation of the database may be a first step of prime importance for construction of a NATIONAL and/or REGIONAL INFORMATION SYSTEM. Obviously, it is merely stated here that it may be a first step, since the development of an information system goes beyond the scope of this methodology; but it is just as true that the availability of such a system may accelerate the application of this methodology.

Another important step in the treatment of information is constituted by the data processing obtained through surveys. In this case, also, auxiliary and main data sheets are presented for each sector, for the elaboration of sectoral balances, as well as the treatment of possible sources of error.

The manual or computerized processing should always guarantee the coherence and consistency of the data obtained on the basis of survey forms (presented for the sake of reference for each sector), which later aid in preparing partial balances, whether these be for an industrial plant or a mining establishment, for each subsector of a particular sector.

If processing is computerized, it is convenient to make the following clarifications:

- It can be said that it is highly useful (and one could dare to say indispensable) for the data to be entered into the computer in the same form in which they were collected. This is equivalent to generating an empty file with the same structure of the original form which, by means of an interactive program, progressively requests and enters data. This method requires a certain programming effort, but it offers the great advantage that the entering, correction and in general everything relative to data management can be done without the participation of arbitrary codes.

- One difficulty in entering data in formats which are exactly like the original form-- which can be resolved by means of programming-- is that the available statistical packages in charge of constructing partial balances are not very flexible in terms of the data-reading formats and, in general, they cannot be read in formats such as those that are being proposed. It is thus necessary to have an INTERPHASE PROGRAM to transform the MANAGEMENT FORMAT into a READING FORMAT.

- The experience in the software existing on the market has not been positive in terms of its use for data management using data-gathering forms such as those proposed for each sector. Nevertheless, given the fact that the market of computer packages is so vast and evolves so rapidly, it cannot be affirmed that no solutions are available, especially taking into account that the new generation of microcomputers makes almost daily progress, both in terms of memory capcity and package supplies.

In summary, an exhaustive investigation should be made into the possibilities for available computers, languages and software packages. The opportune selection of languages and formats will avoid difficulties and will shorten processing time, and at the same time these software packages will permit interaction with the users, thereby enabling greater control of processing.

CHAPTER IV

GENERAL CONSIDERATIONS

1. Characteristics

The methodology presented herein is aimed at covering the theoretical needs of the elaboration of the BEEU in all of the countries of the region. The methodology is valid to the extent that it can be progressively implemented, from the elaboration of a preliminary balance up to the use of a database.

In that connection, no effort has been spared in the field of definitions, in an attempt to establish a coherent conceptual framework, despite the difficulties that the subject of useful energy presents both in terms of application and analysis.

On both levels, special care has been taken with the physical concepts of useful energy and the general efficiencies of each subsector. As for application, an attempt has been made to highlight statistical methods such as surveys and energy audits, for the formation and/or expansion of the database.

This methodology also has the merit of lending itself to application no matter what the state of the art of each sector of the useful-energy balance of each country, as well as the cost and information benefits which it offers. Therefore, applications of diverse scope are envisaged.

2. Advantages

It is important to keep in mind some of the advantages of the BEEU as a tool which facilitates overall energy planning. Taken in isolation, the BEEF only offer a picture of the physical flows and relations of the energy system within a given period.

In its more disaggregated state, based on final consumption, as proposed in this methodology, the BEEU make it possible to visualize the complete energy flow from supply and consumption up to utilization after the last transformation to a useful state. Knowledge about, and mastery of the final consumption "equipment" forms the basis for the analytical principle concerning the possibilities for substitution and competition of rates and prices of different energy sources. It also permits calculation of certain ratios for efficiency, penetration and substitution of technologies, as well as preparation of assesssments of the global energy situation of a country, subregion or region. Nevertheless, only through its relation to other socioeconomic variables can BEEU become an invaluable instrument of energy planning.

The methodology in its present state of development has also

attempted to elaborate the concept of the efficiency of final energy use, which is indispensable for determining policies for rational use of energy. However, it must be kept in mind that in order to arrive at this level of development in the disaggregation of the balance, it is necessary to know beforehand the useful energy up to efficiency of production. For that reason, a cutoff point is being adopted in the matrix of the BEEU-OLADE, up to efficiency of production, letting each country adopt the particular type of evaluation which would coincide with its needs and characteristics, in order to arrive at the efficiency of use.

The methodology, as a theoretical instrument, provides elements to facilitate more in-depth analytical applications without leaving aside those applications of partial scope which could provide a minimal basis for evaluation. In other words, an effort is made to seek a conceptual equilibrium in which the aim of obtaining immediate results does not contradict the long-term objectives of application and analysis.

3. Limitations

As for application of the methodology, there are still some limitations, which range from the diversity and heterogeneity of the energy profiles of the Member Countries up to the same difficulties encountered for structuring and availability of a reliable database.

This uneven development in the countries´energy structures calls for different treatment in terms of methodology application, given that the emphasis on energy policy is different for each country. In other words, the energy exporters foresee the energy prospects or problems differently than the importers do. Furthermore, in those countries where the rural sector and non-conventional sources (firewood, plant and animal wastes, etc.) hold greater importance with respect to final energy consumption, there is a tendency to concentrate on policies related to this field.

Under these circumstances and taking into account the energy profile of Latin America, an attempt will be made to adopt a mechanism for transfering the methodology in keeping with the features of regional, subregional and national energy development.

Although at the regional level OLADE has made efforts to generate the minimum available information in the field of planning, as in the case of the elaboration of the BEEF and in the technical sphere, the initiation of resource inventories in the region, the truth is that there is no coherent, integral regional information system.

The development of BEEU should also constitute, in addition to an element of planning, an effective medium for strengthening the the information apparatus.

This would be sufficient justification for following a systematic process in the area of energy information. It is well known that the implementation of an information system is a complex task in itself and that, besides a methodological structure in line with the needs of the countries of the region, it requires political decision and backing, with a view to accomplishing concrete goals and activities.

To overcome the obstacles in the area of energy information is no easy task, if it is kept in mind that, in addition to an aggressive process of appraisal of its importance and value, it will be necessary to work on the search for a solid institutional infrastructure. Within the process of institutional development for energy in the Member Countries, energy information is unfortunately not given a definite place but left marginal within the institutional structure of the organizations which direct energy policy, thus hindering suitable coordination and, as a consequence, overall system management.

In national and regional institutions, it is common to encounter a dispersion of energy information generation and management. In some countries, the lack of institutional response to the need for information becomes evident in the fact that information is considered as a phenomenon outside the institution.

The lack of control mechanisms calls for the establishment of information systems in order to assure the cycle of information transfer as well as to make available a nationally centralized system as a principle of institutional organization and structure.

Few countries in Latin America have an information system in charge of general coordination and direction in the field of energy; rather, it can be seen that the institutions approach this aspect independently and following criteria which are modified or adapted in keeping with the circumstances or requirements.

A very common obstacle, and one difficult to overcome, is the lack of financing for implementation of this type of project in the field of energy, as in the case of BEEU, which call for surveys and audits as a fundamental means of aggregating the information which will permit more in-depth analysis of the problems of useful energy. It should be underlined that, in a first instance of methodology application, the existing information may be used in combination with partial investigations and estimates. However, what is desirable is to cover, insofar as possible, the full methodological range; this implies having a financial component permitting the development and implementation of this project.

4. Alternative Solutions

It is evident that there are obstacles in terms of the transfer and application of the methodology in a short period of time, as

another instrument for planning and an imperative component in the formation of national information systems in the Member Countries.

The present document, which contains the OLADE Methodology for the Elaboration of Energy Balances in Terms of Useful Energy, seeks to stimulate discussions and analyses by the Member Countries and international organizations, in order to initiate and implement this instrument which also intends to propitiate national coordination of energy sector information up to the level of the consumer and to make available greater knowledge about the components of energy demand.

Under these circumstances, in addition to the reconciliation of criteria in the methodological and conceptual areas, development of the methodology also requires decided political support from the Member Countries in order to achieve the goals and objectives which are geared, above all, to overcoming the limitations discussed above.

Through horizontal cooperation, a TRAINING PROGRAM is proposed by subregion or model country, making it possible to begin to prepare the BEEF and the BEEU in the Member Countries. OLADE considers that their success will come from the transfer of knowledge which the members of the work group formalized to prepare the methodology will be able to offer and provide within the following criteria for aid and support:

- In the solution of doubts and clarifications growing out of the analysis and assessment of the document by each country;
- In the preparation of preliminary BEEU for 1985/1986, through horizontal cooperation and support from national teams;
- In the realization of possible training courses by model countries; and,
- In the exchange of information and experiences.

In order to facilitate the means of an institutional nature for the application of this methodology, the gaps existing in the national information teams and systems must be identified so as to take advantage of the transfer of this methodology and in this way guarantee viability and effective implementation.

To agree on the most appropriate mechanisms and procedures to facilitate integral transfer of the OLADE methodology for the elaboration of the BEEU will undoubtedly be a determining step in the search for the institutional coordination indispensable for development of this program in the short, medium and long terms.

CHAPTER V

G L O S S A R Y

A glossary of terms used in the preparation of useful-energy balances is presented below, with the specific connotations to be given to these terms in order to unify the technical criteria of the countries.

PRIMARY ENERGY

"Primary energy" is understood as the different sources of energy, as they are obtained from nature, whether directly, as in the case of hydro or solar energy, or after a process of extraction, as in the case of petroleum, coal, geothermal energy, etc., or through photosynthesis, as in the case of firewood and other vegetable or plant fuels. The following primary sources have been considered:

Crude Oil

This is a complex mixture of hydrocarbons having different molecular weights, in which there is usually a small proportion of compounds containing sulphur and nitrogen. The composition of petroleum is variable and may be divided into three types, according to distillation residues: paraffin, asphalt or a mixture of the two.

Crude oil is used as a feedstock in refineries, where it is processed to obtain derivatives.

Natural Gas

This is a mixture of gaseous fuels and includes both free natural gas and associated natural gas, present in coal mines or geopressure zones. Herein, both (the net free and associated gas produced) are placed under the same heading due to their similar nature and uses.

- Free Natural Gas

  This is that gaseous fuel mixture constituted primarily by the methane obtained from gas fields.

- Associated Natural Gas

  This is the gaseous fuel mixture which comes from an oil well.

Coal

This is a solid combustible mineral, black or brown in color and containing essentially carbon, as well as small amounts of hydrogen and oxygen, nitrogen, sulphur and other elements, as a result of the degradation of the remains of plant organisms over long periods, due to the action of heat, pressure and other physical and chemical phenomena.

Due to the fact that there are different degrees of change in the process, coal is not a uniform mineral; it can be classified by ranges, according to the degree of metamorphosis in series going from lignites to anthracites, which present considerable differences in terms of volatile matter content, fixed carbon and calorific value.

- Anthracite and Bituminous Coal

  This is the coal which has completed an advanced or medium stage of carbonization, with a net calorific value (NCV) of 5100-8500 Kcal/kg, on an ash-free, humidity-free basis.

- Lignite

  This is found in a less advanced stage of carbonization and has an NCV of 4125 Kcal/kg, on an ash-free, humidity-free basis.

- Peat

  This is a precursor of coal and is formed by the chemical and bacterial decomposition of dead vegetable matter. Because of the action of heat, pressure and other phenomena, peat is transformed into different types of coal.

Hydroenergy

This is the potential energy from a waterflow.

Geoenergy

Geothermal energy is the energy which is stored under the earths surface in the form of heat and which can be transmitted to the surface by a fluid in contact with the hot rock. This fluid is usually water in a liquid state, steam, or a mixture of the two.

Fission Fuels

This is the energy obtained from uranium ore, following processes of purification, conversion and/or enrichment.

Firewood

This is the energy which is obtained directly from forest resources. It includes tree trunks and branches and waste from sawmilling activities, all of which fall under the definition of "other plant and animal fuels" used for energy purposes.

Sugarcane Products

This includes the sugarcane products which are used for energy purposes; among these are bagasse, cane liquor (juice) and molasses.

Other Primary Energy Sources

This concept includes:

- Vegetable or Plant Fuels

  These are the energy resources obtained from agroindustrial and forestry residues.

  Here are included all of the agricultural wastes (except sugarcane bagasse), e.g., rice husks, coffee husks, coconut shells, etc., wastes from sawmills (not included under the concept of firewood nor bagasse), etc., for energy purposes.

- Animal Fuels

  These refer to the residues of agricultural/livestock activities and urban wastes. They can be used directly as fuel in a dry form or converted into biogas through a process of fermentation or a method of decomposition.

- Recovered Energy

  Substances with an energy content produced in industrial plants as a by-product of the production process, for example, furnace gas, black liquor, etc.

- Other Energy Sources

  These include wind and solar energy and any other primary source not included in the foregoing descriptions but relevant in the energy structure of the country.

SECONDARY ENERGY

"Secondary energy" is the term used for the different energy products which originate from the various transformation centers and the destination of which is the different consumption sectors and/or other transformation centers.

The forms of secondary energy considered are as follows:

Liquefied Petroleum Gas (LPG)

This consists of light hydrocarbons, principally propane and butane, alone or in combination, obtained from the distillation

of petroleum and/or the treatment of natural gas.

Gasolines and Naphthas

This is a mixture of light liquid hydrocarbons obtained from petroleum refining and/or the treatment of natural gas, whose boiling range is generally found between 30 and 200 degrees Centigrade.

This group includes:

- Aviation Gasoline

  This is a mixture of reformed naphthas having a high octane number, high degree of volatile matter and stability, and a low freezing point; it is used in propeller aircraft with piston engines.

- Motor Gasoline

  This is a complex mixture of relatively volatile hydrocarbons which, with or without additives (such as tetraethyl lead), is used to operate internal combustion engines.

- Natural Gasoline

  This is a product of the processing of natural gas and it is used as feedstock for industrial (petrochemical) processes and refineries or in direct mixtures with naphthas.

- Naphthas

  These are volatile liquids obtained from petroleum and/or natural gas processing and used as feedstock in refineries, as a solvent in paint and varnish factories, as a cleaning agent, and also in petrochemicals and fertilizers.

Kerosene and Turbofuels

These are liquid fuels constituted by the fraction of petroleum which is distilled between 150 and 300 degrees Centigrade. Kerosene is used as a fuel for cooking, lighting, and running engines, and as a solvent in shoe polish and insecticides for household use.

Turbofuels are a kerosene with a special degree of refining, which has a lower freezing point than regular kerosene. They are used in reaction and turbopropeller engines.

Diesel/Gas Oil

These are liquid fuels obtained from the atmospheric distillation of petroleum between 200 and 380 degrees Centigrade; they are heavier than kerosene and are used in diesel engines and other compression-ignition motors.

Heavy Fuels (Fuel Oil)

This is the residue of petroleum refining and comprises all of the heavy products, which are generally used in boilers, electric power plants and navigation.

Coke

The general term of coke is applied to an unmeltable solid fuel with a large carbon content, obtained from the destructive distillation of coal, petroleum and other carbon materials. There are different types of coke, and these are usually identified by adding to their name, the name of the material from which they originated: for example, petroleum coke. This definition includes petroleum coke and coke plant products.

Electricity

This is the energy composed of electrical charges in motion. It includes the electric energy generated from any resource, whether primary or secondary, in hydroelectric, thermoelectric, geothermal or nuclear plants.

Charcoal

This is the fuel obtained from the destructive distillation of the wood from charcoal plants, in the absence of oxygen. This product absorbs humidity rapidly, so that it usually has a moisture content of 10-15%, in addition to 0.5-1.0% hydrogen and 2-3% ash, with a net calorific value of around 6500 Kcal/kg.

These features may vary according to the wood from which it is derived.

Alcohol

This includes both ethanol (ethyl alcohol) and methanol (methyl alcohol) used as fuels.

Ethanol is a colorless liquid which can be produced by means of fermentation of vegetable matter having a high sugar content, such as sugarcane liquor or molasses; vegetable matter with a high starch content, such as cassava, corn, etc.; and matter with a high cellulose or pulp content, e.g., firewood and plant residues. It can be used as anhydrous or hydrous alcohol, mixed with gasoline or alone, in internal combustion engines.

Methanol is also a colorless liquid that can be produced from various raw materials, such as firewood, vegetable waste, methane, natural gas, charcoal, etc. It is also used in combustion engines.

Process Gases

This category includes the gaseous fuels obtained as by-products of activities in refineries, coke plants and furnaces, as well as the gas obtained from biodigesters.

- Refinery Gas

  This is the non-condensable gas obtained from crude oil refining; it consists mainly of hydrogen, methane, and ethane and is used mostly in the refining process itself.

- Furnace Gas

  This is a gas obtained as a by-product from steel-making activities in furnaces and is generally used for heating in such plants.

- Coke Gas

  This is the gas produced as a secondary product in the intense heating of coal or coke, with a mixture of air and steam in coke plants. It is composed of carbon monoxide, nitrogen and small amounts of hydrogen and carbon dioxide.

- Condensed Gas

  This includes liquid hydrocarbons obtained as a by-product from the treatment of natural gas (ethane, propane, butane and pentane).

- Biogas

  This is the gas, principally methane, obtained from the anaerobic fermentation of biomass waste.

Other Fuels

Here are included both energy and non-energy products.

- Other Energy Fuels

  These are the secondary energy products which have not been included in the preceding definitions and which take part in the energy structure of the country.

- Non-Energy Products

  These are the products which are not used for energy purposes although they have a considerable energy content; among these can be mentioned asphalt, lubricating oils and greases, etc.

- Lubricants

  These are viscous liquid hydrocarbons rich in paraffin wax and obtained by means of the atmospheric distillation of petroleum between 380 and 500 degrees Centigrade.

- Bitumen

  This is a solid hydrocarbon with a colloidal structure, brown or black in color, which is obtained as a residue from a distillation process in a vacuum, of the residues of the atmospheric distillation of petroleum.

ENERGY SUPPLY

This term refers to the total amount of energy available for consumption in the country. Within this concept, the followng variables have been considered:

Production

This refers to the energy produced within the national territory.

When dealing with primary energy, the volumes extracted from national sources are considered.

For secondary energy, all of the output flows from the national transformation centers are considered, prior to accounting for recycling and auto-consumption.

Importation

This includes all of the energy flows, both primary and secondary, originating from outside the countrys borders and entering to form part of the supply.

Exportation

This includes the primary and secondary energy allocated for external supplies.

Variation in Stocks

This is the difference between the stocks at the beginning and at the end of a year, for each form of energy, whether primary or secondary; an increase in stocks is indicated with a plus (+) sign, and vice versa.

Unutilized Energy

This is the amount of energy which, due to technical and/or economic constraints for exploitation or due to demand conditions, is not used. Examples of this type of energy are:

- Spilled petroleum.

- Flared gas (natural or refinery gas).
- Overflows in hydroelectric stations.
- Differences between the mass of steam and/or water extracted from a geothermal well and the mass of steam that feeds into a power plant or other installation.

TOTAL SUPPLY

This is the amount of primary and secondary energy available to satisfy the energy needs of the country, both in terms of final consumption and transformation centers.

TRANSFORMATION

This refers to the primary and secondary energy flows that enter and leave the group of transformation centers, respectively. Physical or chemical transformation is understood as the change of one source of energy into another, by means of any one of the transformation centers included in the matrix.

Losses

These refer to the amount of energy lost in the activities of storage, transportation and distribution of the primary and secondary energy products, from the centers of production to the centers of consumption.

Examples of losses are those which occur in the transmission and distribution of electricity, in the storage and pipeline transport of hydrocarbons, in the distribution of gas, etc.

Losses in the transformation centers are not included, since they are treated separately.

Adjustments

Statistical adjustments constitute a measure of the statistical soundness of the information, by permitting compatibility between the double flow of information, Energy Supply/Consumption, measured independently and avoiding, insofar as possible, the calculation of one variable as a function of the other.

The statistical differences between the two variables and all of the adjustments are included here. These adjustments should not exceed 5%.

TOTAL FINAL CONSUMPTION

This part includes all of the energy flows grouped according to socioeconomic sectors in which they are consumed.

This heading includes:

- Final Energy Consumption

  This item refers to the total amount of primary and secondary products used by all of the consumption sectors to satisfy their energy needs.

- Final Non-Energy Consumption

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

- Total Final Consumption

  This is all of the energy delivered to the consumption sectors, for both energy and non-energy purposes.

USEFUL ENERGY

For the sake of comparison with definitions from other organizations, the differences in useful energy adopted by other international organizations are presented below.

United Nations(*)

Useful energy is effectively transformed into useful work, in the equipment and processes corresponding to the different end-uses, such as the power obtained in an automobile, the light from a bulb, or fluorescent tube, or the heat from the steam produced when fossil fuels are burned. These amounts of useful work reflect the combined effects of the theoretical efficiency of the device, the equipment or the process, as well as the intensity of operation and the form of utilization.

World Energy Conference(**)

This is the energy which is available to the consumer after its final conversion.

A useful-energy balance is a balance established on the basis of accounting of the different energy flows according to their real calorific value, from the primary supply to the useful energy recovered by the final consumer at the outlet of his devices, thus considering the losses suffered in the different phases of transformation and consumption.

Since there is no effective measure of useful energy, this balance is in fact a balance derived from the balance of final

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(*) Concepts and Methods in Energy Statistics, with special reference to energy accounts and balances. United Nations Series F, No. 29.

(**) World Energy Conference Glossary on Energy Balances and Accounting, Pergamon Press, pg. 5.

consumption at the level of final energy, by applying average or estimated efficiencies for the last apparatus in the transformation and assuming a sound knowledge of the park and its efficiencies, which can vary in significant proportions.

Note: Determination of useful energy could be considered as a function of technical procedures, its use and the economic sectors, but these breakdowns present such theoretical and practical difficulties that, currently, only the first solution is being applied.

European Economic Community(***)

Useful energy is the energy available to the consumer after its final conversion.

(***) EUROSTAT - "Useful Energy Balance Sheets 1975," Belgium, 1978.

CHAPTER VI

ENERGY EQUIVALENCIES AND EFFICIENCIES

1. Energy Equivalencies

The flows which make up the energy balance are usually measured using different units. However, in order to close the overall balance and enable the comparative analysis of data and the review of the energy structures in a country, it is useful and necessary to unify the units of measure for the different sources of energy by using a common unit.

The OLADE energy balance is presented in barrels of oil equivalent (BOE), which have the following equivalencies based on the calorific value of oil: 1 kg = 10,000 Kcal.

1 bbl = 159 liters
1 TOE = 7.206 barrels of oil equivalent (BOE)
1 BOE = 0.2082 tons of coal equivalent (TCE)

The sheets which comprise the national balance are usually prepared in the original units; in other words, solid sources in metric tons, gases in cubic meters, and electricity in kilowatt-hours (kWh), etc.

To assure coherence in the basic data, it is important that both the main sheets and the auxiliary sheets of the useful-energy balance follow the same norms.

It would be advisable to compile the sectoral balances (main sheets) in terms of a common unit, which could be the Joule (kilo or tera) or the calorie, and which could be systematically converted into BOE in the overall presentation of the national or regional energy balance.

Thus, we have that:

1 Joule = 0.2388 calories
1 TJ = 0.2388 Tcal
1 Tcal = 4.186 TJ
1 TOE = 10 Kcal
1 BOE = 0.1387 TOE

Generally speaking, before putting the energy balance matrix into any unit, it is necessary to quantify the calorific value of each energy source. This will be defined by means of adiabatic calorie meters, with which the heat given off during energy combustion is measured taking into account the condensation of water vapor. This value is known as the upper or gross calorific value (GCV). With knowledge of the GCV, the lower or net calorific value (NCV) can be calculated; it does not include the heat used

in water vapor condensation. The NCV is calculated by means of the following formula:

NCV = GCV - 9 (xH) (H20) 15 C

where:
H = Enthalpy of water at 15 C
x = Number of hydrogen atoms

The difference between the GCV and the NCV becomes more important when going from gaseous fuels to light liquid fuels, and from the latter to heavy liquid fuels. The dry-base difference in dry fuels may be 10% and in heavy liquid fuels 1%.

The Convention Adopted by OLADE

The BEEF of OLADE, in their current state, evaluate liquid and gaseous fuels according to the net calorific value (NCV), which discounts the latent heat of the condensation of water vapor contained in the combustion gases, which, in practice, is not utilized.

The NCV has been adopted because:

1. It reflects the exact amount of heat contained in each fuel that may be used by the consumer.
2. It facilitates economic comparisons among fuels, for the calculation of relative prices.
3. It permits a clearer picture for decision-making with respect to inter-fuel substitution, based on heat per unit of mass.
4. It does not distort the relative share of the primary sources in a country's energy supply; such distortion becomes more accentuated when gaseous and plant fuels weigh more in the energy structure.
5. It does not artificially increase the real structure of internal energy demand.

From the theoretical standpoint, any convention may be adopted in the national energy balance, as long as it explicitly specifies the corresponding conversion factors for the purposes of analysis and comparison with other balances.

The calorific values of the energy sources presented in the OLADE balance vary according to their origin, composition, humidity content, volatile matter content, etc., for which reason each country should use its own information, obtained from the analysis of the energy sources used. The countries should periodically review these values and make the necessary modifications; thus, the importance of remitting, along with the balance, the information corresponding to the calorific values used.

Nonetheless, there are countries which do not have this kind of information available and which find themselves obliged to use values from other sources and origins. For this purpose, it is suggested that the average calorific values and the conversion factors which are presented in Tables 7 and 8, respectively, be used. These have been defined following the review and analysis of available information and of the factors used by the countries of the area.

With respect to the energy sources considered in the balance, it is worthwhile to note that:

- For petroleum-derived products with non-energy uses, the net calorific value of oil is used.

- For liquefied gas, the net calorific values for propane and butane, which constitute this gas are averaged.

- In the case of Column 8 of the energy balance, known as "Sugarcane Products," the following treatment is proposed:

  i) The sources considered for inclusion under "Sugarcane Products" are the bagasse used as a source of energy and the cane liquor and/or molasses which are feedstock for alcohol production.

  ii) The fuel alcohol and hydrated alcohol for energy and chemical uses and the biogas produced from stillage fermentation are considered as secondary sources.

The energy flow corresponding to the column for "Sugarcane Products" is presented, as follows:


```
                                                     I---FUEL
                                   ENERGY            I(13)
                   FUEL            I-----------------I----INDUSTRY (HEAT)
                   ALCOHOL         I(13)             I
                 I-----------------INON-ENERGY (0)
                 I (16)            I--------------------CHEMICAL INDUSTRY
                 I                   (3)
                 I                                 I------FUEL
                 I                 ENERGY          I  (15)
CANE LIQUOR      I HYDROUS         I---------------I------INDUSTRY (HEAT)
AND/OR MOLASSES  I ALCOHOL         I(22)           I  (7)
-----------------I-----------------INON-ENERGY
                 I (25)            I------------------CHEMICAL INDUSTRY
                 I                   (3)
                 I
                 I BIOGAS
                 I------------------------------------AUTO-CONSUMPTION
                    (2)

                 I (28)-------------------------------AUTO-CONSUMPTION
BAGASSE          I (44)-------------------------------SUGAR INDUSTRY
-----------------I ( 4)-------------------------------BEVERAGE INDUSTRY
 (92)            I (16)-------------------------------ELECTRICITY
                 I                                    GENERATION
```

TREATMENT OF SUGARCANE PRODUCTS IN THE OLADE ENERGY BALANCE

ACTIVITY \ SOURCE	CANE PROD.	BAGASSE	ANHYD. ALCOHOL	HYDROUS ALCOHOL	ELEC.	BIOGAS	TOTAL
01 PRODUCTION	52	92					144
T2 AUTO-PROD. POWERPLANT		-16			7		-9
T7 ALCOHOL DISTILLE.	-52		16	25		2	-9
C1 TRANSPOR.			13	22			35
C2 INDUSTRIAL		48			4		52
C6 AUTO-CONSU		28			3		31
CN NON-ENERGY CONSUMPTI.		3	3				

When cane liquor is used as a primary source, its calorific value can be defined as follows:

1 ton of cane = 923,423 Kcal
270 kg of bagasse = 486,000 Kcal

So that:

730 kg of liquor = 437,423 Kcal
1 ton of liquor = 599,210 Kcal

The net calorific values for sugarcane products are presented below:

SOURCES	Kcal/kg	Kcal/m^3
Sugarcane	923	
Molasses	1,800	
Cane liquor	600	
Sugarcane bagasse	1,800	
Stillage biogas		4,500
Alcohol	6,500	
Wastes	1,500	

In the case of bagasse, if its calorific value is not known but its humidity content is, it can be estimated by applying the following expression:

$$NCV = 4250 - 4850\ H \quad (*)$$

where:

NCV = net calorific value (Kcal/kg)
H = humidity content

Since the humidity contained in the bagasse is usually around 50%, this value can be taken as the average, thus establishing for bagasse a calorific value of 1825 Kcal/kg.

Generally speaking, there are no statistics on bagasse consumption in a sugar mill and/or alcohol distillery. However, there are data on the processed cane, and the amount of bagasse can be obtained from the latter value.

A review of the literature on the subject indicates that the amount of wet bagasse produced fluctuates between 26 and 30% of the processed cane, by weight; this suggests that, when more exact data are not known or available, the average value of 270 kg of wet bagasse per ton of processed cane should be used.

(*) Manual on the OLADE Methodology for Elaboration of Energy Balances

- The calorific value of firewood varies a great deal from country to country; even within one same country, different species of trees, with different degrees of humidity, are used, depending on consumption patterns.

  Some countries have run tests in order to determine an average calorific value for the conditions and species used and, although it is very difficult to generalize, it is suggested that a value of 3,600 Kcal/kg be taken for those countries which do not have better data.

- In the case of the energy source "Process Gases", which includes refinery gas, coke gas, furnace gas, etc., the average calorific value of each one should be kept in mind.

- The case of coal is treated like the case of "Process Gases", i.e., the calorific value for each type of coal should be considered.

- Electricity and Hydroenergy

  Electricity transformation is through the relation:

  1 kWh = 860 Kcal
  1 GWh = 3.6 terajoules

  This is the only method of conversion compatible with the methodology used in developing this balance, which covers the entire energy chain, from production through end-use and which also considers all of the losses involved.

- Geoenergy

  A methodology similar to the one proposed for hydroenergy will be used, considering the energy contained in the water vapor extracted from a geothermal well.

TABLE 8

LOWER (NET) CALORIFIC VALUES: THEORETICAL - AVERAGES

(reference values)

ENERGY SOURCE	AVERAGE CALORIFIC VALUE
Natural Gas	8600 Kcal/cubic meter
Oil	1.38 Tcal/1000 barrels
Liquefied Gas	0.96 "
Gasolines and Naphthas	1.24 "
Kerosene and Turbo Fuels	1.34 "
Diesel and Gas Oil	1.39 "
Heavy Fuels	1.48 "
Petroleum Coke	8700 Kcal/kgr
Gas	
- refinery	8800 Kcal/cubic meter
- coke plants	4500 "
- furnaces	800 "
- piped	4200 "
- biogas	5500 "
Coal	
- Anthracite	7500 Kcal/kgr
- Bituminous	6900 "
- Lignites	6800 "
Coke	
Tar Coke	9600 Kcal/kgr
Firewood	3600 "
Charcoal	6900 "
Sugarcane	1018 "
Ethyl Alcohol	7090 "
Bagasse	1825 "
Electricity	860 Kcal/kWh

TABLE 9

OLADE CONVERSION FACTORS

1	bbl	oil	=	1.0015 boe
1	bbl	gasoline	=	0.8934 boe
1	bbl	aviation gasoline	=	0.8574 boe
1	bbl	natural gasoline	=	0.7638 boe
1	bbl	diesel	=	1.0015 boe
1	bbl	heavy fuels	=	1.0304 boe
1	bbl	LPG	=	0.6701 boe
1	bbl	turbo (jet) fuel	=	0.9799 boe
1	bbl	kerosene	=	0.9583 boe
1000	m^3	free natural gas	=	5.9806 boe
1000	m^3	associated natural gas	=	6.4129 boe
1000	m^3	refinery gas	=	7.9261 boe
1000	m^3	coke gas	=	3.0263 boe
1000	m^3	furnace gas	=	0.6485 boe
1000	m^3	piped gas	=	2.8822 boe
1000	m^3	biogas	=	3.9630 boe
1	ton	coal	=	5.0439 boe
1	ton	coal coke	=	4.8998 boe
1000	kWh	electricity	=	0.6196 boe
1	kilo	uranium	=	71.2777 boe
1	ton	firewood	=	2.5940 boe
1	ton	charcoal	=	4.9718 boe
1	ton	bagasse	=	1.3114 boe
1	bbl	alcohol (ethyl)	=	0.5980 boe

NOTE: These conversion factors have been adopted on the basis of the weighted average of the conversion of all of the Member Countries that have reported.

2. Energy Efficiencies

EFFICIENCIES OF PRODUCTION OF EQUIPMENT BY SECTOR AND SOURCE

CHARACTERISTICS	IDEE	EEC UN	BRAZIL	PANAMA (C.RICA)
RESIDENTIAL COMM/ SERV/PUBLIC SECTOR				
FIREWOOD				
- Clay Oven	20			
- Economic Stove	20		20	
- Open Oven	10		5 1/	7.45 2/
- Three-stone	3-5			
- Spit	5			
- Grill	3			
- Hot Water Tank	24			
- Open-hearth	5		2-5	
- Closed-hearth	20			
- Iron Sheet	11			
CHARCOAL				
- Economic Stove	25		25	
- Open Oven	15		7	19 3/
- Spit	8			
- Grill	3			
- Iron Sheet	20			
LIQUEFIED GAS				
- Stove	45	37	40-50	36+3.9 (62)
- Heater-Cooker	45			
- Heater-Stove	50	67-80	50-65	
- Tank	45	62	50-65	
- Thermotank	50		45-50	
- Lamp	2.5		0.5-1	
- Refrigerator	8.0			
- Iron	36			
KEROSENE				
- Stove	35			
- Heater-Cooker	35			
- Heater-Stove	40			
- Pressure Lamp	2			
- Wick Lamp	1.2		0.1	
- Refrigerator	6			
- Iron	28			

1/ University of Campinhas
2/ +/- 1.42
3/ +/- 3.5

NATURAL GAS				
- Stove	50			
- Tank	50			
- Thermotank	55			
- Heater-Stove	60			
- Boiler	75			
ELECTRICITY				
- Stove	80 4/	75	45-53 5/	82.6 6/ 66.12 (56-75)
- Shower	90	90	90-93	
- Thermotank	95	95	65-80	
- Heater-Stove	80	95-100	100	
- Incandescent Lamp	4.5	6	2-3	
- Mercury Lamp	11		8	
- Fluorescent Lamp	15		7-18	
- Sodium Lamp	18.5		16	
- Air Conditioner8/	90		70-90	
- Ventilator-Fan	90		70	
- Refrigerator	80		80	
- Water Pump	70		70-90	
- Misc.Elec.Applnc.	80		70-90	
- Transistors	100			
- Iron	100			
CHARCOAL				
- Stove		25		
- Oven				
- Three-stone				
DIESEL FUEL				
- Boilers	60	68-73		
TRANSPORT. SECTOR				
AUTOMOBILES				
- Gasoline Engine	18	20	25	
- Alcohol Engine			33	
- Diesel Engine	24	35	35	
- Gas Engine		22		
RAIL				
* Steam				
- Fuel Oil	3.6			
- Firewood	2.7			
- Coal	3.0			

4/ Water heaters
5/ Ceramic and resistance
6/ +/- 2.3
7/ 3.09
8/ Motor

* Diesel					
- Direct	28				
- Electric					
* Electric	85	90			
RIVER					
- Gasoline Engine	18				
- Diesel Engine	20				
- Fuel Oil Engine					
- Steam (Fuel Oil)	7				
AIR					
- Turbopropeller					
- Jet Turbine	18	25			
- Piston					
INDUSTRIAL AND MINING SECTOR					
* Mechanical Force					
- Electric Motors	90				
- Diesel Engine	32				
- Steam Turbine	35				
- Steam Pump					
- Steam Engine					
* Steam/Boiler					
- Diesel	65	68-73			
- Fuel Oil	65				
- Coal	--	60			
- Charcoal	45				
- Bagasse	30				
- Firewood	45				
- Gas	75	70-75			
- Electric	--				
- Other Residues	--				
* Direct Heat/ Ovens 9/					
- Fuel (20-70)					
- Electric (90)					
* Other Uses					
- Lighting 10/					
- Air Conditioning					
- Refrigeration	80				

9/ Due to different efficiency according to size, characteristics, temperature, etc., a considerable range of variation of fuels is taken.

10/ (See Res/Comm/Pub)

AGRIC. SECTOR					
* Tractors and Farm Machinery 11/					
- Diesel Engine					
- Gasoline Engine					
- Alcohol Engine					
* Irrig./Water Pump					
- Electric Motor	70				
- Diesel Engine	20				
- Gasoline Engine	15				
- Windmill	18				
* Transport & Fumigation 11/					
* Other Uses					
- Lighting 12/					
- Refrigeration 12/					
- Drying 13/					
- Water Heating 12/	13				

11/ Efficiencies similar to those of the Transportation Sector

12/ Idem Comm/Serv/Public Sector

13/ Ceramicand resistance

NOTE: Efficiencies from Brazil which do not mention a source refer to those used in the National Energy Balance.

S E C T O R A L   A P P E N D I C E S

I - TRANSPORTATION SECTOR

II - INDUSTRIAL SECTOR

III - RESIDENTIAL SECTOR

IV - COMMERCIAL-SERVICES-PUBLIC SECTOR

V - AGRICULTURE-FISHING-MINING SECTOR

VI - AUTO-CONSUMPTION SECTOR

VII - OTHERS SECTOR

SECTORAL APPENDIX I

TRANSPORTATION SECTOR

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TRANSPORTATION SECTOR

CHAPTER I

GENERAL DEFINITIONS AND BASIC CONCEPTS

1. Disaggregation by Subsectors

No sector offers so many difficulties for disaggregation as does the Transportation Sector. It is convenient to examine the problem first from an exclusively theoretical standpoint, in order to recognize all of the subsectoring possiblities which could be analyzed, and then to adopt a disaggregation "for practical purposes" to construct useful-energy balances (BEEU), with sufficient generality to cover all of the countries of the area. This practical disaggregation should undoubtedly be based on common sense, avoiding both useless repetitions and the inclusion of subsectors whose order of magnitude is irrelevant.

The industrial sector has a tree structure and thus lends itself well to a classification of the ISIC type, where the first digit represents the trunk and the remainder are associated with progressively thinner branches, so that it is possible to arrive at a four- or even six-digit disaggregation. The unit of information -- in this case, the industrial plant-- can be located with no uncertainty on some branch of the tree; and it is on the basis of this organizational approach that databases are prepared, sample designs are formulated and statistical estimators and their levels of reliability are determined.

To follow an equally rigorous treatment in the transportation sector, one begins by asking:

WHAT IS THE UNIT OF INFORMATION TO CONSTRUCT A DATABASE PERMITTING PREPARATION OF USEFUL-ENERGY BALANCES IN THE TRANSPORTATION SECTOR?

Without doubt, the suitable response is: THE VEHICLE, since it is the energy-consuming unit which performs the function of transporting passengers and freight from one place to another.

So, it is necessary to devise a classification in which every vehicle can be placed without error. At first sight, it can be seen that the tree organization is not adequate. In testing a matrix organization in several dimensions, there would be various classifications:

(a) BY MODE OF TRANSPORTATION (6)
- Road
- Rail
- Air
- River
- Sea
- Pipelines

(b) BY OBJECT TRANSPORTED (2)
- Passengers
- Freight

(c) BY NATURE OF SERVICE (2)
- Urban
- Interurban

(d) BY TYPE OF SERVICE (3)
- Public
- Private
- Official

Up to this point, there would be 6 x 2 x 2 x 3 = 72 subsectors Even with these 72 subsectors there would still be fairly heterogeneous groups, e.g., the official-urban-passenger-road transportation would include vehicles as heterogeneous as motorcycles and large buses.

If one continued to add dimensions to the classification, for example:

- Light
- Heavy

the number of subsectors would increase to 144, with the problem that one same type of vehicle would appear in several groups and then the unit of information would in turn have to be subdivided into groups. Stated in this way, the problem would be endless and would become more and more complicated, although this growing complication would not contribute any substantial amount of precision to knowledge about energy in the transportation sector.

Consequently, it is better to adopt a more practical attitude, without losing sight of theoretical consistency. The relative weight of the groups in a disaggregated balance should be kept in mind, and the aptitude of this disaggregation to propose conservation and substitution policies of relevance.

The following disaggregation, in 15 groups, can be considered:

- ROAD
  - Passengers
    - Urban Private (motorcycles, automobiles, campers, pick-up trucks)
    - Urban Public (taxis, large and small buses)
    - Interurban Private (automobiles, campers, pick-up trucks)
    - Interurban Public (taxis, buses)

- Freight

  - Urban (pick-up trucks, trucks)
  - Interurban (trucks, trailers)

- RAIL

  - Passengers

    - Urban Public (trains, subways)
    - Interurban Public (trains)

  - Freight

- AIR

  - Passengers

  - Freight

- RIVER

  - Passengers

  - Freight

- SEA

  - Freight

- PIPELINES

  - Freight

This classification is sufficient for disaggregating the useful-energy balances of the countries of Latin America. It could even be excessive for many countries and hence can be considered a maximum disaggregation. However, it could easily be regrouped into two large categories, PASSENGERS and FREIGHT, and each one subdivided into modes. This form of presentation offers the advantage of establishing two practically unsubstitutable groups within which modes can be substituted.

It can be argued that the division presented herein leaves aside innumerable specifications; for example:

(a) In the transportation of passengers by road, the services provided (schools, factories) are not specified and are therefore confused with public service. It is likely that this transportation, which could be called "private-public" or "special-public", will have features different from those of strictly public transportation, both in terms of the type of vehicle as well as mileage and utilization factors. The same thing would occur with the so-called

"official vehicles" with respect to private transportation, and it can be expected that the operating features of the automobiles assigned to official service for the central or municipal government will be different from the rest of the fleet. Nevertheless, these are MARGINAL SUBPOPULATIONS which, while not specified individually, will be represented in the database if there is a sample framework which covers them so that their (scant) representativity within the population will be transferred to the sample.

(b) Small private aircraft, helicopters and recreational or testing planes will form part of the passenger air service without much concern for finer distinctions. Since all of these will be consumers of aviation gasoline, the quantities of which are known precisely, no major difficultuies are foreseen in determining consumption, although it would be more difficult to find out about the number of passengers transported without devoting great efforts to a specific survey which, for the moment, is deemed unnecessary. With respect to the devices used for fumigation, the proposal is that they form part of the agricultural sector and not the transportation sector, so that in this case the effort to separate them is merited.

(c) Some countries have a considerable park of boats devoted to nautical sports and, in the proposed disaggregation, these will be confused with river or sea transport. Without overlooking the fact that a given country may successfully survey these units, it has not been thought convenient to include them as a specific group in a general methodology meant to serve a considerable number of countries.

(d) In certain cases, the distinction between passenger transport and freight transport is not as clear as it would seem at first sight; in the rural areas of some countries, it is common to see trucks transporting passengers on top of packages and buses which, together with the passengers, carry significant amounts of freight. It is not easy to handle rigorously if the Ministry of Transportation does not have appropriate mechanisms of separation. What is most advisable for the energy sector is to follow the same guidelines as for the transportation sector and to adopt a disaggregation by subsectos which, although it may not be perfect, is well-founded from both the information and institutional standpoints.

The examples given above are only a few of the ones for which the proposed disaggregation by subsectors does not permit adequate discrimination; many others could be found without much effort. To resolve the particular cases in question, the general criterion will always be valid: it consists of comparing the cost of a more detailed separation, whenever feasible, with the information benefit it would contribute. The ability to differentiate the primary from the secondary will save on useless efforts and prevent any doubts.

2. Disaggregation by End-Uses

From the physical point of view, the useful energy corresponding to the transportation sector is mechanical force. Accordingly, the only use would be for the transportation of persons and goods through the development of mechanical work and kinetic energy. (This topic is amply discussed under the next point of this same chapter.) However, this single use can in turn be disaggregated into sub-uses, depending on what kind of motor is in charge of producing the force. Thus, there are:

- Internal combustion engines
- Injection engines
- Steam engines
- Electric motors
- Diesel-electric motors
- Gas turbines

While all of these engines produce mechanical force, they do so with different efficiencies and, when inter-fuel substitutions are examined, these differences will have to be taken into account.

Other marginal uses such as lighting, air conditioning and heating of vehicles will not be taken into consideration, since they would be of slight importance against mechanical energy.

Road transportation has the largest value in practically all of the countries and, to date, it uses only internal combustion or injection engines, because the electric motor is still in the experimental stage. The internal combustion engine uses gasoline in the vast majority of cases, while in recent times the use of other fuels such as alcohol (methanol or ethanol), liquefied gas and liquefied natural gas has been initiated. These different fuels can result in changes in the respective efficiencies.

When cross-referencing disaggregation by subsectors and by products, with a few possible exceptions,all the types of engines are identified. For example, the diesel oil which is feedstock in rail transportation could in principle be used in steam engines (the case is very rare in practice) or in diesel-electric motors.

However, these examples do not merit a greater disaggregation of end-use. It can thus be accepted that the type of engine and, therefore, its efficiency, is determined exclusively by contrasting product with subsector. At least this is always true in road transportation, which, due to its large relative weight, is the means of transportation which has oriented the development of this methodology. There is only one end-use in the transportation sector and it yields only one form of useful energy, known in this methodology as "mechanical force". In this respect there is consistency with the methodology presented for the industrial sector, in which the end-use of steam consumed by the steam turbines to produce movement does not appear under the

end-use of steam but rather under the use of mechanical force, and where the efficiency of production also takes into account the efficiency of the boilers.

In any case, it is convenient to contrast the energy products and each type of engine within each subsector, so that within each group thus constituted there is constant efficiency.

3. Final Energy, Useful Energy and Efficiencies

In a flat world without frictional forces, to move a vehicle and its load, the joint mass of which is "m", over an elementary distance"dx", requires a force "f". When applying this force, the speed of the vehicle increases by "dv", so that the work done will be equal to the incremental kinetic energy:

$$F\,dx = m\,v\,dv \qquad (1)$$

Once the vehicle has attained what could be called its cruising velocity (this would be v = 80 km/hr), no force is needed to keep it in movement, according to the principle of inertia. So, the load could be transferred to any point in the world, with no effort. When close to its destination, it must simply be remembered that, in order to return the vehicle to its resting position, a force equal but opposite to the former will have to be applied, to do an equivalent amount of work, but this time in order to decelerate. Since there are no frictional forces, the driver will not be able to apply the brakes (actually, the concept of braking would not exist in this world), but would have to do something similar when turning on the motor and going into reverse, like an airplane when landing. To do the work 2Fdx, the vehicle has a combustion engine which consumes c liters per kilometer of a fuel whose calorific value is P; therefore, the energy expended to increase or decrease the velocity by dv is cPdx.

Under these circumstances, the efficiency of transforming chemical energy into kinetic energy is:

$$\eta = \frac{m\,v\,dv}{c\,P\,dx} \qquad (2)$$

where it is clear that the numerator represents useful energy and the denominator final energy, both of which are elementary.

In this hypothetical world, it would prove simple to define and measure the magnitudes which concern us. If the mass m is now expressed by means of the weight W and the gravity g, we would have:

$$\eta = \frac{(W/g)\,v\,dv}{c\,P\,dx} \qquad (3)$$

The preceding formula permits calculation of the instantaneous efficiency for transporting W tons over dx kilometers and, by integrating, we would obtain average efficiency. Furthermore, introducing the time interval dt ($v = \frac{dx}{dt}$), in which the changes are:

$$\eta = \frac{(W/g)\ v\ dv}{c\ P\ dt\ v} = \frac{(W/g)\ dv}{c\ P\ dt} \qquad (4)$$

we can see that efficiency will depend only on the acceleration dv/dt of the vehicle, whether to take it from a standing position to the cruising velocity or vice versa. If this acceleration is constant, the efficiency will be too.

From an energy standpoint, it would be a very economical world, since both passengers and freight could travel long distances while consuming little fuel in the first and last meters of the trip. Even in the case in which transit became more complicated and it proved necessary to increase or decrease velocity along the way, the energy consumption would increase but would return to zero if velocity were kept constant.

This example makes it possible to establish a very important concept: "the efficiency of a vehicle on a flat road and in the absence of frictional forces depends solely on acceleration; the useful energy is the kinetic energy of the vehicle plus its load, and final energy corresponds to the fuel consumed in accelerating or declerating."

What happens in the real world? Things are much more complicated. Let us continue with the hypothesis of a flat surface but adding friction forces, mainly the ones which affect the movement of the wheels against the ground, and air drag. Assuming that such forces depend on velocity squared, the work needed to take the vehicle plus its load to a certain speed, and to keep it there, will now be:

$$Fdx = m\ v\ dv - \beta v^2\ dx \qquad (5)$$

where β is the friction coefficient, which depends on numerous factors.

The final energy consumed to do the work will continue to be cPdx, but now it will not be used just to accelerate or decelerate but also to overcome the frictional forces, so that even when the vehicle is traveling at a constant speed, energy continues to be consumed and this consumption is proportional to the distance traveled. For this reason, the real world expends more energy than the hypothetical world of the example.

It can also be understood that in the real world " useful energy" and, therefore, "efficiency" prove much more difficult to define. Hence, what is common is to express consumption in terms of final energy, as a specific consumption c in liters or gallons per

kilometer. This means that, for each kilometer traveled, it is necessary to do at least enough work to overcome the frictional forces.

In fact, the "utility" of a transport vehicle, whether an automobile, truck, plane, train or ship, is to "transport" passengers or vehicles in the real world, so that it is necessary to work against the frictional forces-- but not just against those forces, but rather all of the obstacles which present themselves in the real world. The magnitude transported is commonly expressed in ton-kilometers TKM or passenger-kilometers, PKM; and it is evident that the end-use of the sector is represented by these magnitudes, just as the industrial sector is represented by the value added or physical production. There can thus be an energy consumption per TKM or PKM or value added to compare means of transportation or industrial production technologies among themselves. This is the traditional approach to the problem, without going into the details of more rigorous definitions, which are often confusing.

Nonetheless, it is also common to hear that an internal combustion engine has an efficiency of 14.5% and a diesel engine of 18%, so that an injection engine is 25% more efficient than a combustion engine. What do these values mean? To what useful energy do they refer? What relation is there between these efficiencies and specific consumption to ton- and passenger-kilometers? There is more than one possible answer.

Alternative I

Specific consumption c in gallons or liters per kilometer is considered as the basic information input. With it can be calculated the total consumption Z for a particular means of transportation (subsector), during one year. The useful energy ε is calculated as εz, where is a typical efficiency which depends on the type of engine. If X is the TKM or PKM transported by this means during the year, the relations:

$$\varepsilon = Z/X \qquad \text{or} \qquad \dot{\varepsilon} = \dot{Z}/X \qquad (6)$$

represent the overall unit consumption of this mode of transportation. However, these coefficients should not be called "efficiencies" but rather, more appropriately, "elasticities". Actually, ε and $\dot{\varepsilon}$ can vary from year to year, due to:

- changes in specific consumption c, when there are alterations in the composition of the fleet;

- changes in the load factor of the vehicles, meaning that more (or fewer) passengers or tons can be transported with the same amount of energy output;

- improvements in the road system, meaning that the same trip can be made with a smaller consumption; etc.

So, ε will come from a regression (whether linear or not) between Z and X, just as regressions are done in the industrial sector to determine the consumption/value added elasticity. It would also be an elasticity which captures, in econometric form, the effects of a better or worse "efficiency" in the transportation of passengers and freight and, as such, it is a coefficient apt for making demand projections incorporating the effects of conservation, automobile import policies, increases in the utilization factor, etc. $\hat{\varepsilon}$ also takes into account the thermodynamic and mechanical efficiency of a given type of engine and lends itself to expressing fuel substitutions among the different modes of transportation.

Alternative I thus corresponds to pragmatic definitions of final energy, useful energy, efficiency and elasticity, without worrying about the intimate nature of these concepts, and it permits resolution of the energy planning problems of the transportation sector with acceptable rigor. As can be observed in the following chapter, the coefficient c, which determines final energy, can be calculated by means of surveys, as a function of all of the variables desired, so that very detailed models can be constructed for the bahavior of the sector.

Traditionally, ε , as defined by Equation (6), is called energy efficiency. However, according to the preceding definition, the term "elasticity" is more appropriate" ,and the term "efficiency" is reserved for , as defined by Equation (2).

In this alternative, η has a reference value and is associated with an efficiency of production (of mechanical force). It is useful only for the sake of comparisons between engines at the level of useful energy production, under the assumption that the use of that energy does not depend on the type of engine.

To take kinetic energy as useful energy in the real world does not offer any interest from the physical standpoint, since the mere inclusion of the forces of inertia (associated with kinetic energy) does not permit adequate expression of the work required to transport an object from one point to another; it is also necessary for frictional forces to take part, as can be seen below.

Alternative II

In doing horizontal work against frictional forces, it is necessary to develop a force known as the horizontal thrust, which is much smaller than the weight of the object to be moved. This is the force which must be placed in Equation (5) where Fdx in the expression for useful energy. This is then defined as "the work necessary to accelerate and keep in movement a vehicle plus its load in a field of friction forces." Note that if the movement were no longer horizontal, but rather sloped, gravitational forces would also be in play.

According to this alternative, the efficiency is:

$$\eta = \frac{F\,dx}{c\,P\,dx} = \frac{F}{c\,P} \qquad (7)$$

where cP, or the consumption in calories per kilometer has the dimension of a force which can be called "final force" and which is quite a bit larger than the other "useful force" due to (1) enthropic losses in the heat cycle of the engine; (2) losses due to friction in the engine; (3) frictional losses in the transmission system; (4) other losses such as the ones in the ignition or injection system, etc. So, the friction within the device is manifested in these losses whereas the friction of the device in its totality against the ground and the air drag are manifested in the useful energy. Therefore, this efficiency stated as a coefficient of forces could well be defined as EFFICIENCY OF PRODUCTION.

Undoubtedly, when working with values such as the ones used in Alternative I, reference is being made to efficiency of production. To delve into greater depth in these concepts:

The useful energy of production is then defined as the production of useful force capable of modifying vehicle velocity and of maintaining it against the friction of the ground, water and/or air. Some criterion should be decided on as to what type of ground friction is being considered at this point in the process, since the useful force will be quite different according to the type of terrain. It is proposed that, strictly speaking, one should say: "friction against a flat surface with standard pavement". Hence, efficiency of production in road transportation (and analagously in other means of transportation) depends on:

- The condition of the engine-carburator
- The condition of the auxiliary system (ignition-injection)
- The transmission system
- The design and condition of tires
- The aerodynamic design of the vehicle

In other words, it will depend only on the vehicle design and maintenance features, just as the efficiency of steam production in industry depends on the boiler design and maintenance parameters.

In a second stage, there will be EFFICIENCY OF USE, which will provide an idea of how the useful force produced is employed, under real operating conditions. First, these conditions are examined: (1) the terrain may not be paved or the pavement may be in poor condition; (2) the streets and highways may not be flat, but rather may have ups and downs; (3) a greater amount of traffic calls for slower speeds and stops with the motor running (for example, at traffic lights); (4) etc.

Experience clearly shows that to transport the same load between the same points under these conditions, a final force $c'P$ larger than cP is now needed, and the new energy consumption can be measured. What occurs with useful force is not so clear, however. Take the same vehicle which under ideal conditions consumed a final force cP and produced a useful force F: what useful force should be associated with it when the final force is $c'P$? Theoretically, a new force F', equal to the work necessary to transport the vehicle plus its load under the new conditions, could be defined and measured. This force will usually be greater than F. Nevertheless, it is preferable that a concept independent of F' be worked out, by following a similar approach as to what was done with mechanical force, in the industrial sector.

Take a stationary electric engine which consumes an amount of electricity c to produce mechanical energy E in the shaft. This energy is equal to the kinetic energy of rotation plus the work done against the frictional forces to keep the shaft rotating. The example is equivalent to keeping a vehicle in movement under ideal conditions, since the stationary engine rotates and the vehicle moves along a smooth surface (moving engine). Now by connecting the engine to any mechanism such as an agitator or a cutting instrument, so that, because of the type of process, the engine must accelerate, decelerate and even stop several times, the electricity consumption will have increased to c' owing to the utilization of useful force F.

Likewise, it can be assumed that a vehicle which moves along under real traffic conditions requires more final force per unit of useful force. Overall efficiency is defined as:

$$\eta_1 \; \eta_2 = \frac{F}{c'P} \qquad (8)$$

where η_1 is the efficiency of production defined by Equation (7) and η_2, the efficiency of use, is:

$$\eta_2 = \frac{c}{c'} \qquad (9)$$

In other words, η_2 is defined as the relation between final force under ideal traffic conditions and the same force under real conditions. The advantage of this treatment is that it separates overall efficiency into two factors: one called efficiency of production, which depends on vehicle technology and maintenance, and another called efficiency of use, which depends on traffic conditions and road design.

Alternative III

Along the same lines of Alternative II, the separation of production and use is done beforehand. Useful energy of production is the force necessary to accelerate the engine and to keep it turning at an angular speed w (which can be associated

with the velocity at which the wheels turn during testing without a load), but with the vehicle standing still. This useful force available in the rotating shaft is used when the vehicle is started up under real traffic conditions, and its consumption is c'.

The drawback to this alternative, which basically means taking as efficiency of production the efficiency of an engine operating without a load (as though it were a stationary engine) is that this efficiency would depend only on the engine-transmission technology, leaving for the efficiency of use of aerodynamic drag and friction of the tire against the ground.

4. General Flow for the Balance of Useful Energy (BEEU) in the Transportation Sector

On the basis of the preceding definitions, it is possible to determine the structure of the BEEU for the transportation sector and to define, at the same time, the flows and the equations which relate them. The following chapters will specifically discuss the procedures for collecting and processing data which are proposed for calculating such flows.

First of all, BEEU applied to an automotive unit (vehicle) follow a two-stage scheme: one where the final energy is transformed into the mechanical force produced, and a second where the latter is used under particular traffic conditions in order to provide useful energy. If Alternative I is adopted, only the first stage will be taken into account, whereas Alternatives II and III consider both.

Final Energy	→	Efficiency of Production	→	Intermediate Energy or Useful Energy Produced	→	Efficiency of Use	→	Available Energy or Useful Energy Consumed

In the first stage of application of the methodology, what is proposed is to use the first alternative, so that only the efficiency of mechanical energy production, i.e., the engine, is covered. In later stages, as a function of the specific interests in each country in terms of detailed sector knowledge, Alternatives II and III, which consider efficiencies of use of transportation vehicles, could be taken into account.

As for the BEEU for the entire sector, it will contain:

Final Energy and Useful Energy for each

- Source
- Subsector

It is clear, then, that it will be necessary to design procedures for collecting and processing data in order to make it possible to disaggregate consumption as discussed above. Additionally, and so that this consumption structure will serve the purposes of planning, it is useful to express passenger-kilometers and ton-kilometers with an identical disaggregation. While the latter figures do not form part of the BEEU, they are an indispensable complement to it; among other reasons, in order to provide knowledge on elasticities.

Work will begin by identifying the fundamental parameters of the sector, taking road transportation as a basis since it entails the greatest degree of complexity. The findings of this analysis can easily be extended to other mades of transportation.

The reference universe for the subsectors which comprise road transportation is the number of vehicles N which form the vehicle park, together with their most important features. Among these, mention can be made of:

- The type of vehicle: it is necessary to know N for each category, such as motorcycles, private automobiles, taxis, pick-up trucks, campers, trucks, vans, buses, etc.

- The vehicles in circulation: care should be taken that N represents the real number of vehicles in operation and not simply the number of registered "births". If there is uncertainty in this regard, some mortality model should be applied to remove the units that are no longer in service due to age.

- The cylinder capacity or engine size in cubic centimeters or inches, for each category. It is frequently possible to determine cylinder capacity from the car make and model.

- The transport capacity offered, measured by the number of seats if it is a passenger vehicle, or by tonnage if it is for freight. It is also convenient to know the weight of the automotive units themselves.

- The model or age of each unit within each category.

- The type of fuel, which will usually be gasoline, diesel, LPG, or alcohol.

- The type of service, whether private, official or public.

A good data bank on the vehicle park should contain at least the features enumerated above, although within each category there may be other features which could be of more interest for the transportation sector than for the energy sector, in order to provide for inspection functions (color, number of owners, accidents, etc.)

The license plate number is essential for identifying each unit

within the park and also for establishing regionalization, since many surveys will call for regional sampling.

Of all these characteristics, only the first, i.e., number of units within each category, can be measured through a census. The others can be obtained by means of more or less complicated surveys and, generally speaking, the same surveys can be used to measure operational parameters (primarily, mileage and utilization factors, as seen further on), complemented by others.

The three basic parameters which should always be determined through specific surveys are:

- Specific consumption, in liters or gallons per kilometer.
- Annual mileage L.
- Utilization factor. Φ

To separate final consumption Z by fuel and by subsector and category of vehicle, mileage and specific consumption are needed:

$$Z = N\ c\ L \tag{10}$$

To handle passenger- and ton-kilometers properly, mileage, available capacity Q and utilization factor are used:

$$X = N\ Q\ L\ \Phi \tag{11}$$

In Equations (10) and (11), except for N and sometimes Q, the other variables are random varibales for which the surveys should provide expected values and standard error.

Another reference universe other than the park, which is taking on growing importance, is the one known as vehicle-kilometers; it can thus be defined as:

$$V = N\ L \tag{12}$$

This is applied mainly to interurban transportation, where the procedure for using a widespread survey to count all of the vehicles which travel the highways is becoming popularized in many countries. Vehicle-kilometers are obtained from a sample mechanism known as AVERAGE DAILY TRAFFIC COUNTS and can be carried out manually or through automatization. If this information is available (for it is usually prepared by the inspection agencies of the Ministry of Transportation), it is of great utility in determining mileage and interurban utilization factors as an alternative method to the determination of the park. Note, for instance, that when Equation (12) is divided by the total number of the park, mileage is obtained.

Below, general criteria for taking basic energy surveys on road transportation are provided, remembering that the aim of this document is not to present the results of a case study from a specific country, but instead to establish methodological guidelines of general validity, based on the experience gained in some countries.

The amount of data-gathering procedures which exists in the transportation sector, whether permanent or specific, are so varied that here, more than anywhere else, it is necessary to have a good appraisal of information prior to the surveys which will be carried out.

Generally speaking, it can be said that BEEU in the transportation sector should begin by using available information (if there is any) and then, on the basis of its analysis, the decision will be made as to whether it would be worthwhile to improve the information through successive-approximation surveys. What follows is the way a particular country (Colombia) solved the database problem; the aim of its presentation is to provide a reference supported by practical results.

CHAPTER II

DATABASE FORMATION

ROAD TRANSPORTATION

1. Specific Consumption

An attempt is made to learn about the average energy expenditure in a category or group of vehicles under real operating conditions and then to relate this expenditure to the technical and operational variables which determine it. For this purpose, it is necessary to design a random experiment known as a FOLLOW-UP SURVEY, which consists of monitoring vehicle behavior over a certain amount of time and of measuring consumption.

From the beginning, the technical and operational variables to be measured in the experiment must be soundly selected, taking into account the fact that the remaining ones will form part of the data dispersion around the expected specific consumption values. In order to be able to come up with a good design, it is necessary to have a good assessment and for that it is necessary to do: (a) an exhaustive review of existing information and (b) a pilot survey permitting calibration of the order of magnitude with which the variables in play will influence consumption.

The sampling frame to be applied is an exclusively random sample without replacement of the universe of vehicles in groups or subpopulations. This is not very simple to do and sometimes unresolvable difficulties are encountered. Assuming that the universe in question is available on a computer disk, with which half of the problems would be taken care of, it would be possible to extract a random sample using random numbers. No matter how great the difficulties in extracting this sample, these seem small in comparison with the logistical problems which arise from here on. Only two will be mentioned as examples. (1) Having selected a vehicle from a computer file or an ordered pile of forms does not mean that the owner can easily be located; only if the file is very up-to-date will it also contain data on the last owner and, in most cases, the owners will be scattered over different parts of the country and in remote towns and cities. To do a previous sample of towns and cities would complicate the procedure unnecessarily and would raise the processing costs. (2) The fact of having located the owners, no matter how complicated it may be to do so, does not mean that they will be willing to subject themselves to an experiment which would cause upsets in their daily life and which would not entail any benefit for them. The use of force is impossible in these cases, since there are no appropriate legal instruments, as in the case of population censuses, which are backed by law.

In order to counteract these problems and substantially reduce sampling costs, what has been called a pseudo-random frame has been used; it consists of selecting a group of vehicles whose owners are willing to carry out the proposed experiment, trying to cover the features of the automotive vehicles (model, cylinder capacity, age, representation by cities, tc.) in proportions comparable to those of the universe. For buses, trucks or taxis working through private firms for providing public service, it is necessary for the firms to instruct their drivers to cooperate in the experiment. This type of sample works very well when, as in this case, the results are expressed by means of a model of conditional expectations, usually calculated by a regression analysis as a function of the variables observed, in order later to do weighting based on the proportions in which the variables take part in the universe.

The follow-up surveys can be done on every type of vehicle and can show slight variations in execution, depending on the type of vehicle and on whether or not consumption is in urban or inter-urban areas.

The survey consists of monitoring the vehicle during one or more typical trips, filling the tank with fuel at the beginning and at the end of the run, in order to measure consumption. The secondary units of information are the trips and not the vehicles, and one same unit may appear more than once in the survey, extracted from a universe of trips. The greatest success is obtained when the interviewer travels in the surveyed vehicle and takes the readings himself. It is difficult for the driver to record variables such as number of stops with the motor running (traffic lights, loading and unloading of passengers).

The variables to be treated are:

- Consumption (c)
- Cylinder capacity (K_p)
- Age (ε)
- Average annual mileage (L)
- Average velocity during the trip (v), together with number of stops with the motor running
- Type of terrain, paved or dirt, whichever is predominant
- Dominant slope: inclines, declines or indifferent; this variable is of interest in interurban transport and the sections should be chosen well so that there is a dominant slope
- Height above sea level, which can be expressed as more than 1500 meters or less than 1500 meters
- Hour at which the trip is made: this is of interest for the urban mode and can be expressed in terms of peak hours or non-peak hours

The discontinuous variables are expressed by means of "dummy" functions (T_i).

The data clean-up process is a very important stage, in which it is necessary to detect the anomalies which usually arise from

logging errors. In order to avoid the accumulation of inconsistencies, it is necessary to carry a detailed control of the surveys, as they are done, and to repeat them whenever deemed convenient. A team of well-trained interviewers is the best guarantee for resolving the multiple problems which will undoubtedly arise.

Once it is certain that the data are consistent, they can be analyzed by means of some model responding to the type.

$$\hat{E}(c/K_p,\ \varepsilon,\ L,\ v,\ T\ ) = g(c/K_p, \varepsilon,\ L,\ v,\ T_i) \quad (13)$$

The function g can be found by means of a regression analysis or ranges equivalent to a stratified sample or a sample without fixed effects. It is also important to determine the conditional variance.

$$V(c/K_p,\ \varepsilon,\ L,\ v,\ T_i) \quad (14)$$

The explanatory variables may have more or less weight, according to each case and the countries under study. Something that has been observed in the work done so far is that there is no correlation between consumption and mileage; therefore, the latter variable can be discounted, with great advantages for mathematical treatment.

Knowledge and control of conditional variance is important for the following reason: the experiment as designed captures (1) technological variables and (2) traffic variables, but does not capture (3) maintenance variables such as motor synchronization, condition of the tires, if the motor has been overhauled or not, etc. All of these uncaptured variables form part of the conditional variance and there is no reason why this cannot be considered as constant (homocedasticity hypothesis). The size of this variance will tell us if the chosen sample size is sufficient to obtain good reliability despite having considered (3) as negligible.

Once the model of conditional expectations and its variances has been gauged, by means of the function g, the next step is to determine the probability of the conditional expectations. For this purpose, it is necessary first to analyze the covariances among the explanatory variables, in order to detect possible multicolinearity effects among them. After we are sure that all of the variables included in the function g are independent, the expected consumption is calculated as a function of the marginal distribution functions of these variables. These functions will come either from knowledge about the universe or from some other survey. The following should be kept in mind: before including some explanatory variable in the model, it is necessary to ascertain that the marginal distribution of this variable is known or can be known through some sampling procedure; otherwise, it is preferable to discard it.

The following formula is applied:

$$E(E(c/K_p,\ \hat{\varepsilon}\ v,\ T_i) = \int^{\infty} \ldots\ldots\ g(K_p, \varepsilon, v, T_i)\ f(K_p) f(\varepsilon) f(v) f(T_i)\ dK_p\ d_{\varepsilon}\ ,\ dv,\ dT_i \qquad (15)$$

For the variables of discreet nature such as T_i, the integrals are transformed into summations.

The standard error in the consumption estimator calculated in this way is the square root of its variance and this is the sum of the variance of conditional expectations plus the probability of conditional variance.

A satisfactory sample size for the follow-up samples is not very large, although it depends on the number of variables selected. The survey begins to yield good results starting with a size of approximately 50 cases when only one variable is selected, and can reach a maximum size of 250 samples for a greater number of variables.

It is worthwhile to stress that with this method, which is not very expensive, a very detailed structural model of consumption is obtained as a function of technological features and traffic conditions; all of these are policy variables in long-term planning, which for the first time ever would have explicit, reliable measurements.

2. Mileage

Every vehicle in the universe travels a given number of kilometers in the course of a year, and these are cumulative during its lifetime. The average populational expectation (probability) of mileage is unknown and, by means of the survey discussed under this point, the population expectation can be estimated on the basis of a conveniently designed sample.

Mileage is a very difficult parameter to measure in practice and there is no one unique method which works with one hundred percent certainty in every case. When it is certain that the odometer has worked correctly all the time-- and this happens primarily in relatively new vehicles-- this device can be used to measure the annual mileage. There are several drawbacks which must be resolved by the interviewers. As has already been noted, the first thing that must be done is to verify if the odometer has always functioned properly; if the driver cannot answer, it is better to omit the interview. If the odometer really reflects the cumulative mileage, knowing the model of the automobile (and the month in which it began to work, in the case of the newest automobiles), the annual mileage can be calculated by a quotient. When doing this quotient, the average mileage is being calculated for the years of life of the vehicle, without any possibility of distinguishing different mileages from year to year. If there had been significant changes in the behavior of the vehicles of

the universe with respect to annual mileage, the odometer method would be giving the average mileage for an average year with respect to the age of the individuals in the population.

For the vehicles which already have a certain age and whose mileage gauges are working properly, it is necessary to verify

how many times the device has run a full cycle (there are usually 100,000 km per full cycle).

Then we have the vehicles which do not have odometers or ones in which these have not been working for some time. In these cases. the only way is to find out about the daily, weekly or monthly mileage and to take as valid, the responses which coincides. One question which always works well is weekly or monthly fuel consumption, from which it is possible to obtain mileage by dividing by specific consumption, which is calculated by means of the follow-up survey.

In public-service vehicles, whether these are taxis, trucks or buses, the drivers or firms to which they belong can provide good responses on each vehicle,; the mileage here is more regular and care must be taken to verify how much time during the year each unit has been out of use due to repairs or other causes. Private cars without mileage gauges are, without doubt, the most difficult group to deal with.

Given all of the aforesaid, it is foreseeable that the mileage surveys will have a high degree of rejects. This does not constitute a problem as long as there is no significant correlation between negative responses and some other important variable; this can be analyzed through hypothesis testing with the covariance. It is also useful to analyze the hypothesis of a possible correlation between mileage and age, in the sense that older cars have shorter runs. If this correlation exists, much more care must be taken in sampling in order not to bias the share of older cars.

Great skill is needed in handling the hypothesis testing, in order to judge the quality of the samples and be able to do statistical analyses of crossed correlations.

No matter how complicated the aforementioned procedure proves to be in measuring mileage, there is no other option; its success calls for a suitable combination of refinement in data-gathering together with statistical sample control. The follow-up method like the one used for consumption is not possible in this case, for several reasons: first of all, because in order to obtain good results the monitoring time would be too long, since the sample unit cannot be the trip but rather a group of trips over a given time; furthermore, it is necessary to rely on the odometer, since there is no other measurement procedure. Finally, the vehicles which do not have an odometer would have to have one installed, and this would entail heavy increases in costs and legal and logistical problems. Experience has shown that the spot procedure yields good results when the stages are planned well and the biases which could appear are dealt with opportunely.

As for the sample frame, the procedure of a household survey for private cars has been discounted due to the high cost. Even though from a statistical standpoint it is an adequate frame, it has the drawback that when a visit is paid to the home, the automobile may not be there. The best thing is to investigate cars in their natural environment, i.e., streets and highways. There are countries which, due to the organization imposed by the payment of registration fees and license plates, offer good conceptual frameworks which could be used to advantage. This occurs, for example, when there are certain set dates and places to make payments, in which case these meeting places could easily be converted into representative samples of a given universe.

When this is not true, other mechanisms must be applied.

For the case of determining total mileage (urban plus inter-urban), a method known as the SERVICE STATION SURVEY has been developed; it consists of interviewing vehicles when they go through gasoline stations to fuel up. The method is inexpensive since the mobilization of the interviewers is reduced to a minimum. The underlying idea is that every active vehicle must necessarily visit some service station with some frequency.

The first step consists of sampling stations, which is quite simple since these are well distributed in the cities and on the highways, precisely at those points where traffic is most intense, so that, with a good geographical distribution of stations, all types of vehicles will be captured.

As for the secondary sample units, which are the vehicles, a sample of REPLACEMENT AND UNEVEN PROBABILITIES is taken. This means that if the universe is of a size N, the sample size n can be much larger than N and will tend to be infinite. As for the probability P that a vehicle of mileage L will be chosen, this increases the higher the mileage, since a vehicle which circulates more kilometers in a year will have to fuel up more often. Of course, this probability will not depend only on mileage but also on other factors such as specific consumption, size of the fuel tank, and the habits according to which a driver fuels up with only part of the capacity of the tank.

The average populational mileage is estimated as:

$$\hat{N}\,E\,(L) = \Sigma\, L_i/\hat{P}_i \qquad (16)$$

so that if for every vehicle which has appeared in the sample this probability can be estimated by means of a probability Pi, depending only on the sample, the problem will have been solved. We have shown that, in fact, P can be estimated a posteriori and that the mileage estimator thus constructed is asymptotically unbiased. This demonstration is complex and goes beyond the

scope of this document. It can be consulted in an article entitled "Service Station Surveys," which appeared in one of the issues of OLADE's Energy Magazine.

In order to learn about the interurban part of mileage, it is necessary to apply a different method, based on a COUNTING STATION SURVEY. On a road map, counting these from a certain point at the city limits, measurement stations are set up to capture the vehicle flow without indeterminates for any section of highway included between bifurcations, in a way similar to the procedures commonly used to determine vehicle-kilometers. By counting all of the vehicles which pass through the stations and multiplying by the distance between stations, interurban vehicle-kilometers are obtained. For this purpose, it is necessary to take samples on given days of the year considered "typical" (a survey of days can be done and distribution analyzed). Mileage is then:

$$L_I = \frac{V}{N} \qquad (17)$$

and urban mileage is taken as the difference between the total mileage estimated on the basis of the service station survey.

For the buses involved in urban passenger service, it is not necessary to apply such an intricate sample frame as for the service station survey, and it is much better to recur to a sample of equal probabilities. This is not difficult, since these buses are usually concentrated in firms and/or lines in the different cities. Thus it is important, as a first step, to sample the cities, because mileage may depend significantly on city size.

The case of taxis, whose mileage also depends heavily on city size, can be obtained through taxi companies (if these exist) or through service stations.

A CITY, LINES-COMPANIES and BUS SURVEY can be handled very well by means of a multi-stage sample where: (1) the city sampling is stratified; (2) the sampling of lines and companies can be systematic or stratified, taking the sample of a universe of lines ordered according to the number of buses which they have; (3) within each line chosen, there can be a census or systematic sampling of buses and their mileage can be checked through the company or the driver.

Finally, there is a bus sample for each stratum of the cities and the respective estimates of mileage per stratum must be made.

Before concluding the mileage aspect, it is convenient to develop the already cited method of measurement by means of weekly or monthly fuel consumption a little more. This procedure, which can sometimes be more accurate than the direct measurement of L, consistes of determining through sampling the product cL in gallons per week or per month, by means of consumption divided by price. While measurement may prove easier, the statistical inference of average annual mileage is more complicated. In the first place, weekly or monthly consumption may not be constant throughout the year, since the user responds to the question of how much he uses when the car is in circulation, without taking into account the time which the unit is not in use because of repairs, family vacations, etc. Additional questions related to such times aid in interpreting the results. Another difficulty is that the estimator for expected mileage and its variance will be the expectation and variance of the quotient of two random variables:

$$E(L) = E \ (\ cL \ /c \ )$$

This entails more complex mathematical maneuvers which, although not unsolvable, certainly call for greater care and knowledge in the treatment of the variables involved.

Another procedure for measuring mileage that should be mentioned is the one related to oil changes, in those cases where dates and vehicle mileage are recorded at the time of the previous change. This works only when most of the interviewed users keep such records and it depends on the customs of each coutnry.

3. Utilization Factor

Take Q as the transport capacity for an automotive unit, measured in tons for freight and number of seats for passengers, and take q as the amount of freight or passengers actually transported. The vehicle utilization factor is defined as:

$$\Phi = q/Q \qquad (18)$$

An effort must be made to estimate the expected value in the population for different subsectors and types of vehicle, by means of sampling.

For light passenger vehicles in urban transport, a TRAFFIC LIGHT SURVEY is applied. Previously, a city sample should be done, even though no strong dependence between the utilization factor and city size is expected. Within the cities, traffic lights are selected with an adequate geographical distribution and for each traffic light samples are taken on a work-day and on a non-workday and at different hours, so that there will be a good representation of peak hours and off-hours. If it is desired (and it is possible) to be more rigorous, it would be wise to typify the stoplight-day-hour by volumes of traffic, although this information is not always available in sufficient quantity and quality. When it is not possible, there should be a "sight" distribution of the traffic lights and hours in order to have a good idea of the volumes of traffic. The aid of specialized personnel from the offices of the Ministry of Transportation is of great value in obtaining a good sample. In addition, if

through a pilot sample it is shown that the utilization factor does not depend on the location of the traffic light nor on the hour, a simple random sample is satisfactory.

The survey consists of counting the passengers for each type of vehicle, when these stop at a red light. Thus, very numerous sample sizes are obtained for private cars, taxis, campers, pick-up trucks, in a sample with replacement. Sizes of 500 to 1000 per category are satisfactory.

The expected value is obtained as the simple sample mean, which can also be weighted by volumes of traffic, according to the type of sampling applied. To calculate the standard error of the estimate, it is convenient not to restrict the application of the hypothesis of normality and to use the broad hypothesis of Tchebitcheff, which calls for larger sample sizes but which is valid for any type of distribution. In this case, it is safer and cheaper to take more samples than to study the probability of the mean in all of the possible samples given the risk that this will be influenced by the distribution of the frequency with which the vehicles form lines at the lights.

For urban passenger buses, a more refined version of the BUSLINES SURVEY is used. First, a city sample is run and then a sample of lines and buses, in the same way that the mileage survey was done. Then, a monitoring survey is conducted in the buses at different hours, with the interviewer traveling in the bus and counting the number of passengers present at different (fixed) points along the way. For example, 10%, 20%...100% of the bus route. Then, it is possible to calculate a weighted average of hours, according to the volume of traffic (known) for each line. In reality, the utilization factor for public urban service has a double frequency distribution as a function of hours and the route covered. It is also possible to incorporate the variable workday/non-workday and to do the corresponding weighting.

In sampling of this kind, it is convenient to do hypothesis testing to prove or disprove assumed relations between the utilization factor and the large number of variables that could affect it. Occasionally, a previous ranking survey can be conducted to study the hypothesis and, with those results, a final design can be formulated for the sample. This two-stage procedure can reduce the costs of the final sample design based on a sounder knowledge of the phenomenon.

For urban passenger transport, there can be other approximations other than this survey, depending on the quality and quantity of previous information which can be gathered. A CENSUS or RECORDS SURVEY of firms and offices which inspect transportation can provide new universes of reference such as the number of tickets sold. Also, mileage and utilization factors can be verified in this way, and from the analysis of the information gathered, a need, and the method, for carrying out complementary surveys will appear.

For the interurban mode for freight and passengers, and for all types of vehicles, the COUNTING STATION SURVEY is applied. As mentioned before, the best technique for doing this type of survey is a multi-stage sample by groups. At the same time that mileage and the utilization factor are being investigated, the fixed features, cylinder capacity, make, and model, age and type of fuel can be asked about if they are not known on the basis of a census of the vehicle park. Once a sample of the universe of counting stations has been selected, within it, a systematic vehicle count is taken and the number of passengers is counted. For this purpose, it is necessary to stop the vehicles and the only practical way of doing this is with the help of the highway patrols. The sample sizes are very large, on the order of 100,000 and above, in order to obtain small errors of estimation.

The statistical processing of a survey of groupings proves quite complicated and demands an in-depth analysis of the different unbiased estimators with those which have the least variance; it is often convenient to use biased estimators whose bias rapidly approaches zero if certain conditions are fulfilled. It is then fundamental to look into the particular conditions in which the experiment is done (these can vary a great deal from case to case) and to propose adequate estimators for these.

Ratio and regression estimators can be used advantageously when certain variables which determine the experiment (for example, the number of counting stations by groups or strata of the population) are not correlated to the characteristics which are being measured. Hypothesis and correlation testing is a tool of great value in selecting the estimator best adapted to the experiment.

The transport of urban freight, if it leaves aside private freight, can be covered by means of a SURVEY OF FIRMS. The most important urban freight vehicles correspond to foodstuffs (especially beverages), construction materials and furniture, transported in regular-size trucks which are generally grouped in types. Consultation with the firms chosen in the sample can solve the problem. The universe of firms should be known (institute of statistics, social security, mercantile registers) together with the number of employees and, if possible, the fleet of trucks and their characteristics. A stratified or systematic sample can be done, as a function of the number of employees or the number of trucks.

Care must be taken in conducting this survey so as to ensure that the destination of the freight is not interurban, i.e., that the truck whose freight is picked up at some point in the city will not pass through any counting station for the interurban survey, in which case it would be computed as interurban.

Insofar as the passenger surveys, the measurement is reduced to a problem of counting people; in the case of freight, the situation is more delicate and only in very well organized systems will it be possible to read the weight of the load on the control sheets which the driver carries. Otherwise, the only way to verify

weight is by installing a system of scales, either automatic or manual. These systems are becoming increasingly popular in many countries.

4. Fixed Features

The type of fuel, capacity for transport, make and model, cylinder capacity and age are fixed features of the park and the ideal thing would be to learn about these as part of the census information. When this does not occur, it is possible to turn to surveys geared to measuring the operational features-- principally mileage and the utilization factor-- to obtain estimators for these elements.

For capacity, cylinder capacity, make and age, frequency estimators are sought; and for type of fuel, estimators of bi- or multi-nominal proportion.

Mention has already been made of the fact that in the interurban mode, the fixed features can be obtained jointly with the utilization factor in the sampling by groups at the counting stations. For urban buses, the survey of lines and firms permits identification of the type of bus.

More delicate can be the case of the light-vehicle fleet and although the survey of service stations is a perfectly adequate framework for the fixed features, the sample size demanded by mileage is not sufficient to yield frequency estimators.

For this last case, PARKING LOT SURVEYS have been designed; these consist of visitng sites in which vehicles are parked and recording the make and model. For the latter, even though it is not always possible to know the exact year, ranges can be established by the make of the vehicles. For this survey to be successful, there should be a previous, detailed classification of the park, with knowledge about the most visible details which make it possible to characterize the vehicles using only the instrument of sight inspection.

5. Efficiencies

If Alternative I is adopted, it is sufficient to multiply consumption by subsectors and by type of fuel, according to an efficiency of reference which will depend only on the type of engine and the type of fuel, but not on the design features of the vehicle. Supposing, for the sake of simplicity, that there are only two fuels and two kinds of engines-- gasoline for combustion engines and diesel for injection engines-- and that their respective efficiencies are η and η', in Alternative I all of the vehicles whether cars, buses or trucks, would have the same efficiency if they use the same fuel. The specific consumption will obviously vary not only by type of engine but also by vehicle category. Take c and c' as gasoline and diesel consumption within a homogeneous group. Useful energy per kilometer will be:

$$\dot{z} = \eta c = \eta' c' \quad (19)$$

It must be kept in mind that if an efficiency is adopted for the combustion engine, let us say $\eta = 0.145$. the other efficiency is automatically fixed by Equation (19), at $\eta' = 0.18$ the injection engine. Furthermore, Equation (19), which equates the useful energy produced by different motors, serves as a check on consistency for the specific consumption surveys and it is expected that the conditional expectations of these, for the same explanatory variables, will have a relation approximately equal to the inverse of the efficiencies.

If Alternative III is adopted, there will be two efficiencies; for ease of recording, the one for production will be written as ν and the one for use as μ . Useful energy will now be:

$$\dot{z} = \nu\mu c = \nu'\mu' c' \quad (20)$$

Efficiency of use is given by a consumption ratio as indicated in Equation (9). What is this consumption? Equation (13) provides the answer: if the parameters corresponding to travel on a flat paved highway under ideal traffic conditions are put into this equation, consumption under ideal conditions is obtained in approximate form. If the parameters corresponding to real conditions are not used, greater consumption is obtained. The ratio between the two results in the efficiency of use. A practical rule, but one which makes a lot of sense in theory, is that for one same vehicle, the efficiency of use is obtained as the quotient of highway consumption and consumption in the city. To be more precise, we would say "highway consumption under ideal conditions".

Thus, we have seen how the specific consumption survey will at the same time make it possible to resolve the problem of efficiency of use.

The aspects related to efficiency of production are left to deal with, by adopting the same reference values for Alternative I, or by attempting to develop a more in-depth treatment of the information. Even though the experience gained so far does not yet permit definitive answers, it is evident that the subject opens up interesting prospects for the treatment of useful energy in the transportation sector. It can be imagined that efficiency of production does not only depend on the type of engine but also on the type of vehicle and its mechanical and aerodynamic design. Consultations with vehicle manufacturers and even the laboratory tests measuring the horizontal thrust force that appears in Equation (7) for vehicles of different types, can shed new light on knowledge about one of the most important parameters on planning in transportation sector.

6. General Scheme for a Road Transportation Database

For the purposes of summarization, the surveys discussed in this chapter are listed below in order to show more effectively the relation between these and the respective parameters which they determine.

- CEVE = Vehicle Census
- ESLI = Monitoring Survey of Light Vehicles
- ESBU = Monitoring Survey of Urban Buses
- ESBI = Monitoring Survey of Interurban Buses
- ESCU = Monitoring Survey of Urban Trucks
- ESCI = Monitoring Survey of Interurban Trucks
- EDES = Service Station Surveys
- EDSE = Traffic Light Survey
- ECPA = Parking Lot Survey
- EDEC = Counting Station Survey
- EDEM = Company Survey (Urban Trucks)
- EDLE = Company Lines Survey

The following chart details the interaction between these surveys and the parameters noted:

Groups of Vehicles	Park	Fixed Features	Specific Consump.	Mileage	Utiliz. Factor
Urban light	CEVE	EDES/EDPA	ESLI	DES-EDEC	EDSE
Interurb.light		CEVE	ESLI	EDEC	EDEC
Urban buses	CEVE	EDLE/CEVE	ESBU	EDLE	EDLE
Interurb.buses	CEVE/EDEC	EDEC/CEVE	ESBI	EDEC	EDEC
Urban trucks	CEVE	EDEM/CEVE	ESCU	EDEM	EDEM
Interurb.trucks	CEVE/EDEC	EDEC/CEVE	ESCI	EDEC	EDEC

After the surveys have been done and broken down for consumption, passenger- and ton-kilometers per subsector, it is necessary to compare aggregate consumption figures with the corresponding information on fuel distribution; for example, service station sales plus direct distributors. Both figures should coincide within the statistical error resulting from the standard errors for the different estimators used. If the fit is not good, this will be due to biases in the sampling procedures applied. If the bias is very large, the reason will usually be detected easily.

The sample sizes of the surveys presented do not depend on the size of the population (number of vehicles in the park), but rather on the number of variables desired for inclusion in each test. As a consequence, the cost of setting up a database on road transportation will be independent of the economic size of the country, except to the extent that in a larger country it may be necessary to include more variables in order to have adequate estimators. For example, if the mileage in some vehicle category depends on city size, in a large country a finer stratification will be required and the sample size will be larger than in a small country.

For the sake of reference, reference sample sizes for the different surveys are given below:

ESLI, ESBU, ESBI, ESCU, ESCI: between 40 and 200
EDES: between 500 and 4000
EDSE: betwen 1000 and 10,000
EDEM: between 500 and 2000
EDLE: between 2000 and 6000
EDEC: between 50,000 and 200,000

Obviously, the sample size will be larger, the smaller the confidence interval required for the estimates; and it must be kept in mind that, in calculating total consumption and passenger- and ton-kilometers, variances and confidence itnervals increase. In general, it is quite satisfactory to have a confidence interval of more or less 10%, and acceptable to have one of more or less 15% for Z and X.

NON-ROAD TRANSPORTATION

1. River

This mode-- which would only be of interest to the countries which have large rivers-- is dealt with in a way analagous to that of roadways, and Equations (10) and (11) are applied to calculate consumption, passenger- and ton-kilometers. To resolve these, it is necessary to have:

- A survey on specific consumption
- A survey on mileage
- A survey on utilization factors

The park N should be known through a census or shipping record, which should also provide the number of shipments per: (a) type of fuel (gasoline, diesel, fuel oil); (b) passengers, freight, or mixed; (c) transport capacity Q.

The shipments are usually recorded in a few port offices corresponding to given river basins, so that the geographical movement of these is reduced to just a few navegable rivers which are perfectly identifiable. It thus suffices to take a sample of SHIPMENTS in the port offices which are representative of the characteristics of the park. What would be ideal is that the greatest possible number of shipments from an office could provide the following information:

- Number of routes covered (ports of origin and destination)
- Capacity
- Number of trips per year made in each route
- Fuel consumption for one of these trips
- Freight and passengers transported on one of these trips

The first three items define a more numerous sample, from which the estimator for mileage L for each group of capacity Q can be

extracted. Then it is possible to investigate the likelihood of a correlation between L and Q, which will usually indicate that the large vessels cover more kilometers per year than the small ones do. If this correlation exists, there will be two or more mileage estimators per capacity range o, there may even be a continuous regression between L and Q.

The specific consumption c is, without doubt, a function of Q and nothing more than Q and its most suitable estimator is:

$$\hat{E}(c) = \Sigma\ \hat{E}(c/Q_i)\ \ f(Q_i) \qquad (21)$$

If there is a correlation between L and Q, the estimator for L is analagous to that for c:

$$\hat{E}(L) = \Sigma\ \hat{E}(L/Q_i)\ \ f(Q_i) \qquad (22)$$

In both equations, the marginal distribution function for Q . f (Q_i), is known from information on the park.

The estimator for the conversion factor 0 will be the sample mean, since it will most likely not be correlated to anything.

Once the expectations and variances in the basic parameters are known, one returns to the fundamental equations (10) and (11) and takes expectations and variances in order to obtain the estimator for consumption Z and for passenger- and ton-kilometers X, with which all of the information required on river transportation is generated.

2. Rail and Air

These modes of transportation are treated in a similar way and it is usually not necessary to do surveys, since both the information on consumption as well as on passengers and tons transported is available.

The number of units deployed, as measured in coaches for trains and subways, and in units of aircraft are known, as well as the transport capacity in tons and in number of seats, and the trips made, in terms of number and mileage.

The transport capacity X´is calculated in tons (or passengers) per kilometer. Since the real amount transported X is also known, the utilization factor is:

$$\Phi = X/X' \qquad (23)$$

For consumption Z it must be kept in mind that in the case of trains, it refers only to locomotives or motor-coaches. Through regressions or quotients of X and Z, the elasticities defined by Equation (6) can be calculated, and this will permit a comparison between the energy expended per unit transported under this mode and the others.

International air transport is expressed in passengers and tons (without kilometers), entering and leaving the country, and compared with the respective fuel consumption. Mileage here is not a determining factor because aircraft orient their fueling for return trips to the countries where fuel is cheaper, within the technical possibilities of their flight schedule. The relation between Z and the number of passengers plus international freight will capture this preference of commercial firms, which can vary a great deal from one country to another, according to the respective pricing policies.

Fortunately, the fuels in use in aviation-- aviation gasoline and jet fuel (JP1 and JP4)-- are specific, so that, when the sales of both products on the market are known, the total consumption in air transportation in known. Jet fuel is used in its totality in commercial aviation although a small part might be earmarked for the armed forces. Aviation gasoline is divided into: (1) commercial aviation; (2) fumigation; (3) private aviation (small aircraft for private transportation, air taxis); (4) armed forces. The consumption of commercial aviation is assumed to be known through company records or surveys.

As mentioned previously, fumigation belongs to the agricultural sector and obtention of the respective information should be handled as part of the information of the database for that sector. For such purposes, a survey may be necessary, whether done on farms and/or by fumigation companies.

As for private aircraft, the ones which operate as air taxis are grouped in companies which are usually controlled by the civil aviation authorities through flying licenses. Knowing how many and which ones the companies are, it is possible to consult their records or even the airport records or the civil aviation records. The group of small private aircraft belonging to companies or private individuals will still be left but, since it is slight in number, it is not recommended that a survey be conducted.

3. Sea

The state of organization of the information on this mode of transportation depends a great deal on the countries and, before any data-gathering procedure is applied, an intensive diagnostic study should be done, without eliminating the possibility of some surveying.

First of all, it is necessary to differentiate between transport along the coast and international transport; the former is dealt with in ton-kilometers and the latter in tons transported.

Then, it is necessary to determine whether or not there are "specialized fleets" such as the ones which transport petroleum products, iron, cement, etc., and differentiate them from the general fleets. The first are easy to distinguish because this information is recorded.

Generally speaking, maritime transportation can rely on accurate information on transported freight. If there are also up to date fuel consumption records, it can be treated like air transportation, expressing coastal transport in ton-kiloemeters and international transport in tons. In the latter case, there are also times when ships fuel up with bunker in different countries, according to the convenience of prices.

A very special case in some countries is constituted by the fishing fleets; some of these ships can be real floating industries which process while they transport. There are countries which place fishing consumption in the agricultural and fishing sector, and this consumption should then be separated from the general coastal fleet.

It will not usually be necessary to survey sea transportation in order to estimate utilization factors, but surveys may be required for specific consumption and mileage on inland waterways, in which case the procedure will be the same as for river transportation. In international transport, the fuel consumed is almost exclusively bunker fuel, which, because it has a specialized destination, is known with certainty. Once all of the possible information problems have been solved through records, the decision will be made as to whether or not the information still lacking merits surveys on consumption and mileage.

4. Efficiencies

For non-road transportation, it is recommended that Alternative I be used, since there is no concept relating to the traffic conditions of road transportation to which an efficiency of use can be applied. One exception might be, however, railways, where the rails are the main element of friction against which frictiona forces are developed. It is true that a railroad can be in good or bad condition, and that this will affect the quality of the service by not allowing the trains to travel at maximum speed. Given the way in which useful energy has been defined-- the work done against frictional forces under ideal conditions-- it is clear that, in order to have a unit efficiency of use, the speed of travel should be ideal and optimal; it is the one for which there will be the least final consumption per kilometer. At this point of operation, there is efficiency of production and any later increase in consumption can be attributed to a reduction in the efficiency of use. Thus, there are no theoretical impediments in treating rail transportation with Alternative III. From the practical point of view, however, rail transportation does not require surveys to measure specific consumption, and it would perhaps not be justified for these to be done just to measure efficiency of use. The subject remains open to discussion, however, and can be resolved in the future, without discounting the option that some country in particular, with a well-developed rail system, may want to undertake a deeper study in the near future.

River, sea and air transportation are, without doubt, cases in which efficiency of use, although it can be defined as a theoretical concept, has no practical meaning since the frictional forces occur against natural environments whose conditions cannot be changed.

As efficiencies of reference for application of Alternative I, some values taken from a bibliographic compilation done by the Institute of Energy Economics at the Bariloche Foundation are presented below:

- Steam locomotives using fuel oil	3.6%
- Steam locomotives using firewood	2.7%
- Steam locomotives using coal	3.0%
- Diesel-electric trains	28.0%
- Electric trains	85.0%
- Seagoing vessels using fuel oil	7.0%
- Seagoing vessels using diesel	18.0%
- Jet turbines	18.0%

It would be worthwhile to delve further and expand the bibliography by adding data that the countries might have as an outgrowth of their own experiences.

CHAPTER III

APPLICATIONS

1. General Considerations

As an application of the methodology discussed in this document, the case of Colombia is presented as an example of a country where most of the surveys mentioned in the previous chapters have actually been carried out.

a) Disaggregation by energy sources considers the following products:

- Coal
- Motor Gasoline
- Kerosene and Jet Fuel
- Diesel Oil
- Fuel Oil
- Non-Energy Products

b) Disaggregation by subsectors is:

- Interurban Private Passengers
- Urban Private Passengers
- Interurban Public Passengers
- Urban Public Paasengers
- Urban Freight
- Interurban Freight
- Road Transportation
- Air Transportation
- River Transportation
- Sea Transportation
- Rail Transportation

c) The expected values for the parameters in the road transportation mode are summarized in the table attached herewith, for the following types of vehicles:

- Private Cars
- Campers/Pick-ups
- Small Buses (P 300)
- Buses (P 600)
- Buses (P 900)
- Light Trucks
- Heavy-Duty Trucks (2 axles)
- Heavy-Duty Trucks (More than 2 axles)
- Motorcycles

The 10 above-mentioned categories correspond to the particular way in which the automotive vehicles in Colombia were divided and which has been used for surveys and presentation of the following parameters:

- Annual mileage in km per year
- Specific consumption
- Utilization factor, in number of persons per vehicle or load carried

The three parameters are detailed in the following table, by type of fuel and according to urban and interurban modes.

d) With respect to efficiencies, in the case of Colombia Alternative I was adopted and the following values were taken:

- 14.5% for all of the gasoline engines in road transportation
- 18% for diesel engines, or the values resulting from relating specific consumption when both are known (see Equation (19))
- 20% for diesel oil in sea, river and rail transportation
- 15% for gasoline in air transportation
- 16% for gasoline in river transportation
- 18% for kerosene in air transportation
- 7% for fuel oil in sea transportation
- 10% for coal in rail transportation

2. <u>The Case of Colombia</u>

With all of the foregoing assumptions, the BEEU are be elaborated, including the format and results of for the case of Colombia in the following pages.

TABLE I-1

TRANSPORTATION SECTOR

BASIC PARAMETERS - THE CASE OF COLOMBIA

YEAR: 1983

UNIT: Tcal

BASIC PARAMETERS	Annual Mileage (Km/Year)		Specific Consumption (Gal/Km) GASOLINE		Specific Consumption (Gal/Km) DIESEL OIL		Utilization Factor (Pas-Tn/Vehicle)	
	Urb.	Inter.	Urb.	Inter.	Urb.	Inter.	Urb.	Inter.
Private Cars	6259.65	6047.21	0.03382	0.02706	0.03382	0.02706	1.85	2.59
Campers + Pick Ups	8475.26	5146.40	0.05078	0.04062	0.05078	0.04062	1.91	2.92
Taxis	47993.76	48005.73	0.03911	0.03129	0.03911	0.03129	0.96	2.94
P 300	48500.00	48703.39	0.14050	0.11310	0.11240	0.09050	71.00	72.07
P 600	48500.00	48703.39	0.16650	0.13920	0.14060	0.11310	67.00	67.97
P 900	-	48703.39	-	0.13920	-	0.11310	-	62.55
Light trucks (5 Ton)	41513.00	6987.00	0.07140	0.05712	0.07140	0.05712	(%)45.00	(%)89.50
Heavy trucks (5-12 Ton)	-	53679.63	-	0.12310	-	0.09880	-	(%)89.50
Heavy trucks (two-axle)	-	56932.67	-	0.22370	-	0.17900	-	(%)89.50
Motorcycles	8556.64	-	0.01538	-	-	-	1.00	-

TABLE I-2

TRANSPORTATION SECTOR

BALANCE OF USEFUL ENERGY - THE CASE OF COLOMBIA

YEAR: 1983

UNIT: TCAL

	COAL	GASOLINE	KEROSENE	DIESEL	HEAVY FUELS	NON-ENERGY	FINAL CONS.
FINAL CONSUMPTION	45.5	34302.6	5164.9	6815.0	325.9	723.8	47377.7
.. Private Interurb. Passengers	-	3501.9	-	81.8	-	63.3	3647.1
.. Private Urban Passengers	-	7033.5	-	138.4	-	126.8	7298.8
.. Public Interurb. Passengers	-	3649.6	-	323.9	-	70.1	4043.6
.. Public Urban Passengers	-	8605.3	-	822.9	-	166.2	9594.3
.. Urban Freight	-	4294.6	-	734.6	-	83.3	5117.5
.. Interurban Freight	-	6337.3	-	3917.1	-	178.0	10432.4
. Total Road	-	33422.3	-	6018.7	-	692.8	40133.8
. Air	-	356.8	5164.9	-	-	8.4	5530.2
. River	-	516.4	-	371.2	-	15.5	903.1
. Sea	-	-	-	283.9	-	4.8	608.2
. Rail	45.5	7.1	-	141.2	6.4	2.3	202.5
USEFUL CONSUMPTION	4.5	4983.6	929.7	929.7	22.8	723.8	7880.5

1 Tcal = 100 TOE = 720 BOE

SECTORAL APPENDIX II

INDUSTRIAL SECTOR

INDEX

INDUSTRIAL SECTOR

CHAPTER I

DEFINITIONS AND BASIC CONCEPTS

1. Disaggregation by Subsectors

The need to disaggregate final consumption in industry by subsectors is amply justified, and it represents a logical stage in the evolution of energy balances. One of the most important reasons why, is related to the preparation of models for energy demand projection: whether these are econometric or analytical process models, they are always heavily determined by the relation between energy consumption and some value which is characteristic of industrial production. In the industrial sector, value added is the most commonly used indicator for these purposes. The concept of the elasticity of consumption/value added or energy content thus appears in different definitions, for this is one way to express energy consumption per economic unit generated by industrial production activities.

As a result, the problem of disaggregating consumption is undoubtedly tied to national accounts. Since these are usually based on the international classification - ISIC, then this system will also be used as the methodological basis for disaggregating consumption.

The ISIC classification cannot, however, be translated mechanically into the energy balance. The system is composed of four digits, the first of which indicates the branch of economic activity and the last three of which characterize the finer divisions of the branch.

There is no reason of a theoretical nature to reject the maximum 4-digit classification; furthermore, some countries in the region already have information on energy consumption at this level, at least for some products. The difficulty of working with four digits, and even with three, lies in the sample design, the size of which is excessive and very costly.

It is thought that a two-digit system is the minimum for the current state of energy information in Latin America, and that it would permit OLADE to work out a common pattern for comparisons, which could include all of the Member Countries.

Table II.1 schematizes the classification proposed in this methodology (Groups I), its correspondence to the ISIC and the respective nomenclature. Chart II.2 includes a summary breakdown of the four-digit ISIC classification for the industrial sector.

With reference to Table II.1, it can be observed that for 7 of the groups there is direct correspondence between the energy balance and the two-digit ISIC. These are:

I	1	:	Food, Beverages and Tobacco
I	2	:	Textiles, Clothing, Footwear and Leather
I	3	:	Wood and Furniture
I	4	:	Paper and Pulp
I	8	:	Iron, Steel and Non-Ferrous Metals
I	9	:	Machinery and Equipment
I	10	:	Unspecified

It should be pointed out that the sector "Wood and Furniture" will present very low levels of energy consumption in most countries, and in these cases could be added to "Machinery and Equipment," whose consumption will be of an intermediate magnitude. From the conceptual standpoint, the furniture industry and its raw material, wood, can be considered as manufacture of non-metallic equipment, so that there would be no problem in including it under Group I.9 if such consumption were very low.

In Group I.5, "Chemicals," the subgroup 3530 , corresponding to petroleum refineries, is excluded because the energy balance computes these under the supply sector and also because they must be subtracted from the value added when it is desired to calculate elasticities. In some countries, this may produce a certain amount of confusion, especially in the cases in which the petrochemical facilities are integrated into refineries.

In these cases, it is recommended that an effort be made to separate consumption and value added and to place refineries under "supply" and petrochemicals under "demand". When the refining sector of a country is being planned, this should be done using a special technique proper to supply models. Otherwise, petrochemical consumption is treated as a case of demand projection and thus must be separated.

With the same criterion, it is necessary to eliminate coal distillation in coke furnaces from the "Chemicals" group (other than in iron and steel manufacturing) ; however, in most cases its low relative weight will not increase the enormous effort that separation would entail. If coal liquefaction and gasification installations were to take on importance, they should be given the same treatment as refineries. Alcohol distilleries using vegetable feedstock receive the same treatment, as can be seen in Chapter II of the Base Document.

Group I.6, "Cement," corresponds to 3692 of the four-digit ISIC, and Group I.7, "Stones, Glass and Ceramics," to ISIC 36, except for the subgroup corresponding to Cement. This separation is highly useful since cement-making is one of the heaviest energy consumers, where substitution processes are the most evident. Furthermore, what remains of the ISIC 36 after taking out cement will also account for a very large consumption; so, the practice in some countries is increasingly tending toward separation. One difficulty arises, however, with the ISIC subgroup 3692, which includes not only cement but also lime and plaster, and with the national accounts classified according to the ISIC Version II. There is no other way to separate cement from lime and plaster.

In most countries, both the energy consumption and value added of the cement plants is several times larger than those for lime and plaster. In a first approximation, it could then be accepted that Group I.7 includes only cement consumption and that this is compared with the value added of all of Subgroup 3692, with the awareness that a slight error is being committed.

In a second approximation, lime and plaster consumption can be added to Group I.7, so that its comparison with economic parameters would not offer any difficulties.

One of the most complicated groups to deal with, despite the fact that there are no discrepancies with the two-digit ISIC is I.8, "Iron, Steel and Non-Ferrous Metals." It specifically refers to Coke Plants and Furnaces, the usual practice in the OLADE balance being to place both kinds of installations on the supply side (in transforamtion centers) and to express the flows by means of a double recycling, which proves to be a little vague.

The way in which the problem has now been solved-- and it is not the only way-- consists of leaving coke plants on the supply side and of passing furnaces to the demand side. This approximation is adopted for the following reasons:

- From the point of view of the value added of the group, furnaces are very significant; coke plants are not. Therefore, by leaving furnaces in the group, we can accept the value added just as it comes from the national accounts, considering as negligible the slight error that removing the coke plants would imply.

- The complication of the double recycling in one transformation center at the level of supply then disappears.

- For the energy planner, the furnace is a problem of exogenous demand, whereas the coke plant constitutes the associated supply.

TABLE II.1

DISAGGREGATION OF THE INDUSTRIAL SECTOR IN SUBSECTORS

ACCORDING TO THE ISIC CLASSIFICATION

BALANCE GROUPS	CORRESPONDENCE TO ISIC	NAMES OF SUBSECTORS
I-1	31	FOOD, BEVERAGES, TOBACCO
I-2	32	TEXTILES, CLOTHING, SHOES AND LEATHER
I-3	33	WOOD AND FURNITURE
I-4	34	PAPER AND PULP
I-5	35-3530	CHEMICALS (EXCEPT PETROLEUM REFINERIES)
I-6	3692	CEMENT
I-7	37	IRON, STEEL AND NON-FERROUS METALS (EXCEPT COKE PLANTS IN INTEGRATED IRON AND STEEL MILLS, BUT INCLUDING FURNACE)
I-9	38	MACHINERY AND EQUIPMENT
I-10	39	UNSPECIFIED

TABLE II.2

ISIC CLASSIFICATION OF THE INDUSTRIAL SECTOR

Code of Industrial Groupings and Groups

Code for ISIC groupings and groups	Industrial Activity
311-312	Manufacture of foodstuffs, except for beverages
3111	Slaughtering of cattle, preparation and preservation of meat
3112	Manufacture of dairy products
3113	Canning and preservation of fruits and vegetables
3114	Processing of fish, crustaceans and other seafood and freshwater fish
3115	Manufacturing of vegetable and animal oils and lards
3116	Mill products
3117	Manufacture of bakery products
3118	Sugar mills and refineries
3119	Processing of cacao and manufacture of chocolate and candy
3121	Elaboration of various foodstuffs
3122	Elaboration of animal feeds
3123	Elaboration of dietetic compounds and others

Code for ISIC groupings and groups	Industrial Activity
313	Beverages industry
3131	Distillation, rectification and mixture of alcoholic beverages
3132	Wine industries
3133	Malt and malted beverages
3134	Non-alcoholic beverages and soft drink industries
314	Tobacco industry
321	Textiles manufacturing
3211	Thread, knitting and textile finishing
3212	Articles made from textiles, except apparel
3213	Manufacture of knitted goods
3214	Manufacture of wall hangings and carpet
3215	Manufacture of cords
3216	Manufacture of cotton and cotton blends
3217	Manufacture of wool and wool blends

Code for ISIC groupings and groups	Industrial Activity
3218	Manufacture of artifical and synthetic fibers and blends
3219	Manufacture of other textiles
322 3220	Manufacture of apparel, except shoes
3221	Manufacture of other clothing, except shoes
323	Industry of leather and leather goods and simulated furs and leather, except shoes and other apparel
3231	Tanneries and finishing workshops
3232	Industry of preparation and dying of furs
3233	Manufacture of leather goods and simulated leather, except for shoes and other apparel
324 3240	Shoe manufacturing, except for vulcanized or molded rubber or plastic
331	Industry of wood and wood and cork products, except furniture
351	Manufacture of industrial chemical substances
3511	Manufacture of basic industrial chemical substances, except fertilizers
3512	Manufacture of fertilizers and pesticides

Code for ISIC groupings and groups	Industrial Activity
3311	Sawmills, workshops for dressing lumber and other woodworking activities
3312	Manufacture of wood and cane containers and small cane articles
3319	Manufacture of other wood and cork products
332 2320	Manufacture of furniture and accessories, except those mainly metal
341	Manufacture of paper and paper products
3411	Manufacture of wood pulp, paper and cardboard
3412	Manufacture of paper and cardboard boxes and containers
3419	Manufacture of other pulp, paper and cardboard products
342 3420	Printers, publishers and related industries

Code for ISIC groupings and groups	Industrial Activity
3513	Manufacture of synthetic resins, plastic materials and artifical fibers, except glass
352	Manufacture of other chemical products
3521	Manufacture of paint, varnish and lacquer
3522	Manufacture of pharmaceutical products and medication
3523	Manufacture of soap band cleaning pro- cosmetics and other toiletries
3528	Manufacture of different chemical products
3529	Manufacture of chemical products not specified above
353 3530	Petroleum refineries
354 3540	Manufacture of different petroleum and coal derivatives
355	Manufacture of rubber products
3551	Manufacture of tires and tubes
3559	Manufacture of rubber products not specified above

Code for ISIC groupings and groups	Industrial Activity
356 3560	Manufacture of plastic products
361 3610	Manufacture of objects of clay, ceramic and porcelain
362 3620	Manufacture of glass and glass products
369	Manufacture of other non-metallic mineral products
3691	Manufacture of clay products for constructions
3692	Manufacture of cement,lime,plaster
3699	Manufacture of non-metallic mineral products not specified above
371 3710	Basic iron and steel industry
372	Basic non-ferrous metals industry
3720	Copper and aluminum recovery and castinguminio
3721	Lead and zinc recovery and casting
3722	Tin and nickel recover and casting
3723	Refining and casting of precious
381	Manufacture of metal products, except machinery and equipment

Code for ISIC groupings and groups	Industrial Activity
3811	Manufacture of knives, hand tools and hardware items in general
3812	Manufacture of furniture and accessories, mainly metallic
3813	Manufacture of metal structural products
3814	Manufacture of plumbing and heating products
3819	Manufacture of metal products, not specified above, except machinery and equipment
382	Manufacture of machinery, except electrical
3821	Manufacture of motors and turbines
3822	Manufacture of machinery and equipment for agriculture
3823	Manufacture of machinery for metalworking and woodworking
3824	Manufacture of special machinery and equipment for industry, cept machinery for metalworking and woodworking
3825	Manufacture of office machines, for calculation and accounting
3826	Manufacture of machinery not classified elsewhere, except for metal- and woodworking
3827	Manufacture of machinery and equipment not specified above, except elec.
3829	Manufacture of machines, devices and equipment not specified above
383	Manufacture of electrical machinery, devices, accessories & supplies
3831	Manufacture of industrial electrical equipment
3832	Manufacture of radio, television, and communications equipment
3833	Manufacture of electrical devices and accessories for household use
3839	Manufacture of electrical devices and supplies, not specified above
384	Manufacture of transportation equipment/materials
3841	Naval constructions and ship repair
3842	Manufacture of railroad equipment
3843	Manufacture of automotive vehicles
3844	Manufacture of motorcycles and bicycles

Code for ISIC groupings and groups	Industrial Activity
3845	Manufacture of airplanes
3849	Manufacture of transpotation material, nep
385	Manufacture of professional and scientific equipment, measuring and control instruments , photographic devices and optical instruments
3851	Fabricación de equipo profesional y científico e instrumentos de medida y control, nep
3852	Manufacture of photographic equipment and optical instruments
3853	Manufacture of clocks and watches
390	Other manufacturing industries
3901	Manufacture or jewelry and related articles
3902	Manufacture of musical instruments
3903	Manufacture of sporting goods
3904	Various manufacturing industries
3909	Various other manufacturing industries

2. Disaggregation by Uses

Industrial end-uses cover such a variety that it could be said that every manufacturing technology is characterized by given processes which have an associated pattern of energy end-use. However, for the purpose of presenting the minimum end-uses needed for preparation of the energy balance, the following are proposed:

- steam
- direct heat
- mechanical force
- other uses

    . lighting
    . feedstock and electrolysis
    . transportation*
    . others

* This use is placed in the industrial sector for the purposes of information-gathering, but later the part corresponding to the industrial sector is removed, as shown in Table II.3.

These end-uses are the most suitable expression of the ENERGY NEEDS or USEFUL DEMAND of the industrial consumer. Actually, industry does not require electricity or fuel oil except as a means of running its engines or heating its furnaces. There will then be a demand for steam, for heat, for mechanical force, for feedstock or for lighting.

These demands by use depend basically on two factors:

- the manufacturing technology
- the degree of efficiency with which the technology is utilized in practice

For example, the steam used in sterilization processes in the food industry can be utilized with greater or lesser efficiency depending on pipe insulation and the levels of load loss in the network.

Steam is then an intermediate agent required by the sterilization technology. The way in which it is produced can be altered by different forms of final energy (substitution) or by more efficient use (conservation), but it is a requirement inherent in the technology.

The same line of reasoning can be followed with other forms of useful energy which can be catalogued as true TECHNOLOGICAL INVARIANTS. These offer the advantage of generalization, since they offer the convenience of independence between the energy plannerś perspective and that of the industrial planner. Whereas the latter must think of processes as heterogeneous as sterilization, distillation, fusion, calcination, milling, laminating, etc., it suffices for the former to think in terms of

steam, heat or mechanical force.

Another advantage of this classification is that it maintains the thermodynamic unit in the approach to industrial processes, and the LAW OF ENTHALPY CONSERVATION may be applied to all of them; this is one of the easiest ways of expressing energy conservation. Since enthalpy is a function of state, it is sufficient to know the flows through a closed surface, which includes the process under study, without the need to worry about the innumerable and complex intermediate states through which it passes.

As for the processes which involve electricity, this should invariably be transformed into the theoretical equivalent of 860 Kcal per kWh (which can be considered as the enthalpy content of electricity), so as not to distort the thermodynamic consistency between flows.

Unlike electricity, the enthalpy content of steam depends on pressure, temperature and degree of saturation; and its values can be consulted in steam tables. The case of furnaces is somewhat more complicated and a certain amount of additional conceptual effort is needed to understand the generalization implicit in what has been called "direct heat". Broadly speaking, a furnace (and also the particular case of a dryer) is a place in which some processes such as a chemical reaction, dehydration, calcination, toasting, fusion, liquefaction, evaporation, sublimation, etc., takes place. In all of these processes there is:

- a material agent which undergoes a physical-chemical transformation

- a fuel which, directly or indirectly, contributes the required heat (what is termed "direct heat") and which usually also produces exhaust gases.

It is then possible to do an enthalpy balance between the fuel reaction heat and the remaining enthalpy of the gases and the material agent which the process undergoes, no matter what the nature of the latter.

3. Final Energy, Useful Energy and Efficiency

The foregoing definitions of disaggregation by intermediate uses lead to the concept of efficiency, and simplify its presentation. The best way to visualize the problem consists of observing the energy consumption process in industry in two stages:

- the production of steam, heat, mechanical force, etc., from energy sources.

- the use of steam, heat, mechanical force, etc., in manufacturing processes.

Therefore, there is an EFFICIENCY OF PRODUCTION and then an EFFICIENCY OF USE. The product of these two will yield overall efficiency or simply "efficiency". If energy is now multiplied by source of energy, or final demand by overall efficiency, useful demand is obtained and the difference between the two constitutes the losses. This method is adopted for each end-use.

As recommended in the Base Document and the other sectoral appendices, the first stage of application of the methodology suggests the determination of useful energy, in response to efficiency of production. The determination of efficiency of use and the application of overall process efficiency have been left for a second stage of development.

If only the first of the two efficiencies is known, i.e., production, when it is multiplied by final demand, the useful demand at the level of production, or intermediate demand, is obtained. In summary, it can be said that final energy is that which is measured at the beginning of the process and useful energy at the end. Both of these can be disaggregated by subsectors, by products, and by end-uses.

The problem of determining efficiencies deserves special comment. It is very common in the work on energy demand that reaches the level of useful energy to use ADOPTED EFFICIENCIES from manufacturing catalogs; this practice has been establishing certain standard values which are applied with more or less rigor in different countries.

It is thought that this approximation is sufficient when demand projection focuses on emphasizing the mechanisms of SUBSTITUTION among the various sources which compete in price on a market, to produce the same amounts of intermediate demand. Under these circumstances, it is not so much the absolute value of efficiencies which is of interest but rather their relative value, to reflect the fact that one source is either more or less efficient than another in satisfying the needs of a given technology.

Sometimes it is possible to work with MEASURED EFFICIENCIES, which, although they are preferable to adopted efficiencies, entail the major drawback of high costs for measurement procedures. The only way to measure efficiencies is through ENERGY AUDITS, which reveal thermodynamic parameters for the industrial plants. Even so, it is very difficult to generalize these values statistically for a numerous group of industries. It becomes necessary to work with measured efficiencies when what is desired is to express the mechanisms for CONSERVATION or RATIONAL USE OF ENERGY (RUE), because these entail the need to do audits.

The two efficiencies which have been defined (production and use) are visualized in the three basic energy uses: the case of steam is the simplest, since it is produced in a boiler and clearly shows that production and use are physically separate. In the case of mechanical force and direct heat, the separation is not physical but rather conceptual.

Mechanical force is produced in the shaft of motors and turbines

and is used, for example, in a process to cut metal pieces or in a fluid agitator.

Frequently, the motor and the mechanism of use (such as the agitator or cutting piece) will be integrated into a single unit but, when overall efficiency is being studied, a conceptual separation can be made between the instrument which produces energy and the one which uses it. Continuing with this example, the motor may be efficient because its magnetic circuits are in good condition but the worn blades of the agitator may dissipate energy; therefore, there are two possible causes of inefficiency: one in production and another in use.

In the case of direct heat, something similar occurs: production takes place in a furnace having a characteristic efficiency, but the discharge gases and the agent which receives the heat are energy sources which are utilized to a greater or lesser extent (heat recycling), and which characterize an efficiency of use.

With respect to other end-uses, it is worthwhile to note that:

There could be a good deal of argument as to the efficiency of lighting, and values range from 6% to 100%, according to the criteria used. Feedstock, electrolysis, cleaning, etc., should have a fictitious efficiency of 100%, since they do not correspond to a truly energy use. All of these end-uses are unsubstitutable with respect to sources, and they do not lend themselves to major conservation programs.

In the case of transportation (outside the plant), no comments will be made here, because its consumption does not correspond to the industrial sector.

4. BEEU Applied to an Industrial Unit

Here, an attempt is made to apply the technique of FLOW DIAGRAMS, to the units of industrial manufacturing, following the guidelines of the principle of energy conservation. This is the same technique used to design the energy balance for a country or region. The industrial diagram is presented in Figure II.1.

In general terms, an industrial plant performs the dual function of buying and producing energy, in the form of primary and secondary sources, which are later transformed into useful forms such as those defined under Point 2 (steam, direct heat, mechanical force and other uses). The ENERGY BOUGHT is disaggregated by source, according to those presented in the energy balance matrix.

First of all, it is possible to develop the concept of NET ENERGY INPUT (NEI), which is defined as the energy which enters the plant, disaggregated by sources, without any duplication. In many cases, the NEI will be equal to the energy bought but, in order for the treatment to be completely general, the following should be kept in mind:

- If the plant sells energy, commonly electricity and sometimes steam, these sales should be subtracted from the purchases. In calculating the NEI, in the particular case of electricity, it is possible to obtain a negative input when the sales to other plants or to the public service grid are based on auto-production.

- Some plants may have hydraulic generators using a current of water of its own or leased. If the turbinated hydroenergy is not bought, it should figure as an input so that there will not be an imbalance.

- There are plants which produce substances having an energy content as by-products of the production process, e.g.:

  - the black liquor and stillage from the paper industry
  - the reformed products of the chemical industry
  - the furnace gas from the iron and steel industry
  - the LD gas from iron metallurgy

It is worthwhile to group these forms of energy as a primary source called RECOVERY, which is incorporated into the OLADE energy balance, under the concept of "Other Primary Sources".

Once the NEI has been identified, its flows for each one of the sources (see Figure II.1) should be specified. The first thing that can be done with the energy which enters is to use it in AUTO-PRODUCTION of electricity, through:

- the aforementioned hydraulic generators
- diesel groups
- gas turbines

Hydro and the corresponding fuels should be subtracted and the respective electricity should be added to the purchases. In the same way, the coal which feeds into the iron and steel coke plants will be a negative flow, and the coke produced will be a positive flow.

The second use that can be given to the input is INDIRECT AUTO-PRODUCTION of electricity through steam. The situation is a little more complicated since the steam comes from recycling in the boiler to feed into the steam turbogenerators. It will therefore be necessary to do the boiler balance previously-- which in this logic of flows appears afterwards in order to express the steam in terms of the fuels which produces it-- subtracting it from the respective NEI and at the same time computing auto-produced electricity in the NEI.

A third concept which should now be included is the following: fuels such as gasoline and diesel oil bought by many industries for use in the trucks which distribute merchandise. In the present methodology, this end-use forms part of OTHERS; however, it does not correspond to the industrial sector but rather to the

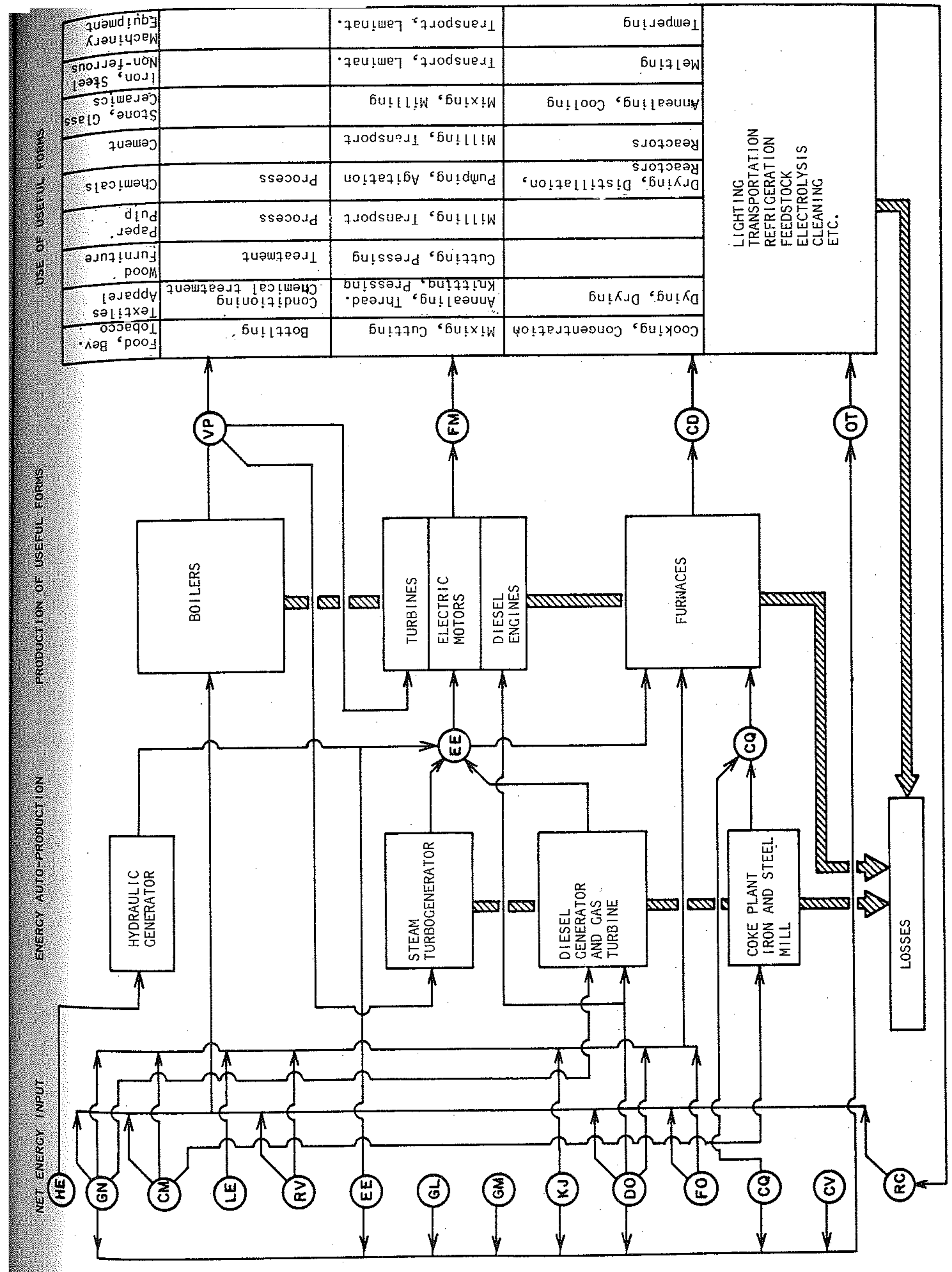


FIGURE II-1 ENERGY BALANCE FOR INDUSTRY

transportation sector, although it would seem to be an industrial consumption.

If the flows related to direct auto-production, indirect auto-production and transportation are added to or subtracted from the NEI, as need be, an important function is obtained. It is known as FINAL CONSUMPTION BY SOURCES in the plant and, when it is added by sources, it can be much lower than the NEI. The difference lies in the fact that part of the apparently industrial flows of the NEI should be placed on the supply side (auto-production of electricity and coke plants) and the rest under final consumption in another sector, i.e., transportation.

Final consumption by sources can now be compared to FINAL CONSUMPTION BY END-USES. When dealing with electricity, this can feed into: (1) motors and (2) resistance furnaces. The fuels which are utilized in (1) diesel engines, (2) heating ovens and (3) boilers and the steam from the boilers can be recycled in (4) steam turbines or centrifugal pumps for use as mechanical force. Here again, there must be transformation of the steam flows recycled in the fuels which gave them origin, in order to separate them between steam and mechanical force. There should be consistency, but not equality, between final consumption by sources and the sum of final consumption by end-uses: between the two there is variation in stocks and statistical error.

Table II.2 summarizes all of these ideas: it starts with net energy input, which, after the addition or subtraction of the flows related to auto-production and transportation, yields final consumption. This is disaggregated by end-uses, and efficiency of production is also indicated. In the lower part, the intermediate useful consumption is calculated first, as a result of the summation of useful consumption weighted by the respective efficiencies of production. Then, the efficiencies of use are noted (depending on the end-use or the source), and useful consumption is calculated by weighting intermediate consumption according to these efficiencies. Finally, losses are calculated as the difference between final consumption and useful consumption. The column of the right-hand side ultimately reflects the total useful consumption, useful consumption by sources and average efficiencies.

It is not the intention of this methodology to recommend the adoption of specific values for efficienies. However, in the event that no other sources are available, some indicative ranges must be established; these are presented in the glossary cited in the Base Document).

5. BEEU Applied to the Industrial Sector

Under the preceding point, it has been seen that, on the basis of a flow diagram conceived of in a general form, practically all of the data which comprise the energy balance of an industrial plant can be placed in the form of a double-entry table. This shows how the energy balance for the entire industrial sector of a

country or region can be presented. However, it can be seen that if one wants to visualize all of the data it covers, the proposed disaggregation call for a four-entry table, the four entries being:

- By subsectors (10 plus Total = 11)
- By uses (4 plus Total = 5)
- By products (according to the OLADE balance = 21)
- By type of consumption (final, useful, efficiencies and losses = 4)

The OLADE balance puts the most numerous dimension (energy sources) in the columns, and this practice should be respected in the presentation of the industrial balance. So that it can be done in one (or, maximum, two) double-entry sheets, it will be necessary to omit some information.

A system using one main data sheet and another auxiliary sheet is proposed.

The main data sheet will contain maximum detail on final consumption and a summary of data on useful consumption, as shown in Table II.4.

The auxiliary data sheet (Table II.5) is nothing more than the right-hand side of the table in Table II.4 (starting from the column for final consumption by sources) for each industrial subsector. There will thus be 10 sheets for each country and they will form part of the countryś own energy balances; however, these should not necessarily form part of the matrix of the OLADE balances, even though they should be attached for inclusion in the OLADE data bank.

The auxiliary sheets represent the final stage in data processing for the industrial survey. The aspects related to:

- DATA SHEETS
- ANALYSIS OF EXISTING INFORMATION
- SAMPLE DESIGN
- SAMPLE EXPANSION

will be discussed in Chapter II, which is devoted to the formation of databases for the preparation of detailed BEEU for the industrial sector. Thus, between the initial stage, represented by the balance per plant, and the final stage, corresponding to a countryś balance by subsectors, there are instruments of a statistical nature which aid in going from one stage to another. Figure II.2 schematizes the relations among the principal components of a project to construct disaggregated BEEU for the industrial sector.

TABLE II.3

INDUSTRIAL SECTOR

SOURCES	ENERGY INPUT	AUTOPRODUCTION		USE IN TRANSPORT	FINAL CONSUMP. BY SOURCE	FINAL CONSUMPTION & (EFFICIENCY) BY SOURCE/USE			
		DIRECT	BY MEANS OF STEAM			NET STEAM	DIRECT HEAT	MECHANICAL FORCE	OTHER USES
HE		(-)							
GN		(-)		(-)					
PT				(-)					
CM		(-)		(-)					
LE				(-)					
RV				(-)					
EE		(+)		(+)					
GI									
GO				(-)					
KE				(-)	(-)				
DL		(-)		(-)	(-)				
CP				(-)					
CQ		(+)							
CV									
RC				(-)					
TOTAL									
INTERMEDIATE CONSUMPTION (PRODUCTION OF USEFUL FORMS)									
EFFICIENCY OF USE									
USEFUL CONSUMPTION									
LOSSES									

TABLE II.4

ANALYTICAL FORMAT

SOURCES	ENERGY INPUT	AUTOPRODUCTION		USE IN TRANSPORT	FINAL CONSUMP. BY SOURCE	FINAL CONSUMPTION & EFFICIENCY BY SOURCE & USE			
		DIRECT + COKE	BY MEANS OF STEAM			NET STEAM	DIRECT HEAT	MECHANICAL FORCE	OTHER USES
HE									
GN									
PT									
CM									
LE									
RV									
EE									
GL									
GM									
KJ									
DO									
FO									
CQ									
CV									
RC									
TOTAL									
INTERMEDIATE CONSUMPTION (PRODUCTION OF USEFUL FORMS)									
EFFICIENCY OF USE									
USEFUL CONSUMPTION									
LOSSES									

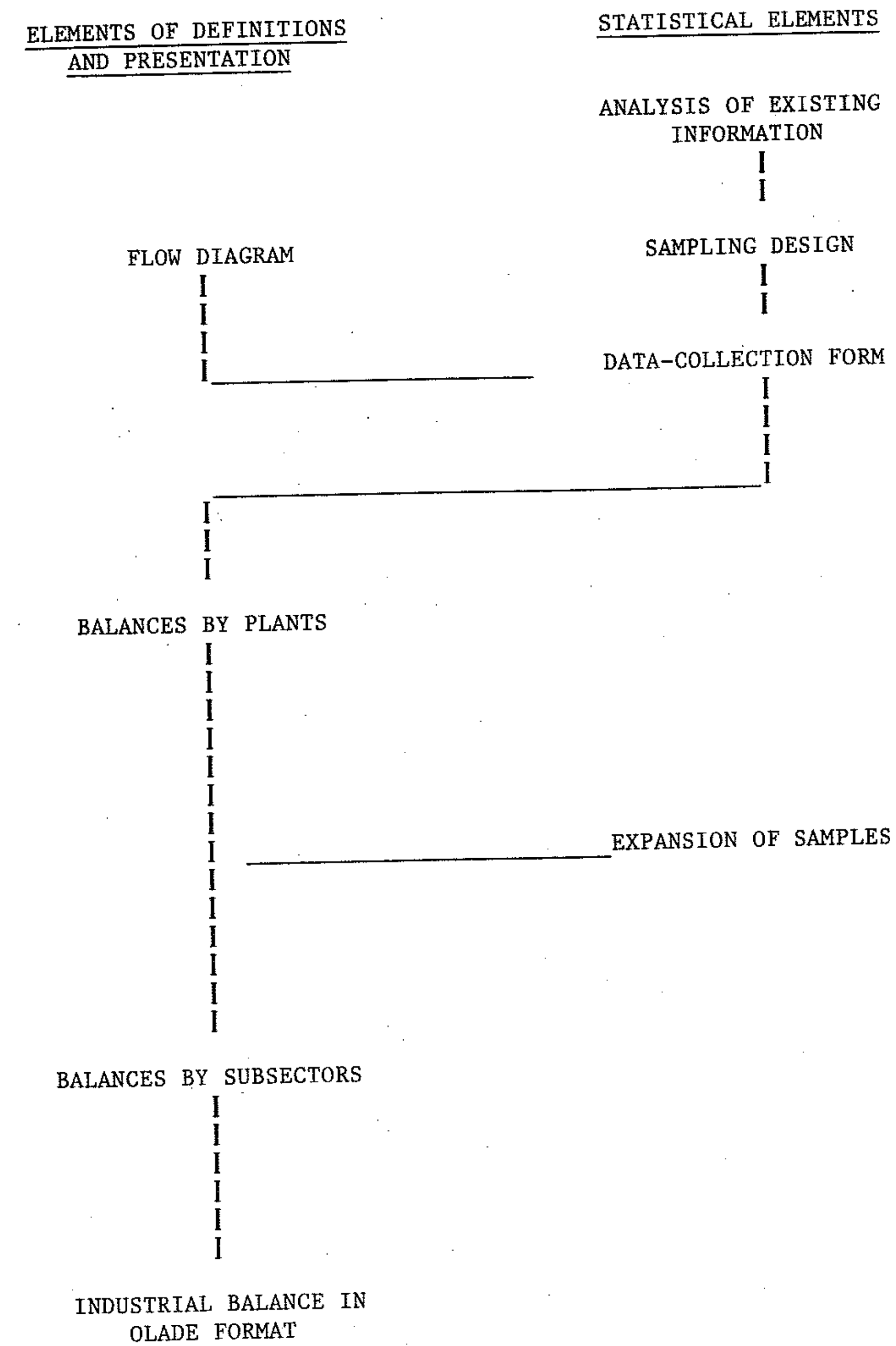
CHART II.5

PRESENTATION OF DISAGGREGATED ENERGY BALANCES FOR THE INDUSTRIAL SECTOR

SOURCES	PRIMARY	SECONDARY
FINAL CONSUMPTION		
. Subsectors (10)		
.. Steam		
.. Direct Heat		
.. Mechanical Force		
.. Other Uses		
. Total Final Consumption		
.. Steam		
.. Direct Heat		
.. Mechanical Force		
.. Other Uses		
. Useful Consumption		
.. Steam		
.. Direct Heat		
.. Mechanical Force		
.. Other Uses		
. Average Efficiency		
.. Steam		
.. Direct Heat		
.. Mechanical Force		
.. Other Uses		

FIGURE II.2

SCHEME FOR THE EXECUTION OF A PROJECT DESIGN FOR INDUSTRIAL ENERGY BALANCES



CHAPTER II

DATABASE FORMATION

1. Data-Collecting Form

To develop the proposed methodology, which culminates with the preparation of national balances up through useful energy, it will be necessary to undertake a series of data-gathering steps. A survey must be done, and a data sheet permitting construction of balances by plant will be used for that purpose.

Since the unit of information is the industrial plant and in it there can be different sections of data recording, the technique of constructing a form by MODULES has been preferred. Each one of the modules is identified with some physical section of the factory in which specific processes take place, data on which will be compiled. In each country, the contents of the form to be used should be decided on after the particular situation has been reviewed; however, it is possible to determine contents of reference such as those shown in Figure II.3, including 9 different modules. In the first, general data on the firm are indicated, e.g., output, by major products and their monetary value; number of employees, shifts and hours worked per year, etc. The latter information is important as a check on consistency when the hourly flows must be turned into annual values.

Module II records the movements of energy purchases and their prices, sales, and auto-production, and thus permits calculation of the net energy input.

The other modules are aimed at developing a balance for each one of the kinds of intermediate production equipment, such as those described in the flow diagram of Figure II.1. Not only energy flows are noted, but also installed power capacities and efficiencies. With respect to the latter, it should also be pointed out whether these are standard or catalog values, or measured values.

With few exceptions, energy units are not specified in one single form, and it is permissible to use a different unit for each flow. This is for the purpose of having the information go directly from the records to the modules, without any uncontrolled conversions, which are always sources of error. Thus, the use of abitrarily selected conversion factors can also be avoided; the most appropriate thing to do is to convert them by means of a computer program utilizing fixed factors for all of the units employed in industry.

The most complicated situation of flow measurement is with steam, due to the fact that most industries do not have flow meters (or if they do, they do not record the readings) in the required

MODULE I. GENERAL DATA PERIOD:

SUBSECTOR AND ACTIVITY	NAME OF FIRM				LOCATION OF PLANT			
PRODUCTS (Names)								
CAPACITY AND QUANTITY OF PRINCIPAL PRODUCTS	Product	Amount	Product	Amount	Product	Amount	Product	Amount
VALUE (Specify currency)								
VALUE OF TOTAL PRODUCTION	Work on holidays YES ☐ NO ☐		NUMBER OF EMPLOYEES					
SHIFTS WORKED Indicate Schedules					HOURS WORKED DURING YEAR			

MODULE II. ENERGY BOUGHT AND AUTO-PRODUCED

FUEL	UNIT	AMOUNT	$ PAID IN A YEAR
Natural Gas			
Coal			
Firewood			
Vegetable Waste			
Electricity Bought			
Electricity Auto-Produced			
Electricity Sold			
Total Electricity			
Liquefied Gas			
Gasoline			
Kerosene			
Diesel Oil			
Fuel Oil/ Crude Oil			
Coke			
Charcoal			
Recovery			

MODULE III. FUELS USED TO PRODUCE ELECTRICITY IN DIESEL/TURBOGAS SETS

FUEL	UNIT	AMOUNT	Electricity Produced kWh
Natural Gas			
Fuel Oil			
Total Electricity			
EQUIPMENT		Installed Capacity kW	Efficiency
Diesel Engines			
Gas Turbines			

MODULE IV. FUELS USED TO PRODUCE STEAM. STEAM PRODUCED AND STEAM USED TO PRODUCE ELECTRICITY

FUEL	UNIT	AMOUNT
Natural Gas		
Coal		
Vegetable Waste		
Diesel Oil		
Fuel Oil		
Recovery		

	AMOUNT	PRESSURE	TEMPERATURE
High			
Medium			
Low			
Total Value in Kcal			
EQUIPMENT IN BOILERS	TYPE	CAPACITY	Efficiency
STEAM AND ELECTRICITY		Steam Used Kcal	Electricity Produced kWh
EQUIPMENT IN STEAM TURBINES	Installed Capacity	Turbine Efficiency	Cumulative Efficiency

FIGURE II.3

DATA-COLLECTING FORM

MODULE V. DIRECT HEAT

FUEL	UNIT	AMOUNT
Natural Gas		
Coal		
Firewood		
Vegetable Waste		
Electricity		
Kerosene		
Diesel Oil		
Fuel Oil		
EQUIPMENT IN FURNACES - TYPE	Capacity	Efficiency

MODULE VI. MECHANICAL FORCE

FUEL	UNIT	AMOUNT	
Electricity			
Diesel Oil			
Steam			
EQUIPMENT IN MOTORS AND TURBINES	Installed Capacity	Efficiency	Hours of Utilization
Electric Motors			
Diesel Engines			
Steam Turbines			

MODULE VII. OTHER USES

FUEL (Unit)	Lighting Transport	Refrigeration	Pirolysis Feedstock	Others (specify)
Natural Gas ( )				
Electricity ( )				
Liquefied Gas ( )				
Gasoline ( )				
Kerosene ( )				
Diesel Oil ( )				
Coke ( )				
Charcoal ( )				

MODULE VIII. DISTRIBUTION OF THE THREE BASIC FORMS BY PROCESS. INDICATE NAMES OF PROCESSES, PERCENTAGE OF USE AND EFFICIENCIES (if known)

NAME OF PROCESS					
Steam					
Mechanical Force with Electricity					
Mechanical Force with Other Fuels					
Direct Heat with Electricity					
Direct Heat with Other Fuels					

MODULE IX. OBSERVATIONS

(confidential)

places. Module IV permits specification of three different steam qualities, which are: high, medium and low. Obviously, the ranges and temperatures for each quality cannot be specified a priori. Experience has shown that it is best for the informant to do this since temperature and pressure readings are more accurate and readily available than flow measurements; if ranges were used, the real values would be lost and these are of great importance for caloric calculations using steam tables.

In Module VI the principal difficulty lies in the number of hours that electric motors are used per year. The data which should be collected in the form are hours weighted by installed power capacity, since what is of interest is the time which the average installed kilowatt functions in the whole plant, thus taking into account installed capacity that is used as a reserve or that which is out of use or in manitenance.

Module VIII is geared to examining in which processes the intermediate forms are used, and with what efficiencies, for the purpose of providing guidelines for the determination of efficiency of use.

2. Analysis of Existing Information

Before applying a data sheet such as the one described under the preceding point, a SAMPLE DESIGN should be planned and, before the sample design, there must be an INFORMATION ASSESSMENT. It is not possible to establish a unique criterion for how to carry out a country's information assessment, due to the fact that each one's special circumstances make the problem of constructing an energy database for the industrial sector a particular problem. However, the following general considerations can be formulated:

First of all, a diagnostic should be done of the UNIVERSE OF REFERENCE over which the sample will be taken and expanded. This universe is characterized by two main values:

- INDUSTRIAL ENERGY CONSUMPTION AND ITS DISAGGREGATION BY SUBSECTORS

- NUMBER OF INDUSTRIAL FIRMS BY SUBSECTORS

The existing data-collection instruments should be reviewed, e.g., censuses and industrial surveys carried out in recent years. On the basis of these, the countries can be classified according to the following categories:

- Electricity and fuel consumption and the number of industrial establishments are known for a two-digit ISIC division.

- Electricity consumption and the number of industrial establishments are known, for a two-digit ISIC classification, but not fuel consumption.

- Consumption by subsectors is not known, but the number of establishments is.

The third case is the most frequent in the countries of the Latin American region; in most of them periodical industrial surveys of an economic nature are carried out, according to which industrial plants are identified for the national accounts and information on production, value added, number of employees, etc. is gathered. These surveys form the basis for the preparation of input-output matrices sufficiently generalized to suppose that all of the countries of the area will have this instrument available.

It does not go without saying that, if there are countries which do not have this basic information of an economic nature for their industrial sector, they should begin to gather it before doing an energy survey of a specific nature-- with a form like the one discussed in the preceding point-- since it is not possible to design or expand a sample when the characteristics of the universe from which the sample is to be extracted is unknown. For such countries, the recommendation is to start with an industrial census of a general nature and to collect data on electricity and fuel consumption.

It is worthwhile to comment here on a fact which frequently arises, and which should be the subject of a good assessment in order to focus the design of an industrial survey on energy uses successfully. We refer to the situation in which there is knowledge about the sales of energy companies to industrial clients by subsectors (two-digit ISIC). The sales are not strictly consumption, but they are very similar. Besides, the most common case is for this information not to be complete; instead, only some distributing firms have it, or have it for only some products. If this information is partial, it cannot be taken as the universe; however, it may constitute a SUBUNIVERSE OR SUBPOPULATION, the use of which can be of great utility for the design and expansion of energy samples. No general technique can be offered for dealing with with subpopulations, since in most cases they must be treated invidually. An attempt is only made to stress the fact that, many times, they serve as a very suitable tool for indicating a sound approach; the good criteria and experience of the specialist will do the rest.

As for the universe of reference, it is of interest to investigate the relation between energy consumption and number of establishments. The experience of most of the countries is that just a few establishments account for relatively high percentages of industrial consumption; these percentages increase a lot in the beginning when more establishments are added, and much less later on. This is true because heavy equipment (large boilers, furnaces, heavy-duty engines) is concentrated in relatively few MACROCONSUMERS. Thus, if the industrial plants of the universe are ordered according to decreasing consumption, a distribution like the one shown below is obtained:

- 1% of the establishments account for 80% of total consumption

- 10% of the establishments account for 95% of total consumption

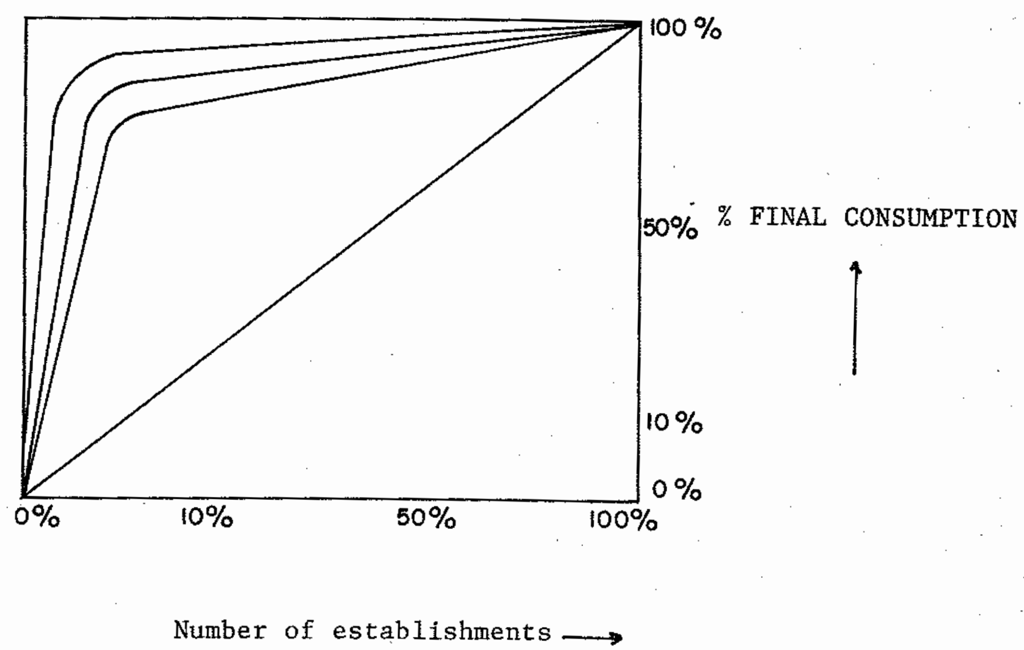
- 1% of the establishments account for 60% of electricity consumption, 70% of diesel consumption, and 90% of fuel oil and coal consumption

These figures, which are only of an indicative nature and may vary from country to country, nevertheless express the order of magnitude of a widely accepted rule which, due to linguistic simplicity, may be termed the LAW OF ASYMMETRIC PROPORTIONS. This means that the distribution function of the two properties which characterize the population is totally asymmetric and can be located in the upper part of the diagonal, as observed in Figure II.4.

This rule of assymetry varies, however, when applied to the different branches of industry; the largest assymetries appear in the most numerous subsectors, e.g., food, textiles or chemicals. In subsectors represented by a few large-capacity units, such as cement or iron, the curves approach the diagonal, reflecting the fact that consumption per establishment has a similar order of magnitude. When the subsectors are joined, the most numerous ones nevertheless impose asymmetry on the group as a whole and this property is tapped to make a sample design providing good representativity, overall and by branches.

FIGURE II.6

Relation between Industrial Consumption Levels and Number of Establishments - Law of Asymmetric Proportions



3. Guidelines for Sample Design

Even though no strict design applicable to all of the countries can be established, since it depends on the collection of previous information, it is possible to establish general criteria on which to base this design. In order to develop the ideas which follow, some very general hypotheses are taken; met in a large number of countries, these are as follows:

Hypothesis 1- The country has an economic survey on the manufacturing industry, which is done periodically and which provides information for the two-digit ISIC, both on the number of existing establishments and on the main economic features (employment, production, value added, etc.).

Hypothesis 2- The aggregate sales of electricity and fuel made by the firms of the sector by subsector and in two digits are known.

Hypothesis 3- The aforementioned law of asymmetric proportionalities between energy consumption and number of industrial establishments.

Under these hypotheses, it is necessary to apply a technique of STRATIFIED SAMPLING WITHOUT FIXED VALUES. The first thing that must be done is to stratify the population; since consumption is not known before sampling is done, the population cannot be stratified on the basis of consumption. However, some economic variable that is assumed to be strongly correlated to consumption, such as the ones already mentioned-- value added, production value, number of employees, fuel and lubricant consumption, etc. Notice that a correlation variable is needed, but this does not imply that it has a deterministic relation to consumption: the relation is statistical. Stratification by correlation works well, and it is convenient to do a posteriori corrections to include those macroconsumers (presumably few) which statistically speaking remain outside the chosen selection criterion.

Once an adequate variable has been chosen, it is necessary to define the cutoff intervals for forming the strata, i.e., what the ranges for grouping the establishments according to this variable will be. It is very difficult to provide a general mechanism for making the cutoffs, and it is best to treat the problem as a case study. For example, if a survey shows that the industrial plants that have more than 200 employees represent 70 or 80% of the value added of the sector, that group is defined as the UPPER STRATUM; the other strata are derived somewhat arbitrarily according to the implicit share of the variable; for example: 200-150 employees, 150-100, 100-50, fewer than 50.

What is important is to isolate the upper stratum, which will be of OBLIGATORY INCLUSION and which will have a sample size equal to 1% of the total population. This stratum is expected to account for 80% of consumption and, since all of the elements are being shown, the variance in the estimators will be equal to zero and the results will have a 100% reliability. It does not matter that this upper stratum concentrates, for example, 100% of the cement plants and only 0.5% of the food plants since the latter will presumably account for 70 or 80% of the consumption of their branch. For the rest of the strata, it is recommended that a new subdivision be done by subsectors. Thus, 30 or 40 new strata, containing approximately 99% of the establishments, will be obtained. Here, there is a division of possible approaches to follow for completion of the sample; this depends on the quantity and precision of the existing information and on the objectives of the study. For example:

- If consumption by products and subproducts can be calculated reasonably well through statistics on sales and distribution by the firms, it is sufficient to sample only the upper stratum and to expand the results by end-uses, equipment and efficiency, against this consumption, for each one of the branches of industry. This is a valid procedure as long as the sample estimators indicate the DOMINANT END-USES BY SOURCES AND BRANCHES. For example, if 100% of the diesel oil that is used in the foods industry in the upper stratum is for generating steam, it can be expected that the same thing will occur in the other strata. After examining all of the cases of DOMINANT END-USES, some doubtful cases may remain, because the lower stratum will have behaved differently from the upper one. This can be dealt with through a very simple qualitative survey, which, if necessary, may be quite numerous. For instance: Is diesel oil used more in boilers or in furnaces? Depending on the findings, a quantitative sample may be taken.

- If there is no knowledge about consumption by subsectors, i.e., the preceding hypothesis would not be met, but consumption is known for all of the sources for the entire industrial sector, and the subsectoral consumption can be precisely ascertained through this survey, it is necessary to take samples on each one of the 30 or 40 strata into which the population is divided. The universe of reference will no longer be consumption, but rather the number of establishments in each group and work will then be done with 30 or 40 subpopulations, for which average consumption will be estimated by energy source. Within each stratum, either a simple or systematic random sample may be taken of, for example, 1% of the individuals in the subpopulation. If the variance of the estimators is unacceptably large, there are two approaches: to increase the size of the sample, keeping the same stratification, or to make the latter more refined, giving a smaller range to the stratification variable utilized.

  Later, the estimators are calculated by branches, according to the guidelines for stratified sampling and, finally, these estimators are included within the stratum of obligatory inclusion. The final variance by branches will decide if the estimate is reliable.

- As long as this possibility exists, it is preferable to infer consumption by subsectors by means of a more numerous survey than the survey of end-uses which is the subject of this study. This is achieved by adding Module II of bought energy to the survey or economic census of the industrial sector, which is theoretically supposed to exist in the country. This module is very simple and does not require the visit of specializaed surveyors. Hence, the same organization which is carrying out the economic survey can gather and process the data. This will provide information on population and subpopulations before applying the survey of end-uses, the execution of which would be much more complicated and costly.

- If it is desired also to have an estimate of consumption and uses at the regional level (within a country), the chosen regionalization should also form part of the stratification, thus increasing the number of groups and, therefore, the cost of sampling and processing.

- The methodology explained thus far can be applied conveniently to a centralized industry. In general, the so-called rural industry (bakeries, brickmakers, boilers, block brown-sugar factories, fermented beverage plants, etc.) do not form part of the systems of economic surveys nor of national accounts. This type of industries, which many times consume large amounts of low-efficiency, non-commercial energy, constitutes a special subpopulation, about which nothing is usually known. The survey to be done therein can usually be dealt with by applying only Module V (direct heat), since it comprises furnaces which operate with discontinuous loads (batches). The production value is estimated on the basis of the number of loads produced in a year. In the case of these industries, the sample designs should be based on the features of more remote settlements, such as production of bricks, bread or lime in artesan-level units, and one should proceed with pilot surveys and investigations in order to gauge the order of magnitude prior to sampling per se.

As has been seen, the execution of a stratified sample depends on the possibility of ordering the industrial establishments of the population according to a criterion which is expressed by some variable correlated to consumption. In this stage of sample design, utmost care must be taken and we can affirm that, if a good stratification is attained, the resulting sample sizes will fluctuate between 1% and 2% of the individuals of the universe, with levels of reliability between 90 and 95% for the main variables.

In any case, a good sample design is necessary, but not sufficient, for success. It is also necessary to assure that the collected data are correct, and this is done through visits by specialized surveyors to the industrial plants. These surveyors should preferably be chemical, mechanical or process engineers and, only through dialogue with their colleagues in the industry, will they be able to transform a not always well-organized mass of data into the systematic information requirements of the data sheet.

4. <u>Guidelines for Data Processing and Sample Expansion</u>

In order to guarantee the consistency of the data gathered with a form like the one in Figure II.3, an energy balance must be done for each plant, using a form like the one in Table II.3, and preferably using a computer program.

The facilities and drawbacks presented by computerized processing were described in Chapter IV of the Base Document; it only remains to be mentioned that an exhaustive investigation should be carried out on the possibilities of the computers, languages and packages available, as well as of the administrative and reading formats.

Take manual consistency processing for all of the physical flows at the level of final consumption, or take the input flows into the transformation equipment. As for the output flows, which correspond to what has been defined as intermediate useful consumption, these should be checked together with the efficiencies of production. Furthermore, it is very probable that in most cases the output flows of direct heat, mechanical force and steam will not be calculated on the basis of adopted efficiencies, since there are no registers at the exit of the transformation equipment. A careful analysis of the efficiencies declared by the industrialists should therefore be done, and all of those values which fall outside the range should be rejected. It is sometimes better to adopt average efficiencies for groups of industries having transformation equipment using similar technologies and to apply these to the individual plants. By applying these efficiencies to final consumption by use, the intermediate useful consumption is obtained. Then, the efficiencies of use of the intermediate forms are analyzed to obtain useful consumption and losses.

The energy balance by plant indicates whether the survey under analysis is correct or not. There are two types of sources of error: ERRORS IN DATA COLLECTION AND ERRORS IN DATA HANDLING. The former are solved by resampling and the latter are detected by means of a consistency program. Once all of the errors have been detected and taken care of, there are consistent surveys, in which the following can be verified:

- The net energy input for each source is equal to the sum of: direct or indirect auto-production, non-industrial final consumption, and industrial final consumption.

- Industrial final consumption for each source is approximately equal to the sum of final consumption by end-uses.

- The measured or adopted efficiencies of production have acceptable values, in keeping with the technology of the transformation equipment.

- The efficiencies of end-use adopted are in line with the results yielded by the energy audits, in the event that these have been done. Otherwise, standard patterns can be adopted or 100% can simply be taken until there is better knowledge about the problem.

The second stage consists of expansion of the sample by means of the application of inferential statistical techniques to determine the population estimators of the energy balances. Here again there is an option for approaches, depending on the characteristics of the country under study. Rather than doing a case study under hypothetical conditions, only general processing guidelines can be given.

It is useful to work with the AVERAGE PARTICIPATION COEFFICIENTS for each source in each end-use for each subsector.

These coefficients, through hypothetical examples, express that:

- 100% of the natural gas in the cement industry is used for heat

- in the foods industry, 70% of the fuel oil goes into steam, 20% into heat, and 10% into mechanical force

- in machinery and equipment, 65% of the electricity goes into mechanical force, 20% into heat, and 15% into lighting, etc.

From the statistical point of view, the foregoing values represent SAMPLE MATHEMATICAL EXPECTATIONS and will be taken as POPULATION EXPECTATION ESTIMATORS, whenever the ESTIMATED VARIANCE of these estimators is low. In other words, to produce the value added of the group, the members distribute the sources among the end-uses in a similar way, at least in a given region where there is sufficient supply of this energy. When the energy endowment among the end-uses in a group is not very uniform, it is because the group is not homogeneous. In general, heterogeneity disappears the more refined the classification. Further refinement should be sought by incorporating a third or fourth digit of the ISIC classification.

In general, these participation coefficiencts for sources in end-uses will be independent of the size of the plant and they will actually reflect the characteristics of the transformation processes in groups of plants that work with given energy needs for given manufacturing technologies. They will not depend on substitution among energy sources, and they may be applied to an historical time series of consumption by energy sources.

Example: if 70% of the natural gas and fuel oil is earmarked for steam, this percentage continues to be valid even though the gas has increased to 4% annually and fuel oil has declined to 10% over the last ten years. The coefficient expresses end-use under given conditions of supply: if fuel oil is consumed, 70% is used in steam; if gas is consumed, 70% also goes to steam, but it does not matter how much of either fuel is consumed.

It is thus important to be able to characterize all of the sample by means of a MATRIX OF PARTICIPATION COEFFICIENTS of minimal variance and to do a diagnostic of sample data. Until one is sure that these coefficients are capturing the homogeneity, if necessary, they can be tested or rejected by applying more or less complicated statistical tests, according to the situations.

Since these coefficients are stable over time, at least while there are no substantial changes in the industrial production processes, they provide both a basis for sample expansion through historical time series, and a tool for forecasting future demand. In this methodology, it is of interest to underscore their capacity for end-use in sample expansion.

If the country has an historical series of consumption by sources and subsectors, it will then be sufficient to multiply these series by the respective coefficients in order to draw up series of final consumption by end-uses and useful consumption by sources and by end-uses. The problem of expanding end-use on the basis of known consumption is thus resolved.

If the country does not have a series, one should be constructed on the basis of the survey discussed herein and then the same procedure of multiplication by the participation coefficients is followed. Now we are facing a more complicated problem, which could be stated as follows: simultaneous expansion of uses and consumption by subsectors, assuming that total consumption by sources is known.

The sample provides final consumption by sources and subsectors. To go from there to final consumption for the population, several expansion methodologies may be applied, depending on the particular circumstances of the country under analysis. The simplest case is to suppose that the sample distribution is applied to the entire population, and then the total consumption by sources is multiplied by the sample shares for the sources in the subsectors. This simple method yields good approximations when the sample has covered 90% or more of consumption, but it has the drawback that it cannot be used to reconstruct an historical series, since one could hardly sustain that if the same sample had been taken five years before, the percentages by subsectors would have been the same. Unlike what happens with the participation of end-uses within a subsector, these are not stable over time, since the historical evolution of the branches of industry is not usually homogeneous. Application of another resource consisting of the search for some relation between the expanded consumption for the year in which the survey was done and some economic indicator of industrial production by subsectors is commonly used, for which there are historical data and the historical series of consumption is thus reconstructed. The drawback is that the consumption series and the indicators need to be correlated in order to determine the parameters which will be used in the demand projection models.

The most general procedure, and the most complicated, consists of following the guidelines of stratified sampling. Given its particularity for trying to explain a large variety of situations which can arise, it is indicated by means of a very simplified example. Let us suppose that in a country there are 10,000 industrial establishments whose fuel oil consumption is 1,000,000 barrels; that 200 units have been sampled, of which 100 belong to the stratum of obligatory inclusion, and the other 100 to a second stratum. The first stratum yields a sample consumption (equal to the population) of 800,000 barrels, which are redistributed equally by subsectors. There are then 200,000 barrels left for distribution. The sample consumption of the second stratum shows given consumption per capita by subsector, which when multiplied by the respective number of establishments, and added yield a consumption of 350,000 barrels instead

of 200,000. The error is due to the large variance and this is in turn due to insufficient stratification. It is to be expected that a more refined stratification would lead to some per capita consumption which would yield a distribution by subsectors, the sum of which would be close to more than 200,000 barrels, but there would always be a difference to be corrected. What is important is to set a limit of acceptability between the distributed sum and the real value and then to accept the latter as the sum, maintaining the shares suggested by the sample. Relatively large errors can be accepted, since they will only affect 20% of consumption, whereas the remaining 80% is exact.

For reconstruction of historical time series by subsectors, assuming the industrial consumption by sources of energy to be known, it is recommended that the following resource be used: when taking the complete sample for a given year, questions can also be asked about historical information, only for Modules II and III and the part of electric power auto-production with steam in Module IV. Hence, an historical estimate can be made of net energy input and its components for the groups of firms which provide this information. With this, annual participation is obtained by sources and by subsectors, and these are applied to industrial consumption by sources.

CHAPTER III

APPLICATIONS

1. General Considerations

This chapter applies the methodology presented previously to some specific countries. As examples, the cases of Colombia and Brazil are presented, since they are two countries of widely available information on the topic. The case of Colombia is obviously very closely tied to this methodology, since its most immediate antecedent is the study on industrial surveys carried out within the Energy Information System (EIS) of the National Energy Study (NES).

The data for analyzing the case of Brazil were taken from the publication "Preliminary Report on the Useful-Energy Balance" (August 1984).

Some differences were found with respect to the proposed methodology in terms of disaggregation by subsectors and some values assigned to efficiencies. For example, it can be seen that the case of Brazil does not register consumption in the subsector "Wood and Furniture". Furthermore, the subsector "Machinery and Equipment" does not appear clearly in the balance included in the aforementioned publication and the sector "Others", unlike in Colombia, where it appears with very significant levels of consumption. In order to offer elements for clearer criticism, the adopted disaggregation is detailed in the following table:

Cement	Cemento
Iron	Ferroguca e Ago, Ferroligas, Mineracao e Pelotizacao
Machinery	
Chemicals	Quimicos
Foods,...	Alimentos,...
Textiles,...	Textil,...
Paper,...	Ceramica
Others	Outros

In relation to energy products, the following equivalencies have been taken:

Natural Gas	Gas Natural
Coal	Carvao Vapor
Firewood	Lenha
Diesel Oil	Oleo diesel
Fuel Oil	Oleo combustivel
Liquefied Gas	Gas licuado
Gasoline	Naftas (considered negligible)
Kerosene	Kerosene
Industrial Gases	Gas
Coke	Coque de carvao mineral
Electricity	Electricidade
Charcoal	Carvao vegetal
Vegetable Waste	Bagaco de canha
Recovery	Outras fontes primarias e secundarias

It is possible that there have been errors of interpretation in the assignation of subsectors and products, which could be corrected after the review of the preliminary document with a view to a final version.

The treatment given to the two cases examined is exactly the same and consists of:

- generation of a file containing final consumption by subsectors and by sources

- generation of as many files as subsectors containing the coefficients of participation by sources and uses and the levels of adopted efficiencies.

Through a computer program, the information from the two files is read and combined, and the form for the useful-energy balances for the industrial sector are prepared.

The base data come in both cases from a broad survey plan carried out in the respective countries.

TABLE II-6

INDUSTRIAL SECTOR

FINAL FUEL CONSUMPTION - COLOMBIA

YEAR: 1983 UNIT: Tcal

	FOOD BEVERAGE	TEXTILE APPAREL	SHOES LEATHER	WOOD FURNIT.	PAPER PULP	CHEMICALS	CEMENT	STONE GLASS	IRON	MACHIN-ERY	OTHERS	TOTAL
NATURAL GAS	262.08	15.49	15.65	118.31	189.98	2984.30	2740.61	72.07	235.97	38.49	10.32	6683.00
OIL	367.04	163.10	46.47	.00	32.56	215.49	4.74	1025.49	389.09	6.22	43.22	2293.00
COAL	1092.65	1125.15	13.65	2.60	1602.25	650.00	5391.10	2483.00	234.00	.00	.00	12594.00
FIREWOOD	19.44	.00	.36	.36	.00	.00	.00	75.24	1.08	.36	1.00	96.00
VEG. RESIDUES	5689.50	.00	.00	.00	359.63	.00	.00	.00	.00	.00	.00	6049.00
ELECTRICITY	916.76	558.66	52.72	45.75	428.71	1586.10	548.85	128.74	531.57	319.32	23.82	5140.00
LIQUEFIED GAS	28.50	7.60	.28	.00	5.60	7.69	.00	30.78	15.58	3.23	.00	99.00
KEROSENE	23.27	22.48	.66	.66	.53	66.37	6.92	302.97	36.18	15.43	9.97	485.00
DIESEL OIL	186.02	92.18	4.55	13.66	13.39	124.61	88.73	127.37	174.71	85.28	114.95	1025.00
FUEL OIL	828.36	324.86	32.12	4.74	338.92	310.95	423.72	322.20	149.63	22.64	65.27	2923.00
COKE	.00	.00	.00	.00	.00	89.28	.00	.00	358.56	1.92	.00	449.00
CHARCOAL	.00	.00	.00	.00	.00	17.55	.00	.00	.00	.00	.00	17.00
INDUSTRIAL GAS	.00	.00	.00	.00	.00	.00	.00	.00	380.40	.00	.00	380.00
RECOVERY	.60	4.80	.00	.00	536.30	66.60	.00	.00	.00	.00	.00	608.00
TOTAL	9414.23	2314.31	166.47	186.09	3507.88	6118.94	9204.67	4567.87	2506.76	492.89	267.55	38747.00

TABLE II-7

INDUSTRIAL SECTOR

PARTICIPATION AND EFFICIENCY OF FUELS FOR END-USES - COLOMBIA

YEAR: 1982

	STEAM PARTICIP.	FINAL EFFICIENCY	DIRECT HEAT PARTICIP.	DIRECT HEAT EFFICIENCY	MECHANICAL FORCE PARTICIP.	MECHANICAL FORCE EFFICIENCY	OTHERS PARTICIP.	OTHERS EFFICIENCY
NATURAL GAS	100.00	74.90	.00	.00	.00	.00	.00	.00
OIL	100.00	74.90	.00	.00	.00	.00	.00	.00
COAL	94.91	74.90	.00	.00	5.09	51.10	.00	.00
FIREWOOD	83.79	74.90	.00	.00	14.55	51.10	1.66	100.00
VEG. RESIDUES	77.42	67.80	.00	.00	22.58	51.10	.00	.00
ELECTRICITY	.00	.00	.93	85.00	86.24	80.50	12.83	100.00
LIQUEFIED GAS	1.73	74.90	84.75	72.40	.00	.00	13.52	100.00
KEROSENE	.00	.00	100.00	72.40	.00	.00	.00	.00
DIESEL OIL	32.22	74.90	58.58	72.40	9.20	30.00	.00	.00
FUEL OIL	88.73	74.90	3.50	72.40	6.51	51.10	1.26	100.00
COKE	.00	.00	.00	.00	.00	.00	.00	.00
CHARCOAL	.00	.00	.00	.00	.00	.00	.00	.00
COKE GAS	.00	.00	.00	.00	.00	.00	.00	.00
RECOVERY	100.00	74.90	.00	.00	.00	.00	.00	.00
TOTAL	75.32	.00	1.88	.00	21.83	.00	.97	.00

TABLE II.8

INDUSTRIAL SECTOR

INDUSTRIAL ENERGY CONSUMPTION - COLOMBIA

: 1983

UNIT: Tcal

Industrial Subsector Use	Natural Gas	Oil	Coal	Fire-wood	Plant Waste	Recovery	Total P.E.	Elec-tricity	Liquefied Gas	Kerosene	Diesel Oil	Fuel Oil	Coke	Charcoal	Indus. Gases	Total S.E.	TOTAL
Food, Beverages and Tobacco	262	367	1093	19	5690	1	7431	917	29	23	186	828	0	0	0	1983	9414
Steam	262	367	1037	16	4485	1	6088	0	0	0	60	735	0	0	0	795	6883
Direct Heat	0	0	0	0	0	0	0	9	24	23	109	29	0	0	0	194	194
Mechanical Force	0	0	56	3	1285	0	1343	791	0	0	17	54	0	0	0	862	2205
Others	0	0	0	0	0	0	0	118	4	0	0	10	0	0	0	132	132
Textiles and Apparel	15	163	1125	0	0	5	1309	559	8	22	92	325	0	0	0	1006	2314
Steam	15	146	1093	0	0	0	1254	0	0	1	28	314	0	0	0	343	1597
Direct Heat	0	17	0	0	0	5	22	39	7	21	64	9	0	0	0	140	162
Mechanical Force	0	0	32	0	0	0	32	452	0	0	1	2	0	0	0	455	487
Others	0	0	0	0	0	0	0	67	1	0	0	0	0	0	0	68	68
Leather and Footwear	16	46	14	0	0	0	76	53	0	1	5	32	0	0	0	90	166
Steam	16	46	14	0	0	0	76	0	0	0	0	32	0	0	0	32	108
Direct Heat	0	0	0	0	0	0	0	8	0	1	5	0	0	0	0	13	13
Mechanical Force	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	40	40
Uso	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	5
Wood and Furniture	118	0	3	0	0	0	121	46	0	1	14	5	0	0	0	65	186
Steam	80	0	3	0	0	0	83	0	0	1	14	5	0	0	0	19	102
Direct Heat	38	0	0	0	0	0	38	1	0	0	0	0	0	0	0	1	39
Mechanical Force	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	43	43
Others	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	2
Paper and Pulp	190	33	1682	0	360	536	2721	429	6	1	13	339	0	0	0	787	3508
Steam	142	33	1584	0	56	536	2349	0	0	1	7	188	0	0	0	195	2544
Direct Heat	0	0	0	0	0	0	0	2	6	0	6	151	0	0	0	165	165
Mechanical Force	48	0	19	0	0	1	67	395	0	0	0	0	0	0	0	395	462
Others	0	0	0	0	304	0	304	32	0	0	0	0	0	0	0	33	337
Chemicals	2984	215	650	0	0	67	3916	1586	8	66	125	311	89	18	0	2203	6119
Steam	1359	213	508	0	0	49	2130	0	0	0	68	255	0	0	0	323	2453
Direct Heat	816	2	73	0	0	0	891	149	3	48	56	56	32	0	0	344	1234
Mechanical Force	38	0	59	0	0	1	108	1174	0	0	0	0	0	0	0	1175	1282
Others	772	0	0	0	0	16	788	263	5	19	0	0	57	18	0	361	1150
Cement	2741	5	5391	0	0	0	8136	549	0	7	89	424	0	0	0	1068	9205
Steam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Heat	2741	5	5391	0	0	0	8136	0	0	0	20	424	0	0	0	444	8580
Mechanical Force	0	0	0	0	0	0	0	532	0	0	69	0	0	0	0	601	601
Others	0	0	0	0	0	0	0	17	0	7	0	0	0	0	0	24	24
Stone, Glass and Ceramics	72	1025	2483	75	0	0	3655	129	31	303	127	322	0	0	0	912	4568
Steam	0	0	41	0	0	0	41	0	0	2	5	21	0	0	0	27	68
Direct Heat	72	1025	2442	75	0	0	3615	11	30	298	119	302	0	0	0	759	4374
Mechanical Force	0	0	0	0	0	0	0	107	0	0	3	0	0	0	0	110	110
Others	0	0	0	0	0	0	0	11	1	3	0	0	0	0	0	16	16
Iron, Steel and Non-Ferrous	236	389	234	1	0	0	860	532	16	36	175	152	359	0	380	1647	2507
Steam	0	53	194	0	0	0	246	0	0	1	17	6	0	0	215	238	485
Direct Heat	236	320	0	0	0	0	556	142	7	35	154	144	359	0	153	994	1550
Mechanical Force	0	17	40	0	0	0	57	366	0	0	4	0	0	0	13	382	439
Others	0	0	0	1	0	0	1	24	9	0	0	0	0	0	0	32	33
Machinery and Equipment	38	6	0	0	0	0	45	319	3	15	85	23	2	0	0	448	493
Steam	1	6	0	0	0	0	7	0	0	13	10	16	0	0	0	38	45
Direct Heat	38	0	0	0	0	0	38	86	0	3	70	7	2	0	0	168	206
Mechanical Force	0	0	0	0	0	0	168	0	0	5	0	0	0	0	0	173	173
Others	0	0	0	0	0	0	65	3	0	0	0	0	0	0	0	69	69
Others	10	43	0	0	0	0	54	24	0	10	115	65	0	0	0	214	258
Steam	0	43	0	0	0	0	43	0	0	0	115	65	0	0	0	180	223
Direct Heat	10	0	0	0	0	0	10	3	0	0	0	0	0	0	0	3	14
Mechanical Force	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	18	18
Others	0	0	0	0	0	0	0	2	0	10	0	0	0	0	0	12	12
Final Industrial Consumption	5683	2293	12594	97	6050	608	28325	5141	99	485	1025	2823	450	18	380	10422	38748
Steam	1875	907	4473	17	4460	586	12318	0	1	17	322	1635	0	0	215	2191	14509
Direct Heat	3950	1369	7906	76	0	5	13306	450	76	429	603	1122	392	0	153	3225	16531
Mechanical Force	86	17	215	3	1285	1	1607	4086	0	0	99	56	0	0	13	4254	5860
Others	772	0	0	2	304	17	1095	605	22	39	1	10	58	18	0	753	1847
Consumo Util	4818	1268	8441	31	3985	459	19001	4263	66	262	569	1912	101	18	211	7481	26482
Steam	1404	680	3350	12	3024	439	8909	0	1	13	242	1225	0	0	161	1641	10559
Direct Heat	2598	580	4981	15	0	3	8176	368	43	210	297	648	123	0	44	1734	9910
Mechanical Force	44	8	110	1	656	1	821	3289	0	0	30	30	0	0	6	3354	4175
Others	772	0	0	2	304	17	1095	605	22	39	1	10	58	18	0	753	1847
Average Efficiency	.7209	.5528	.6702	.3184	.6387	.7548	.6708	.3291	.6655	.5393	.5552	.6772	.4014	1.0000	.5552	.7178	.6835
Steam	.7490	.7490	.7490	.7490	.6780	.7490	.7233	.0000	.7490	.7490	.7490	.7490	.0000	.0000	.7490	.7490	.7272
Direct Heat	.6576	.4233	.6300	.2004	.0000	.6791	.6145	.8184	.5679	.4891	.4931	.5778	.3136	.0000	.2850	.5375	.5995
Mechanical Force	.5110	.5110	.5110	.5110	.5110	.5103	.5110	.8050	.0000	.0000	.3000	.5110	.0000	.0000	.5109	.7885	.7124
Others	1.0000	1.0000	.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

TABLE II-9

INDUSTRIAL SECTOR

FINAL FUEL CONSUMPTION - BRAZIL

YEAR: 1983 UNIT: Tcal

	FOOD BEVERAGE	TEXTILE APPAREL	SHOES LEATHER	WOOD FURNIT.	PAPER PULP	CHEMICALS	CEMENT	STONE GLASS	IRON	MACHINERY	OTHERS	TOTAL
NATURAL GAS	.01	.00	.00	.00	100.00	4770.00	230.00	30.00	1090.00	.00	.00	6220.00
OIL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
COAL	1560.00	99.97	.00	.00	1089.00	1380.00	9289.99	119.99	550.03	.00	.00	14289.00
FIREWOOD	15210.00	1590.00	.00	.00	5180.00	770.00	.00	11419.99	.00	50.00	50.00	38920.00
VEG. RESIDUES	40010.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	40010.01
ELECTRICITY	6030.00	3240.00	.00	.00	4430.00	7990.00	1950.00	2500.02	12770.00	10170.00	11190.00	60270.02
LIQUEFIED GAS	180.00	40.00	.00	.00	40.00	799.99	.00	330.00	430.00	.00	680.00	2500.00
KEROSENE	230.00	250.00	.00	.00	40.01	70.00	.00	70.00	250.00	.00	540.01	1450.01
DIESEL OIL	1210.00	80.00	.00	.00	150.01	2130.00	340.00	69.99	2279.99	.00	1350.00	7610.00
FUEL OIL	8860.01	4570.00	.00	.00	5710.00	16220.00	5390.00	4010.00	14420.00	1760.00	7720.01	68660.01
COKE	.00	.00	.00	.00	.00	.00	.00	.00	32390.02	30.00	660.00	33060.02
CHARCOAL	.00	.00	.00	.00	.00	.00	3999.97	.00	31039.97	1000.02	.00	36039.96
INDUSTRIAL GAS	160.00	20.00	.00	.00	10.00	.00	.00	.70	6030.00	200.00	350.00	6840.00
RECOVERY	.00	.00	.00	.00	.00	220.00	470.00	.00	500.00	2320.00	80.00	3590.00
TOTAL	73450.00	9889.99	.00	.00	16750.00	34350.02	21669.97	18620.00	101750.01	15530.00	27470.00	319480.00

TABLE II-10

INDUSTRIAL SECTOR

PARTICIPATION AND EFFICIENCY OF FUELS FOR END-USES - BRASIL

YEAR: 1983

	STEAM PARTICIP.	FINAL EFFICIENCY	DIRECT HEAT PARTICIP.	DIRECT HEAT EFFICIENCY	MECHANICAL FORCE PARTICIP.	MECHANICAL FORCE EFFICIENCY	OTHERS PARTICIP.	OTHERS EFFICIENCY
NATURAL GAS	.00	.00	.00	.00	.00	.00	.00	.00
OIL	.00	.00	.00	.00	.00	.00	.00	.00
COAL	86.30	60.00	13.70	10.00	.00	.00	.00	.00
FIREWOOD	86.10	60.00	13.90	10.00	.00	.00	.00	.00
VEG. RESIDUES	100.00	60.00	.00	.00	.00	.00	.00	.00
ELECTRICITY	77.70	95.00	15.50	37.00	6.20	90.00	.00	30.40
LIQUEFIED GAS	.40	65.00	70.80	27.00	28.80	25.00	.00	.00
KEROSENE	1.80	80.00	198.20	27.00	.00	.00	.00	.00
DIESEL OIL	12.70	80.00	26.40	27.00	60.90	35.00	.00	.00
FUEL OIL	86.90	80.00	13.10	27.00	.00	.00	.00	.00
COKE	.00	.00	.00	.00	.00	.00	.00	.00
CHARCOAL	.00	.00	.00	.00	.00	.00	.00	.00
COKE GAS	.30	80.00	99.70	27.00	.00	.00	.00	.00
RECOVERY	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL	.00	.00	.00	.00	.00	.00	.00	.00

TABLE II.11

INDUSTRIAL SECTOR

INDUSTRIAL ENERGY CONSUMPTION - BRAZIL

1983

UNIT: Tcal

ndustrial Subsector se	Natural Gas	Oil	Coal	Fire-wood	Plant Waste	Recovery	Total P.E.	Elec-tricity	Liquefied Gas	Kerosene	Diesel Oil	Fuel Oil	Coke	Charcoal	Indus. Gases	Total S.E.	TOTAL
ood, Beverages and Tobacco	0	0	1500	15210	40010	0	56700	6030	100	230	1210	8860	0	0	160	16670	73450
team	0	0	1346	13055	40010	0	54452	4085	1	4	154	7699	0	0	0	12544	66996
irect Heat	0	0	214	2114	0	0	2328	935	127	226	319	1161	0	0	160	2928	5855
echanical Force	0	0	0	0	0	0	0	374	52	0	737	0	0	0	0	1163	1163
thers	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	36	36
extiles and Apparel	0	0	100	1590	0	0	1690	3240	40	250	80	4570	0	0	20	6200	9890
team	0	0	64	1590	0	0	1654	130	7	88	35	4533	0	0	0	4794	6448
irect Heat	0	0	35	0	0	0	35	32	26	162	32	37	0	0	20	310	345
echanical Force	0	0	0	0	0	0	0	2884	6	0	13	0	0	0	0	2903	2903
thers	0	0	0	0	0	0	0	194	0	0	0	0	0	0	0	194	194
aper and Pulp	100	0	1090	5180	0	0	6370	4430	40	40	150	5710	0	0	10	10380	16750
team	100	0	1090	5170	0	0	6360	377	0	40	10	4984	0	0	0	5412	11772
irect Heat	0	0	0	10	0	0	10	84	14	0	59	725	0	0	10	832	923
echanical Force	0	0	0	0	0	0	0	3836	25	0	81	0	0	0	0	3942	3942
thers	0	0	0	0	0	0	0	133	0	0	0	0	0	0	0	133	133
hemicals	4770	0	1372	770	0	220	7132	7990	800	70	2130	16220	0	0	0	27210	34342
team	0	0	627	479	0	220	1322	376	262	5	731	14290	0	0	0	15664	16986
irect Heat	4770	0	745	294	0	0	5809	336	526	65	935	1930	0	0	0	3792	9601
echanical Force	0	0	0	0	0	0	0	6336	11	0	464	0	0	0	0	6812	6812
thers	0	0	0	0	0	0	0	943	0	0	0	0	0	0	0	943	943
ement	230	0	9290	0	0	470	9990	1950	0	0	340	5390	0	4000	0	11678	21670
team	0	0	0	0	0	0	0	2	0	0	1	162	0	0	0	165	165
irect Heat	230	0	9290	0	0	470	9990	113	0	0	2	5228	0	4000	0	9344	19334
echanical Force	0	0	0	0	0	0	0	1776	0	0	337	0	0	0	0	2113	2113
thers	0	0	0	0	0	0	0	59	0	0	0	0	0	0	0	59	59
Stone, Glass and Ceramics	30	0	120	11420	0	0	11570	2500	330	70	70	4010	0	0	70	7050	186
Steam	0	0	0	0	0	0	0	5	0	1	3	100	0	0	0	110	110
Direct Heat	30	0	120	11420	0	0	11570	855	327	69	38	3904	0	0	70	5268	16938
Mechanical Force	0	0	0	0	0	0	0	1625	3	0	29	0	0	0	0	1658	1658
Others	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	15	15

Iron, Steel and Non-Ferrous	1090	0	550	0	0	500	2140	12770	438	250	2280	14420	32390	31040	6030	99610	101750
Steam	0	0	17	0	0	0	17	26	1	0	14	591	0	0	0	631	648
Direct Heat	1090	0	514	0	0	500	2104	10842	403	249	301	13829	32390	31040	6030	95083	97188
Mechanical Force	0	0	19	0	0	0	19	1826	26	1	1965	0	0	0	0	3819	3837
Others	0	0	0	0	0	0	0	77	0	0	0	0	0	0	0	77	77
Machinery and Equipment	0	0	0	50	0	2320	2320	10170	0	0	0	1760	30	1000	200	13160	15530
Steam	0	0	0	34	0	0	34	92	0	0	0	545	0	0	13	650	684
Direct Heat	0	0	0	16	0	2320	2336	3549	0	0	0	1214	30	1000	187	5981	8317
Mechanical Force	0	0	0	0	0	0	0	3234	0	0	0	0	0	0	0	3234	3234
Others	0	0	0	0	0	0	0	3295	0	0	0	0	0	0	0	3295	3295
Others	0	0	200	4700	0	80	4980	11190	680	540	1350	7720	660	0	350	22490	27470
Steam	0	0	200	1847	0	0	2047	201	7	8	108	3111	0	0	0	3437	5484
Direct Heat	0	0	0	2853	0	80	2932	1779	555	532	801	4609	660	0	350	9885	12218
Mechanical Force	0	0	0	0	0	0	0	8538	118	0	441	0	0	0	0	9097	9097
Others	0	0	0	0	0	0	0	671	0	0	0	0	0	0	0	671	671
Final Industrial Consumption	6220	0	14282	38920	40010	3590	103022	60270	2500	1450	7610	68660	33080	36040	6840	216450	319472
Steam	100	0	3344	22212	40010	220	65887	5892	279	147	1055	36017	0	0	14	43405	109291
Direct Heat	6120	0	10919	16708	0	3370	37117	18525	1979	1302	2487	32643	33080	36040	6826	132983	169999
Mechanical Force	0	0	19	0	0	0	19	30430	241	1	4068	0	0	0	0	34740	34758
Others	0	0	0	0	0	0	0	5423	0	0	0	0	0	0	0	5423	5423
Useful Consumption	3535	0	6284	17903	24006	1587	53315	43929	1040	534	3331	40476	27526	25853	2933	145622	19837
Steam	89	0	2266	14103	24006	132	40595	5607	182	120	884	29777	0	0	9	36578	77173
Direct Heat	3447	0	4016	3801	0	1455	12719	8947	708	414	1023	10899	27526	25853	2924	78187	90905
Mechanical Force	0	0	2	0	0	0	2	27387	60	0	1424	0	0	0	0	28871	28872
Others	0	0	0	0	0	0	0	1986	0	0	0	0	0	0	0	1986	1986.
Average Efficiency	.5583	.0	.4400	.4600	.6000	.4420	.5175	.7289	.4159	.3683	.4377	.5895	.8321	.7173	.4288	.6728	.6227
Steam	.8920	.0	.6775	.6349	.8000	.6000	.6161	.9515	.6505	.8152	.8380	.8267	.0000	.0000	.6504	.8427	.7061
Direct Heat	.5632	.0	.3678	.2275	.0000	.4317	.3427	.4831	.4032	.3180	.4113	.3278	.8321	.7173	.4283	.5884	.5347
Mechanical Force	.0000	.0	.1050	.0000	.0000	.0000	.1050	.9000	.2479	.3500	.3500	.0000	.0000	.0000	.0000	.3811	.8307
Others	.0000	.0	.0000	.0000	.0000	.0000	.0000	.3663	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.3663	.3663

SECTORAL APPENDIX III

RESIDENTIAL SECTOR

INDEX

RESIDENTIAL SECTOR

CHAPTER I

DEFINITIONS AND BASIC CONCEPTS

1. Disaggregation by Subsectors

From the standpoint of energy planning, the need to disaggregate the residential sector into Rural and Urban subsectors is justified on the basis of consumption profiles differentiated according to energy sources and on the basis of the reality of the large migratory movements in a rural-to-urban direction currently existing in the region.

The urban residential sector uses more energy sources whose production, distribution and pricing are controlled by large enterprises and by the State, whereas rural residential consumption is more intensive in the use of uncontrolled forms of energy such as firewood, charcoal, agricultural wastes, etc.

For their part, the migratory movements from rural areas to urban areas have a heavy impact on the demand for controlled energy (such as electricity and liquified petroleum gas) and thus constitute an important planning parameter.

Eventually, it will be possible to opt for greater disaggregation: into urban, small urban, and rural subsectors, which might be more in line with the features of population distribution in a given country.

At any rate, it is important for the definition of subsectors to be the one adopted in each country for carrying out censuses or household surveys, since this considerably facilitates making data compatible and probably reduces the need for field investigations.

It is worthwhile to note that the subsectors proposed herein are not made up of homogeneous groups of consumers and, furthermore, there are large disparities in consumption within these, as a function of levels of income.

2. Disaggregation by End-Uses

Within the subsectors under consideration, energy is consumed to meet the different needs of equipment using quite diversified sources. The present document will consider disaggregation by the following energy end-uses and equipment associated with these end-uses:

- Heating

  Energy consumed for space heating in homes, hot-water radiators, electric radiant heaters coupled with fans or not, gas

heaters, coal heaters, etc.

- Air Conditioning/Ventilation

  Energy used to run electric air-conditioning units, fans, air circulators, etc.

- Cooking

  Energy allocated for cooking on or in stoves, burners, isolated conventional or microwave ovens, immersion heaters, etc. whether electric or run on fuels.

- Water Heating

  Energy whose destination is heating water for personal or household use, in electrical showers, cumulative or flow-feed heaters, whether electric or run on fuel.

- Refrigeration

  Energy consumed to refrigerate food in electric or fuel-run refrigerators, freezers, etc.

- Mechanical Force (electrical appliances, water pumps and others)

  Energy used to operate electric or fuel-run motors for different types of equipment, such as water pumps, blenders, waxers, vacuum cleaners, etc.

- Lighting

  Energy consumed in internal and external lighting for homes, in incandescent , fluorescent or vapor (mercury or sodium) lamps. gas or kerosene-vapor lamps, wick lamps using kerosene or other oils, lanterns, battery-run lamps, candles, etc.

- Radio-Electronics

  Energy used in laser, communications and information equipment such as televisions, radios, micro-computers, etc.

- Others

  Energy used in electrical equipment and others.

3. Final Energy, Useful Energy and Efficiencies

Final energy is that consumed in the home to satisfy given needs, which may be lighting, food refrigeration, water heating, etc. The problems related to final energy appear in the disaggregation of this consumption by end-uses, since there are difficulties in determining the values consumed for each end-use. For example, in the case of electricity, there is no problem in knowing the total monthly consumption in a household, since it is measured by the distributing company (utility) and recorded for billing purposes. However, within the home there are not meters for the consumption of each device. In order to disaggregate the consumption of this source, it is therefore necessary to investigate the real potential of the different electrical appliances and the consumption habits of the members of the household. The same thing may occur with other sources, such as the tank of liquefied petroleum gas, which may be connected so as to feed simultaneously into more than one device (e.g., the stove and a water heater). Here, also, the total monthly LPG consumption can easily be obtained, but its disaggregation by devices will depend on knowledge about the variables which determine consumption in each one of these devices.

For its part, the concept of useful energy involves some problems related to measurement of the efficiency of energy transformation in the equipment, thus requiring a more in-depth discussion.

In an ideal thermodynamic machine (reversible processes), the relation between the work that can be recovered (dW) using a certain amount of energy (final energy dQ) is known as thermodynamic efficiency and may be expressed as a function of the temperaturs of the hot and cold sources, as follows:

$$\eta = \frac{dW}{(-dQ)} = 1 - \frac{T^c}{T} \qquad (1)$$

where $T^c > T$. The case of $T^c < T$, corresponding to refrigerators and heat pumps, will be dealt with further on. For the machines which carry heat from a hot source to a cold source, efficiency is always less than the unit ($\eta < 1$), so that part of the energy consumed is dissipated in the form of heat in the environment and the rest can be tapped. The latter part, which is actually utilized, can be termed useful energy, E_u. Therefore, the relation between useful energy and final energy is given by:

$$E_u = \eta E_f \qquad (2)$$

Since real machines do not work with reversible processes, nor with a succession of reversible processes, their efficiency is always lower than thermodynamic efficiency, the latter being the maximum theoretical limit for the efficiency of a machine or thermal device.

Refrigerators and heat pumps are pieces of equipment which displace heat from a cold source to a hot source. The thermodynamic efficiency of this type of equipment, defined in a way analagous to the one above, is usually known as the coefficient of performance, and may be expressed as:

$$\eta = \frac{-dQ}{-dW} = \frac{T^c}{T^h - T^c} \qquad (3)$$

where:

$(T^c < T^h)$

The coefficient of performance assumes values larger than the unit ($\eta > 1$). Real refrigerators and heat pumps always have values lower than those calculated by this formula, since they do not work with quasi-static processes.

For this type of equipment, useful energy, as defined previously, will be expressed in the following way:

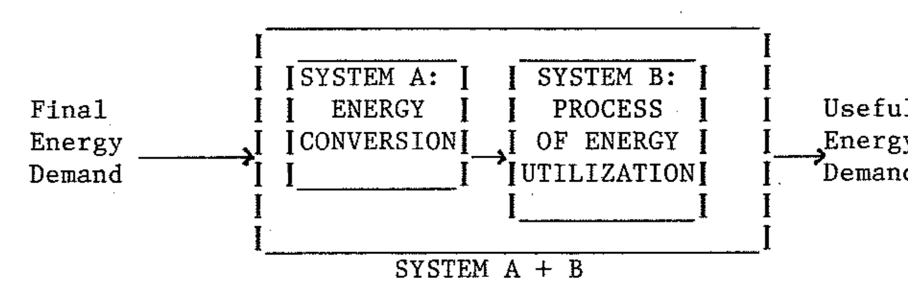
$$E_u = \eta E_f \qquad (4)$$

assuming values always larger than those for final energy.

More generally speaking, we can define the efficiency of any type of energy-converting equipment as the relation between the energy or work recovered at the outlet of the equipment and the energy consumed to do this work or to generate this new form of energy. We will thus have a conceptually homogeneous definition for all of the end-uses described in section 2 of this chapter. This generalization will permit measurement of this parameter in a more or less simple fashion, even for the generation of mechanical force and lighting.

The different types of energy-converting equipment can be divided into two systems: in conversion per se and in energy end-use. In the case, for example, of water heaters with storage units, the electricity or fuel is used to heat water in a tank; when a faucet is opened, the heated water must travel through the pipes until reaching the point of use, so that we may think of an efficiency of transformation of the electricity or fuel into heat (sometimes known as efficiency of production) and of an efficiency of use which, in the example, is due to heat loss through the insulation of the walls of the tanks and the pipes. A generic scheme illustrating this situation can be seen below:

FIGURE III.1



Several types of energy-conversion equipment , in practice, are separated into two systems: conversion and application or use of energy. The difficulties in measuring the efficiency of System "A + B" have led to the preparation of some useful-energy balances which include only the efficiency of System A, sometimes known as the first transformation (in the case of the balance of the OECD, for instance, where useful energy is defined as that recovered by the final consumer at the outlet of the conversion devices). When this limit is taken for the system to be measured, various simplifications are possible , the most important of which are those related to refrigerators, air conditioners, and heat pumps, where the efficiency of electric motors and not that of refrigeration systems as a whole is measured; similarly, for the equipment which generates mechanical force, the measurement is concentrated in the motors, omitting the information related to the efficiency of the equipment for application of the mechanical force, such as the blades of a fan or a water pump, etc.

Therefore, as in the case of the Residential Sector, the efficiency of the equipment used (on side A of the figure for System "A + B") can be determined in a relatively simple way with laboratory measurements, and it is possible to include this information in the OLADE balance, taking the efficiency of conversion as though it were the overall equipment efficiency.

It is even possible to include a measurement of the additional losses derived from the habits of equipment use, defined as the relation between equipment consumption under ideal and real conditions. In practice, this relation can be taken as equal to the unit for most end-uses, excluding perhaps cooking and space-conditioning equipment, due to this "poor use" which could entail a substantial increase in energy consumption. The concrete conditions for preparing the balances for each country will indicate up to what point the measurement of efficiencies should go. In any case, it is suggested that in the first stage of application of the methodology only efficiencies of production be applied, leaving for later stages the determination of efficiencies of use and the application of overall efficiency.

In order to determine useful energy, it is necessary to know:

- the main types of devices used by final energy consumers;

- the amounts of final energy really consumed in these devices; and,

- the efficiencies of these devices under normal operating conditions.

The first two requirements are the subject of analysis in Chapter 2 of this sector document. The efficiencies of the devices can be the subject of specific research in each country, in view of the fact that experience shows that the real values encountered in practice are frequently different from those indicated by

manufacturers. Since it is impossible to measure this performance, it is preferable to use the information available in studies carried out previously or, when this is lacking, information from technical literature at the level of manufacturers. Some indicative values are presented in Table III.1.

4. <u>Energy Balance Applied to a Residential Unit (Household)</u>

Energy is bought, gathered (in some cases, such as firewood and vegetable wastes) and occasionally generated (in a few cases within the rural subsector), thus forming the Net Energy Input (NEI), which is the energy that enters the household, disaggregated into several sources and then transformed into useful forms. For those households which also render small services or produce goods that demand energy, this consumption should be subtracted from the NEI and transferred to the corresponding sector, so as not to create errors in the determination of the sectors consumption. The NEI will be disaggregated into the following sources:

LE - Firewood
RV - Vegetable Wastes
EE - Electricity
GL - Liquefied Gas
KJ - Kerosene
CV - Charcoal
etc.

This list includes only those energy products of major consumption, although practically all of the sources considered in the OLADE balance could appear in the residential energy consumption.

The NEI can be considered equal to the final consumption by sources since in most cases there are no stocks; when these exist, they are negligible with respect to the energy consumed annually.

Final consumption by sources can be related to final consumption by end-uses. The consumption of the electrical devices which account for the different end-uses of energy in the home (refrigeration, space conditioning, lighting, mechanical force, etc.) will be aggregated and related to the final electricity consumption which appears on the electric power bill; in the same way, fuels should be considered according to the different end-uses and related to final household consumption.

The analytical procedure for carrying out the above is illustrated in Figure III.2. Work starts with final consumption by sources, which should be coherent with the disaggregation of consumption by end-uses. In the lower part of the figure, the totals for final consumption by end-use and useful consumption are calculated as the sum of final consumption weighted by the respective efficiencies of production. Finally, losses are calculated as the differences between final and useful consumption.

TABLE III.1

RESIDENTIAL SECTOR

ENERGY CONVERSION EFFICIENCY
(Taken at the outlet of the first conversion)

Water heating without storage:	electric	90-93%
	gas	50-65%
Water heating with storage:	electric	65-80%
	gas	45-50%
Cooking:	gas oven	40-50%
	electric stove	40-80%
	wood stove	5-20%
	charcoal stove	7-25%
	gas stove	7-9%
	conventional electric oven	10-25%
	microwave oven	35-42%
	wood oven	2-7%
Lighting:	incandescent lamp	2-3%
	fluorescent lamp	7-18%
	mercury-vapor lamp	8%
	sodium-vapor lamp	16%
	fluorescent bulb	40%
	gas lamp	0.5-1%
	kerosene lamp	0.1%
Heating:	electric	100%
	coal	5-10%
	fireplace	2-5%
	gas	50-65%
Electric Motors:	(refrigerator, air conditioner, air circulator, drive-force generators in general)	70-90%

Note: Large intervals have been adopted in order to include a larger number of observations.

This procedure takes into account only the efficiency of the first transformation. In order to account also for efficiency of use, it is necessary to apply a scheme similar to the one proposed for the Industrial Sector for useful energy in an industrial unit.

5. Energy Balance Applied to the Residential Sector

The energy balance for the residential sector can be presented with the aid of the diagram proposed in Figure III.2. Different schemes should be worked out for the subsectors (2 or 3, according to point 1 of this chapter) and for the entire sector.

In addition to these, an auxiliary chart should be presented with the efficiencies considered by use and by source, so that the methodology of calculation will be completely clear and will aid in the task of planning for future demand. This table can be presented in the format shown in Figure III.2, eliminating the lower part (the lines "Total," "Average Efficiency by Use," "Useful Energy Consumption," and "Losses").

These tables represent the final product of the task of preparing an energy balance in terms of useful energy for the Residential Sector.

FIGURE III.2

RESIDENTIAL SECTOR

ENERGY BALANCE APPLIED TO A RESIDENTIAL UNIT (HOUSEHOLD)

SOURCES	HEATING	AIR CONDITIONING /VENTILATION	COOKING	WATER HEATING	REFRI-GERATION	MECHANICAL FORCE	LIGHTING	TOTAL CONSUMPTION BY SOURCES AND AVG. EFFICIENCY
PT								
GN								
HE								
CM								
LE								
RV								
GI								
GO								
KE								
DL								
CD								
EE								
CV								
CQ								
TOTAL								
AVERAGE EFFICIENCY BY USES								
CONSUMPTION OF USEFUL ENERGY								
LOSSES								

CHAPTER II

DATABASE FORMATION

1. Significance of Sample Surveys

Sample surveys can be defined using a technique which, given a known universe and a limited number of observations, permits the inference of conclusions about the entire universe.

Refinement of the statistical theory and development of sampling techniques, mainly for the purposes of market surveys, assure high levels of reliability, in some cases larger than those possible to attain in observations of the entire universe: some experts in the area of statistics have suggested that the census, traditionally done once every ten years, could be eliminated with the execution of annual sample polls.

The apparent contradiction of affirming greater precision for an observation done as a sample over one done in the entire universe reflects the significance and limitations of a sample survey.

The defense of sample survey lies in the great difficulty of observing the entire universe with sufficient detail. For example, in the case of the census, the fact that it is carried out once every ten years and the large number of interviews to be done call for the rapid training of a large number of interviewers and the use of relatively simplified questionnaires. The low level of detail of the information gathered and the inevitable errors of observation committed in the execution end up generating larger distortions than those which could occur in a well-planned sample survey.

The opponents of sample surveys, however, point to (a) the difficulty of carrying out a sample if the universe is not known and (b) the possible sample biases that oculd heavily distort the results.

Despite these arguments, for a study on energy end-uses in the residential sector, the sample survey is without doubt the most appropriate data-gathering technique. The sample offers two specific advantages:

- With the execution of a small number of surveys (depending on the size of the country and on its socioeconomic characteristics, it can be sufficient to do 5000 to 30,000), it becomes possible to conduct a study which, extended to all consumers, would be impossible both technically and economically;

- The limited number of surveys allows the use of broad questionnaires and qualified technicians, to compile a set of data which it would not be viable to gather with larger surveys.

The major difficulty in the execution of a sample survey lies, as noted by its critics, in the danger of introducing systematic selection (drawing) biases which could in turn introduce serious distortions in the results, or even invalidate them. The only way of reducing errors to a minimum are (a) previous study of the universe, permitting the review of the results, and therefore discovering possible distortions and (b) elaboration of simple and reliable selection techniques.

It would be impossible in a few short pages to discuss the different techniques used, the exhaustive treatment of which would demand a separate document. Consequently, the present document limits itself to providing some specific indications and to underscoring the main elements which characterize a sample survey in the area of energy end-uses in the residential sector.

The first indication is the recommendation that any survey to be conducted has the support of a statistical expert operating in the country and, insofar as possible, methods and subsamples coherent with those used in the countrys̃ compilation of official statistics. This recommendation is important not only in assuring the technical quality of the project but essential in permitting a reliable test of the results of the investigation: it is preferable to lose the detail of the geographical distribution of energy consumption in non-homogeneous regions than to generate a consumption distribution in areas in which there are no disaggregated demographic data to verify the validity of the sample.

The second indication is the need for a previous study of the universe to be surveyed. The sources which keep a record of data of great significance for the study of residential energy consumption are scant. When beginning a survey without a previous review of data, the risk is run of improperly dimensioning the sample and preparing an insufficient questionnaire.

As for characterization of a survey on residential energy consumption, it is opportune to note some comments on the particular features of this type of toal. The first refers to the unit which is the subject of the survey. Given the very definition of "residential," the subject of the study is consumption in the home; the unit of investigation will therefore be the household. It should be remembered that, in given situations, the units of observation can be different. For example, condominiums present an energy consumption which must be broken down among many households; furthermore, there can be situations in which consumption must be analyzed in the broadest terms, as in the case of collective residences (boarding houses) or communes. According to the country, it is necessary to anticipate different levels of observers, so as to guarantee adequate significance in the data. In order to have an idea of the weight that phenomena of this type can have in a survey, it is sufficient to cite the fact that, for the condominiums of the city of Sao Paulo (Brazil), the average additional consumption per family among the residents of the apartments is 50 kWh/month, i.e., only a little more than 30% of the average household consumption citywide (154 kWh/month).

Generally speaking, it can be said that in the life of a household, energy enters as a source which permits the functioning of more or less complicated equipment involved in day-to-day living. Therefore, copnsumption is tied to having equipment and to the pace and style of the populations̃ way of life. The variable which most affects consumption is the income of the consuming unit, since it is what determines the possibility of owning equipment, what the lifestyle will be and, ultimately, what resources will be available to pay for the energy consumed.

In countries having very highly-stratified income, as in Latin America, energy consumption (especially commercial energy such as electricity and petroleum products) can be concentrated in a small fraction of the countrys̃ population: from 10 to 20% of the population can be responsible for more than 50% of the total consumption of the residential sector.

In a sample survey, assurance of the representativity of a modest part of the population becomes extremely difficult, because it calls for a notable increase in the number of observations to be analyzed. Continuing with the example of Sao Paulo, if the survey had not been stratified for consumption but done linearly for the number of households, it would have been necessary to do more than 10,000 interviews in order to obtain statistical representativity among the major consumers. Through stratification, the selection was able to ensure the same margin of error with only 800 interviews.

This highlights the fact that, whenever possible, the investigation should be with a stratified selection of energy consumption.

Research stratification does not only refer to the need to be aware of the largest energy consumption recorded; it also implies the need to have better knowledge about the mechanisms of end-use. In fact, low energy consumption reflects end-uses aimed at covering the basic requirements of housing, lighting and cooking. To cover these, there is little variation: the pace of living and eating patterns tend to be constant. As consumption increases, other demands are covered and there is greater variation in equipment and costs. The larger number of surveys to be carried out with the increase in consumption serves precisely to assure that this variation is taken into account.

2. Previous Study of the Universe of Consumers

It is impossible to enumerate all of the sources of knowledge about the universe, since these vary from country to country and from region to region, but they can be grouped into three different categories:

2.1 General Sources
2.2 Sources of Information on Energy
2.3 Sources of Information on Equipment

2.1 General Sources

The primary source of information is constituted by population censuses, which are carried out in almost all the countries every ten years. No matter how synthesized, the census offers, at the very least, a general picture of the consistency and distribution of the population in the territory, including number of families, number of households, number of members of the family, age ranges, floor space or number of rooms. One essential element, present in most censuses, is the distribution of families as a function of income. This element is of great utility because the distribution of energy consumption shows a strong correlation to income. This data can therefore be used to construct a series of preliminary hypotheses on energy consumption distribution.

The construction of a series of synthetic census charts, accompanied by preliminary hypotheses on energy consumption, permits an initial picture of the country and the tentative preparation of a series of sampling models.

Besides the census, which is the primary source of information, there can be specific surveys which are indispensable for obtaining better knowledge about the universe. The surveys which are done most frequently are:

- National sample surveys on the economic situation and cost of living. These usually collect data on energy consumption per household and on the weight of energy consumption in the cost of living and the family budget. They are important not only because of the data which they contain, but also because they offer a proven model for sampling in the country. Whenever possible, it is convenient to use the same techniques, both because they have been proven effective in the country and because they offer elements for verifying the quality of the results.

- Local sample surveys which are generally carried out by local authorities such as prefectures, by regional entities and by development organizations and which provide detailed data on given regions.

2.2 Sources of Energy Information

For the commercial sources of energy in general, annual BEEF are published by the corresponding ministries or secretariats (according to the country: Mines and Energy, Energy, Industry and Trade). The data are usually available with different levels of territorial aggregation or by sources.

The cross-referencing of socioeconomic data extracted from the census with the consumption data supplied by territory normally gives a good indication of the energy profile of the country, with some details on residential consumption by energy source, thus permitting the reconstruction of elements such as:

- Percentage of residences with electric power, average consumption of such residences, and total consumption of electricity in the residential sector;

- Distribution and consumption of energy sources of petroleum origin for residential end-uses, in some cases permitting identification of cooking, lighting, water and space heating, mainly by sources such as LPG, kerosene and other fuels.

The firms which distribute electricity and petroleum products, whether public or private, can supply data on residential consumption in a more detailed form. It is important to have access to these data and to the occasional surveys conducted by the firms, because they usually give a substantially more detailed disaggregation than the one available at the national level.

The use of biomass at the residential level is usually difficult data to obtain. In any case, it is important that official sources such as the Ministry of Agriculture or the offices in charge of forest supervision be consulted.

It is important to remember that all of the information gathered prior to the investigation will make it possible to better dimension the sample and to orient the questionnaire in the most appropriate way.

2.3 Source of Information on Equipment

Residential energy consumption depends to a great extent on the equipment utilized. Knowledge about the availability and quality of the equipment used in the country is essential for permitting a preliminary overview of the country and for facilitating the preparation of the respective file. The survey on availability of household appliances can be divided into two parts: one quantitative and one qualitative.

From the quantitative point of view, it is possible to review the statistics on production or importation available in public entities and commercial establishments. The latter sometimes have available market surveys and consumer profiles to support their marketing policies.

These surveys, despite the fact that they do not supply data homogeneous with those of official surveys, may permit the construction of consumer profiles and relate the possession of specific electrical appliances to family income. In market surveys in general, the different variables are analyzed on a regional basis, making it possible to complement census data.

Historical data on equipment sales, associated with estimates of useful lifetime, can permit the construction of preliminary hypotheses about the possession of equipment, to be confirmed in the survey, and other hypotheses on the distribution of energy consumption among the equipment.

A qualitative analysis of marketed equipment offers two justifications: to facilitate preparation of the questionnaire and data-gathering and to permit preparation of specific recommendations for the reduction of energy consumption, once the survey has been concluded.

The execution of a qualitative analysis of equipment can be entrusted to a university research laboratory or another accredited institution. In the case of imported equipment, it is possible to request data from the efficiency tests which are run in most of the industrialized countries. The most important types of equipment to be tested are those related to lighting, refrigeration, water heating and space conditioning. It is worthwhile to note that the measurements taken in laboratories do not supply data directly applicable to the field; in general, it is necessary to introduce correction factors in order to adapt them to local conditions such as temperature, grid tension, and calorific value of the petroleum products used.

In testing, it is important to take into account the variables existing in user behavior that might affect energy consumption, because these variables should be checked during an interview in order to obtain more reliable responses. For example, in the case of an automatic washing machine, it is not important to ask about the duration of the wash, which could vary according to the load or the waters intake pressure. Most models have a fixed specific consumption, depending on the cycle used.

Summarized in a table, the characteristics of the principal equipment marketed in the country can serve as support in the preparation of the questionnaire and in the residential field survey.

Once the investigation has been concluded, a comparison of the consumption of the different types of equipment can permit preparation of technical standards for production, thereby assuring less energy consumption, or the modification of import laws with a view to providing incentives for the entry of more efficient devices.

3. Sampling Methods

After the data on the situation of a country in general, and its energy situation in particular, have been compiled and analyzed, plans for samples and selection techniques can begin to be studied.

Depending on the availability of data and/or resources, it is

possible to follow three basic approaches to surveys and selections:

- Survey of all of the residential universe on a geographical basis.
- Survey of the universe having electric power, using the lists provided by the utilities.
- Typological survey, using an intentional selection, choosing homogeneous groups of consumers and attempting to outline the energy consumption profile.

A sample of the entire universe may appear to be preferable. However, in reality, it is a complex survey which can demand a long time for execution and a great deal of experience in sampling. Its execution could be justified only in countries in which statistical information is scarce and the electrification index is lower than 50%. Under these conditions, execution would become more complex, equivalent to a preliminary census.

When there is more information and the electrification index is higher than 50%, it is always preferable to conduct a survey dividing the universe into two subuniverses: residences with electric power and those without. This division corresponds to the possibility of using different sampling systems and to an effective difference in the nature of the two subuniverses, which even calls for use of different questionnaires.

The first subuniverse, of residences with electric power, usually represents the most advanced sector of the economy, near the large centers of production and consumption. Lists available from utilities provide preliminary knowledge which facilitates the survey and permits immediate identification of consumers. This sector represents the degree of evolution which will be attained by the second sector when it enters the phase of electrification.

The second subuniverse, of the residences connected to the electric power grid, usually represents the least economically developed stratum, the farthest away from the large centers. This is the essential feature of the stratum, so it is important for its homogeneity to be verified. In fact, in some regions there can be relatively well-to-do residences not connected to the electric power network. To proceed with identification, it is possible to do a preliminary test studying the importance of specific equipment such as absorption refrigerators run on LPG or kerosene, stationary generators and similar devices.

Once there is preliminary knowledge about this stratum, it is possible to prepare a sampling plan which, in keeping with the specific conditions of the country, can follow a typological criterion, with selection of typical agglomerations in which the patterns of use are analyzed, or a random sampling criterion on a geographical basis.

3.1 Survey on a Geographical Basis

A sample survey based on the geography of a country, region or city entails the basic difficulty of needing to have a clear picture of population distribution in the territory (and sometimes its features) so that it will permit the distribution of surveys in the different areas and establish homogeneous random selection criteria for the households to be surveyed.

The most commonly used technique for the plan of sampling, selection and estimation is the self-weighted selection in multiple stages, which was disseminated during the 1960s for household surveys. This technique was consolidated in 1969 by the United States Census Department, in a publciation entitled: "Atlantida: A Case Study on Household Sample Surveys," which presents the base methodology for sample surveys in any country. During that decade, the United States Agency for International Development and the Inter-American Institute of Statistics provided many Latin American countries with methodological support for the implantation of a system of continuous household polling. Therefore, it is a fairly well-known methodology, of fairly widespread application. If a sampling system of this type has been implanted, what is suggested is that the survey on energy consumption follow this methodology.

Otherwise, it is recommended that the methodological bibliography presented herewith be studied, because it would be impossible to go into detail on this aspect in just a few short pages.

In the following pages, it is worthwhile to discuss the basic principle of surveying and its influence on the study of energy problems.

The basic criterion for the sampling plan consists of generating a series of primary and subsample units which will permit the drawing of a fixed number of observations through successive random selections

The complexity of the construction of a sample of this type lies in the need to have previous knowledge of the universe, in order to assure respresentativity. One essential element in assuring representativity is that the units of sampling and subsampling be perfectly identifiable, possibly coinciding with the headings used for the demographic census.

In dividing the territory into large regions, the primary unit of sampling can be the minimal administrative unit, probably muncipalities, which should be grouped according to size. In general, within the municipalities, those having a population larger than 100,000 inhabitants or regional capitals are considered self-representative, thus making the probability of selection equal to 1. In the other municipal groups, selection will be random.

Once the other secondary units of the sample have been established, a similar procedure is followed until reaching the units of the last stage, represented by the households, which will also be selected in random fashion, according to the number of interviews to be done.

This sampling mechanism, conceptually simple but of complex application, can entail some constraints for the surveys of final energy use, especially when the sample is small. This technique assures a proportional sample with the consistency of the population, since the subject of the survey is energy consumption, which can have strong variance. With random selection of the population interviews, it is possible to underestimate the consumption of some strata of the population. The phenomenon is especially serious in Latin America, where the heavy concentration of income tends to generate large imbalances in the distribution of energy consumption. In Guatemala, for instance, 0.1% of the families are responsible for 3% of the total energy consumption, and 7% of the families are responsible for 35% of the electricity consumption. In a sample survey, to collect the details on consumption distribution among population strata of this order of magnitude demands working with margins of error on the order of 1% or less, thereby excessively increasing the number of interviews.

The solution for reducing the number of interviews is to try to stratify the selection in the regions having the largest energy consumption. Data on consumption distribution on a geographical basis are therefore essential, even disaggregated by source if possible. Using as a parameter the sum of the consumption of all of the energy sources, we can obtain distortions as a function of the different efficiencies recorded among sources: traditional fuels, mainly firewood, offer a relatively low efficiency. Adding together the traditional and commercial fuels, we can ease the differencies in the patterns of end-use. Returning to the example of Guatemala: 7% of the population accounts for 35% of the electricity consumption. If the balance is done including all of the sources, this figure drops to 12% of the total residential energy consumption. There is obviously a profound difference between a high consumption of traditional fuels and a high consumption of commercial energy sources.

Therefore, whenever there are data on regional consumption of energy sources, it is recommendable to weight the sample for energy consumption by region. If such data are not available or are not very reliable, the monetary income of the region could be used as a weighting factor.

3.2 Listing Survey

In a list of electricity consumers, selection is much easier than in the geographical survey. The first advantage is that all of the universe is included in the list and, therefore, the selection can be made using a mathematical method, with the certainty of covering the entire universe. The second advantage is that it permits previous detailed knowledge because it makes available elements such as recent consumption, historical consumption, type of connection, and supply tension; and in some cases it is possible to record other variables such as type of construction, location (urban or rural area) and type of use (agricultural, residential, mixed).

It is a good rule to carry out a preliminary study of the list before proceeding with the selection. Especially if the list is stored in an electronic system, it is worthwhile to extract randomly selected lists according to the main variables, to order these (lower to higher) by average monthly consumption, and to include total sums with the numerical consistency of the consumers by consumption stratum. The list may follow the model shown below:

Model 1

Monthly Consump-tion kWh	Number of Consumers	Total Consump-tion MWh/month	Average Consump-tion kWh/month	Total No. Consumers

The monthly consumption used to order the consumers merits comment. In countries in which there is a marked seasonal variation, consumption should be calculated as the average of the consumption over the last twelve months. When there is not a notable change in seasons, consumption can be calculated on the basis of the consumption of the last three to six months. Therefore, it is convenient always to use an average consumption in order to avoid biases in the reading of the meters or temporary situations registered in residential consumption. After selection of the households to be surveyed, it is useful to extract a list of the monthly consumption of each residence over the last twelve months.

In a stratified universe, in which the distribution of events is not balanced, the quadratic deviation offers only an indication of variance.

Once the distribution of consumers by ranges of consumption within the universe is known, it is possible to proceed with the selection of the size of the sample and with the random selection.

Sizing of the sample should take into account two different elements: availability of trained personnel and of funds to carry out the survey with the desired degree of precision. It is important that these operations be carried out with the support of a statistical expert; there are specific indications regarding this methodology under numbers 1 and 5 of the bibliography for this chapter.

Selection

Once the sample size (n) of N consumers has been determined, the selection can be done sequentially within the list, choosing a consumer X after a random result r, with 0 [r [n,

where:

N = total number of consumers in the list
n = number of surveys to be selected

With a selection of this type, the probability that each stratum will be drawn is equal to its frequency in the list, so that the sample is self-representative.

Despite the advantage of self-representativity, a sample of this type offers the disadvantage of a large series of surveys among the average consumers (which usually show little variance in their energy consumption patterns) and a limited number of surveys among large consumers (which have a large variance).

The most suitable way to carry out a stratified selection consists of assuming two variables: (a) numerical consistency of consumers per stratum and (b) consumption, thus increasing the representativity of the consumers having the largest monthly consumption.

Continuing with the example of the survey run in the city of Sao Paulo, the following interview distributions were obtained, using a linear selection or a corrected version of the optimal Newman distribution, to assure representativity in the first and last strata:

Model 2

Monthly Consump-tion Stratum	Total Universe	Linear Sample	Corrected Newman Distribution
0 - 300	77 571	29	30
31 - 200	1 208 350	469	293
201 - 500	587 444	224	326
501 - 1000	45 123	17	56
+ - 1000	7 774	3	30
T O T A L	1 926 262	735	735

A comparison of the three columns allows us to visualize the advantages of each type of selection. In the linear sample, the consumers have an equal probability of being selected. Therefore, the greatest representativity is attained for the strata with the largest numerical share; 63% of the interviews are done among the consumers which show little variation in their consumption patterns, without sufficient coverage of the last and next-to-the-last strata, which account for more than 10% of energy consumption.

Using a corrected version of the optimal Newman distribution, the interviews decrease among the average consumers and greater representativity among those of largest consumption is assured, thus guaranteeing representativity in all strata.

Expansion and Certification of Results

Once the survey has been conducted, the expansion of the results is determined by the chosen selection mechanism.

In the case of a linear selection over the number of consumers, there is direct correspondence with the universe: the features covered in each survey correspond to the characteristics of a number of consumers equal to the relation between the sample size and the number of consumers in the universe.

$$\text{Expansion factor} = \frac{\text{total number of consumers}}{\text{number of interviews}} \qquad (1)$$

If the interviewing is stratified, there is an expansion factor per stratum; thus:

$$\text{expansion factor for the nth stratum} = \frac{\text{number of consumers in the nth stratum}}{\text{number of interviews}} \qquad (2)$$

If in the course of the survey a new feature were found, which would divide the universe into two subuniverses, the expansion should be done using a weighting factor which would indicate the proportion of consumers in each subuniverse and subsample.

The concept will be best clarified by using a practical example:

In the Sao Paulo survey, it was found that the meters (and therefore the universe represented by the list) had two biases: a meter can serve only one family or more than one. From a sociological point of view, it interests us to know consumption per household and not per meter. When the survey was concluded, the consumers were divided into two subuniverses: one with meters serving one single family and another with meters serving more than one.

The treatment given the data can be seen in the sequence of Models 3 through 9.

Model 3 reproduces the characteristics of the stratified meters by range of monthly consumption. The right-hand side incorporates the data from the interviews done; the left-hand side, their expansion for the city of Sao Paulo.

Models 4 and 5 present the situation of shared meters, dealt with first at the level of meters, and secondly at the level of households.

Models 6 and 7 present the situation of the meters which serve slum areas, dealt with first at the level of meters, and secondly at the level of households.

Model 8, obtained from the difference between 3 and 4 and 6, shows the situation of the meters which serve one single family.

Model 9, obtained from the sum of 8 and 7 and 5 (added in the stratum of monthly consumption per household), shows the situation of household consumption.

The Expansion Factor

The advantage of distributing the universe a posteriori is that it permits evaluation of information not contained in the list, e.g., consumption per household, division of consumption into urban and rural areas or by apartments and houses, or even other variables not used in the selection phase.

Reserves

In the execution of a field survey, there are always consumers selected which, for one reason or another, cannot possibly be surveyed. There are many reasons why, but the most frequent cases are as follows:

- Refusals

  The person refuses to be interviewed. Since there is no possibility for forcing him, there can be a reduction in the number of refusals by:

  - insisting on the confidentiality of the data;
  - undertaking a campaign of clear information on the importance of the survey;
  - giving prizes or donations to the persons who attend the interviews.

- Impossibility of Locating the Address

  With the aid of the utility company, using the person who reads the meters or the respective maps, it becomes easier to identify addresses.

- Impossibility of Locating the Interviewee (not found at home)

  In order to define the problem, before anulling the survey, it is necessary for the interviewer to visit the address three times, at different hours and on different days of the week, even in periods outside the normal working hours.

As a rule, it is convenient to avoid substituting interviews not conducted because systematic biases can be introduced, which would alter the quality of the findings or could offer a distorted picture of the universe; for example, representativity could perhaps not be assured among the types of consumers which live in isolated areas or areas of difficult access or among families in which all of the members work.

3.3 Typological Survey (Cluster Analysis)

This type of analysis can be applied when there is no list for the universe, as in the case of the residences not connected to the electric power grid, or when there is a homogeneous class of consumers, e.g., the residents of low-income housing developments around large cities.

A typological survey may represent an adequate mechanism for learning about the universe, without the need to recur to complex statistical sampling on a territorial basis.

In this case, it is necessary to define the universe clearly and to study the variables so that the results, despite the fact that they will not permit expansion, will permit visualization of the relation of the sample to the universe. The study of the variables depends strictly on the socioeconomic and geographic characteristics of the country; therefore, it is left up to the criteria of the analyst, who should have an in-depth knowledge about the universe to be surveyed.

For the sake of example of the variables to be treated, assume a survey to be taken in a rural area of a hypothetical country in which rural electrification is less than 10%. The part with electric power can best be approached on the basis of a list from the utility company. In the area without electric power, it is important to analyze the social and geographical variables which might affect energy consumption.

It is possible to group the relevant variables into three different categories: socioeconomic variables, climatic variables and energy availability variables.

Socioeconomic Variables

The essential elements are represented by the categorization of economic activity under headings such as agriculture, livestock-raising, vegetable and mineral extraction.

Within these variables, it is important to define elements such as size of farms, type of crops, and type of management. For example, there is a huge difference between the surface area of colonists' large farms and a small farm, or between a region of extensive cattle-raising and another of intensive coffee-raising. A mining region has features different from those of an agricultural zone. Therefore, the regions of a country should be grouped as a function of these variables, in an attempt to define

homogeneous areas. Whenever possible, in the definition of regions, it is opportune to maintain the groups used by other entities, e.g., by the Ministry of Agriculture.

Climatic Variables

Average temperature and humidity are the two variables which most affect residential energy demand, primarily in terms of space conditioning and the demand for hot water for the purposes of hygiene. It is important to separate these variables, to which a third can be added: altitude. In fact, the higher the altitude, the greater the thermal variations to which the climate is subject, thus generating greater demand for energy in heating processes. This phenomenon is especially perceivable in the use of water for cleanliness; in the higher regions, there is a tendency to heat water more frequently.

Geographical variables should be used for a second stratification of the defined regions. For example, it may become necessary to divide a homogeneous coffee-growing area of small farms into two regions, as a function of the climatic variations recorded in two different areas.

Variables for Availability of Traditional Energy

Residential energy consumption can be strongly influenced by the local availability of energy sources,. The variables which should be taken into account are the existence of native plants, the existence of reforestation and, indirectly, the size and type of land management. In areas of intensive cultivation or small farms, or even in semi-desert areas, there is a tendency to see a notable reduction in the availability of firewood, which significantly affects energy consumption. These variables, like the ones above, should be used in the distribution of the previously defined regions.

Once the population has been grouped by homogeneous areas, one or two localities in each area are selected for surveying. The locality having been chosen in keeping with the number of residences, there can be total coverage or a sample survey. In any case, the results of the survey will yield a series of types which constitute merely an indication of the pattern of end-use, not a total balance of the energy consumption of the population. Even so, especially when the energy source in use is native, the analysis permits a fairly realistic picture of the orientation of energy consumption and aids in understanding the two most serious problems of indigenous sources:

i) the environmental impact of the consumption of local sources, primarily the effects on plant cover and possible energy shortages;

ii) the potential demand for commercial energy, principally electricity and oil derivatives, in the case of an expansion of the distribution networks.

Finally, the typological survey makes it possible to compile information not usually available on the type and efficiency of the equipment which consumes traditional energy.

4. Data-Gathering Instrument

A good questionnaire depends on a sound assessment and on a good pilot survey by which to gauge it. The questionnaire presented herewith should be taken as indicative, since, respecting the first affirmation of this paragraph, the final format should be a function of the assessment and pilot survey carried out in each country or region. Several of the questions in the first module can be answered from existing surveys.

In addition, it should be noted that the questionnaire proposed here should be applied to households; another supplementary one should therefore be prepared to deal with the problem of collective consumption in condominiums and community residences. This can be formulated with questions on the existing equipment and the amounts paid on the collective gas and light bills. The distribution of the global consumption among the apartments can be done in the same way as the distribution of the expenses of the condominium, i.e., according to the percentage of surface area of the dwelling in relation to the overall area of the condominium.

One last observation should be made in relation to the units of measure of firewood consumed in the home. Experience has shown that firewood and other biomass fuels are gathered or marketed in regional units which should be the subject of a previous survey in order to determine their equivalencies with conventional metric units. Such a survey will enormously facilitate the work of completing the questionnaire and will substantially reduce the level of error in the responses.

SURVEY FORM

RESIDENTIAL SECTOR

SURVEY

RESIDENTIAL CONSUMPTION OF USEFUL ENERGY

QUESTIONNAIRE

City: District:

Neighborhood: State:

MODULE 1

GENERAL INFORMATION

1. Characteristics of the consumers̃ residence and of the region.

1.1 Location of the residence.

1.2 Do you carry on some economic activity in the home which would influence energy consumption? If so, what?

1.3 What is the area of the residence?...... m(2)

1.4 How many rooms does the residence have?

...... living room	...... bedrooms	...... kitchen
...... bathroom	...... garage	...... others

1.5 Are you served by public networks of:

...... gas? ...... electricity? ...... water?
...... do you have a power meter?
...... does the meter serve other homes?

1.6 What is the predominant activity in the area where the residence is located?....................................

1.7 What is the average ambient temperature?

in winter ...... C in summer C

1.8 At what altitude is the residence located?..............

1.9 How many permanent residents are there in the home? .....

1.10 What is the familys̃ monthly income?

1 to 2 MS	2 to 5 MS ......
5 to 15 MS	15 to 20 MS ......
More than 20 MS	(MS = minimum salaries)

1.11 How many people work? .....

1.12 In what type of activity?

Owner ......
Own boss ......
Other ......

Public employee ......
Employee in a private firm ......

MODULE 2

TOTAL ENERGY CONSUMPTION

2. Specify what kind of energy is used and how much is consumed:

Energy Source	Where used?*	Unit of Measure	Duration of the Unit in Days	Monthly Consump	Annual Consump
Piped gas					
LGP					
Electricity**					
Firewood					
Coal					
Kerosene					
Diesel					
Gasoline					
Others					

---					

* 1 - lighting
2 - cooking
3 - refrigeration
4 - water heating
5 - space heating
6 - air conditioning
7 - mechanical force
8 - others

** If the electricity is auto-generated:

- generator make .... power cap. ....

- fuel used ...... consumption ...... per day, month or year

- percentage of attention to household needs ......

- hours of generation per day ....

MODULE 3

ENERGY END-USES

3. Lighting

3.1 To light the house, do you use electricity or some other source?

( ) Electricity (continue with 3.3)

( ) Another source (continue with 3.2)

3.2 Others

T Y P E	Amount	Unit of Measure	Duration of the Unit in Days	Monthly Consump
Gas lamps				
Kerosene lamps with incandescent shade				
Oil lamps				
Wick lamps Fuel				
Others (specify)				

3.3 The incandescent lamps are:

T Y P E	No. de Lamps	Average Daily Use			
		0-1 hour	1-3 hours	3-6 hours	6 hrs. +
.... watts					
.... watts					
.... watts					
.... watts					
... .watts					

3.4 The flourescent lamps are:

T Y P E	No. of Tubes	Average Daily Use			
		0-1 hour	1-3 hours	3-6 hours	6 hrs. +
.... watts					
.... watts					
.... watts					
.... watts					

4. Cooking

4.1 Characterization of the Stove and Conditions of Its Use

T Y P E	Amount	With an oven?	No. of burners	Size of burners	Used which meals? *	Average useful burners per day
LPG stove						
Piped-gas stove						
Elec. stove						
Wood stove						
Coal stove						
Kerosene stove						
Others (specify)						

* 1 - Breakfast 2 - Lunch 3 - Dinner

4.2 Energy Consumption in Cooking

TYPE	Use (days per week)	Use (hours per day)	Unit of Measure	Duration of unit in days	Monthly Consump. *
LPG stove					
Piped-gas stove					
Elec. stove					
Wood stove					
Coal stove					
Kerosene stove					
Others (specify)					
Horno					

* In the case of electric stoves, note power capacity.

4.3 What type of wood stove is used?

( ) Masonrywork

( ) Metal

( ) Only loose rocks

( ) Others (specify)

4.4 How is the wood stove used?

( ) Continuously ( ) In the open air

( ) Discontinuously ( ) In a closed environment

( ) To heat water for bathing and other sanitary purposes

( ) For space heating

( ) Others (specify)

4.5 The firewood consumed come from:

( ) Naturally fallen wood

( ) Felling of native forests

( ) Felling of man-made forests

( ) Wastes and residues

4.6 Does your stove have an exhaust pipe?

( ) Yes ( ) No

4.7 How many people eat each day?

(1) at breakfast ......
(2) at lunch ......
(3) at dinner ......

5. Refrigeration

5.1 What type of refrigeration do you have and what is its consumption?

TYPE	Make	Model *	Unit of Measure	Duration of the unit in days	Monthly Consump. *
Electric					
Gas					
Kerosene					

* Also specify the number of doors and type of defrosting.

** In the case of electric refrigerators, note power and size (capacity).

5.2 The refrigerator is located:

Where sunshine enters	( ) Yes	( ) No
Next to a stove or oven	( ) Yes	( ) No
With surrounding ventilation	( ) Yes	( ) No

5.3 In what number (position) is the regulating knob set?

In winter .... In summer ....

5.4 Freezer

Make: ......
Model: ......
Capacity: ...... Vertical ...... Horizontal ......
Months of use per year: ......

6. Water Heating

6.1 What kinds of showers do you have?

No.	Electric(*)	Gas (**)	Make	Model
1				
2				
3				

(*) Maximum power ...... Minimum power ......
(**) Unstored gas

6.2 How are the showers used?

No.	Number of baths per week	Months of year connected/power		Average duration each bath (minutes)
		Maximum	Minimum	
1				
2				
3				

6.3 What type of electric faucets do you have?

Make	Number	Power	Time of Use per Day	Months of Use per Day

6.4 What type of central water heater do you have?

Number	Elec.	Gas	Other	Capacity	Make	Model (power)
1						
2						
3						

6.5 How is the water heater used?

Number	Number of Baths per Week	Average Duration of Each Bath (minutes)
1		
2		
3		

6.6 Is your water heater permanently connected?

( ) Yes

( ) No For how long? ...... hours/day

6.7 How many points of simultaneous use are there?

....

7. Heating and Air Conditioning

7.1 What type of air conditioning do you use?

Make: ....

Model: ....

Power: ....

BTU/HR: ....

7.2 How is it used?

Time of Use	Cooling	Heating
months/year		
hours/day		

7.3 What type of space heating do you have and how is it used?

T Y P E	No. of Heaters	Make Model	Unit of Measure	Duration of unit in days	Monthly Consump. *
Electric					
Gas					
Coal					
Other (specify)					

* In the case of electric heaters, specify power.

Time of Use	Electric	Gas	Coal	Other
months/year				
hours/day				

8. Others

8.1 What are the electric and electronic devices that you have in good working order?

Item	Product (Mechanical Force)	No.
01	Blender	
02	Electric mixer	
03	Juice extractor	
04	Electric knife	
05	Can opener/knife sharpener	
06	Meat grinder	
07	Coffee mill	
08	Slicer	
09	Vacuum cleaner	
10	Waxer	
11	Crusher	
12	Stove extractor	
13	Extractor	
14	Ventilator	
15	Water pump	
16	Drill	
17	Typewriter	
18	Razor	
19	Massager	
20	Sewing machine	
21	Lawn mower	
22	Peeler	
23	Food processor	
24	Pump	
25	Ice cream maker	
26	Others	

	(Radio-Electronics)	
27	Stereo equipment	
28	Calculator	
29	Record player	
30	Radio	
31	Slide projector	
32	Videocassette recorder/player	
33	Message recorder	
34	Others	

Item	Product (Heat)	No.
35	Yogurt maker	
36	Cotton candy machine	
37	Popcorn machine	
38	Grill (Sandwich maker)	
39	Toaster	
40	Coffeemaker	
41	Electric pot	
42	Electric oven	
43	Mini-Dog(Brosterizer)	
44	Plastic sealer	
45	Micro-wave oven	
46	Clothes dryer	
47	Dishwasher	
48	Heater	
49	Bottle warmer	
50	Hair dryer	
51	Clothes washer	
52	Water heater	
53	Others	

8.2 What type of washing machine do you use?

Make: ....
Model: ....
Power: ....
Use-days/week: ....
Use-hours/day: ....

8.3 What type of television set do you have?

TV	Black and White	Color	Make	Model	Use (days per week)	Use (hours per day)
1						
2						
3						
4						

8.4 Does use of the television set change on weekends?

( ) No

( ) Yes - Explain ....
....

8.5 What type of iron do you have and how is it used?

Make	Model	Can temperature be adjusted?	Use days/week	Use hours/day
1				
2				
3				
4				

CHAPTER III

APPLICATIONS

1. General Considerations

This chapter will present the Residential Sector results obtained from the BEEU prepared for Brazil by the Ministry of Mines and Energy (MME).

The results presented herein can serve as a reference for application of the proposed methodology. Some bibliographical references are also included for consultation by interested countries.

2. The Case of Brazil

The BEEU basically covers the following stages:

- identification of the end-uses of the various energy sources;
- identification of the consumption equipment used and assessment of its efficiency;
- evaluation of the destination of final energy in the different end-uses; and
- determination of useful energy by multiplying final energy consumed by the respective efficiency (efficiency of production, as conceived of under the methodology proposed by OLADE).

The balance was prepared using studies developed previously in the country, i.e., there was no consumer survey.

Although the results of the Brazilian balance are aggregated in a different form, it was possible to disaggregate them according to the end-uses considered in the methodology proposed by OLADE, as shown in Tables III.1 to III.4:

Table III.1

Destination of Final Consumption of the Different Energy Sources for Selected End-Uses

Table III.2

Average Efficiencies of Energy Sources in End-Uses

Table III.3

Consolidated BEEF, Indicating the Share of Each Energy Source in Final Energy Consumption, Its Efficiency and the Composition of Useful Energy

Table III.4

Destination of Final Consumption for Selected General End-Uses, Their Efficiency and the Composition of Useful Energy

TABLE III.1

RESIDENTIAL SECTOR

DESTINATION OF FINAL ENERGY

(%)

End-Use/ Source	Elec- tricity	Firewood	LPG	Kerosene	Gas	Charcoal
Air Condition- ing and Venti- lation	2.0	-	-	-	-	-
Cooking	-	100.0	99.0	-	81.7	100.0
Lighting	29.4	-	-	100.0	-	-
Refrigeration	33.4	-	-	-	-	-
Mechanical Force	1.4	-	-	-	-	-
Radio- Electronics	8.3	-	-	-	-	-
Water Heating	19.8	-	1.0	-	18.3	-
Others	5.7	-	-	-	-	-
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

TABLE III.2

RESIDENTIAL SECTOR

EFFICIENCY OF END-USES

(%)

End-Use/ Source	Elec- tricity	Firewood	LPG	Kerosene	Gas	Charcoal
Air Condition- ing and Venti- lation	62	-	-	-	-	-
Cooking	-	10	45	-	45	10
Lighting	4	-	-	0.2	-	-
Refrigeration	62	-	-	-	-	-
Mechanical Force	62	-	-	-	-	-
Radio- Electronics	100	-	-	-	-	-
Water Heating	100	-	58	-	583	-
Others	100	-	-	-	-	-

TABLE III.3

RESIDENTIAL SECTOR

FINAL ENERGY AND USEFUL ENERGY

Year: 1983 Unit: BOE

Sources	Final Energy Consumption (1)	%	Useful Energy Consumption (2)	%	Efficiency (2)/(1) %
Electricity	25,596	12.4	14,785	32.5	58
Firewood	139,752	67.4	13,975	30.6	10
LPG	34,754	16.8	15,682	34.4	45
Kerosene	1,555	0.8	3	-	0.2
Gas	1,598	0.8	756	1.7	47
Charcoal	3,747	1.8	378	0.8	10
TOTAL	207,002	100.0	45,579	100.0	22

1 Tcal = 100 TOE = 720 BOE

TABLE III.4

RESIDENTIAL SECTOR

FINAL ENERGY AND USEFUL ENERGY

Year: 1983 Unit: BOE

Sources	Final Energy Consumption (1)	%	Useful Energy Consumption (2)	%	Efficiency (2)/(1) %
Air Conditioning/Ventilation	430	0.2	296	0.7	62
Cooking	179,263	86.6	30,449	66.7	17
Lighting	9,108	4.4	318	0.7	3
Refrigeration	8,487	4.1	5,287	11.6	62
Mechanical Force	399	0.2	253	0.5	62
Radio-Elec.	2,070	1.0	2,070	4.7	100
Water Heating	5,796	2.8	5,484	11.9	95
Others	1,449	0.7	1,449	3.2	100
TOTAL	207,002	100.0	45,579	100.0	22

1 Tcal = 100 TOE = 720 BOE

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SECTORAL APPENDIX IV

COMMERCIAL-SERVICES-PUBLIC SECTOR

INDEX

COMERCIAL-SERVICES-PUBLIC SECTOR

CHAPTER I

DEFINITIONS AND BASIC CONCEPTS

1. Disaggregation by Subsectors

The Commercial-Services-Public Sector includes a variety of activities in which the features of energy consumption are substantially different.

To the extent that the intention is to use BEEU as a tool for energy assessment, it becomes imperative to disaggregate the sector in a set of relatively homogeneous activities, both insofar as energy requirements and the evolution of their level of activity.

This proves to be of fundamental importance in explaining the variations produced in the energy consumption of the sector.

Furthermore, both the BEEU and the energy assessment constitute a point of departure for demand forecasting analyses.

The definition of the subsectors should thus necessarily be tied to the organization of the macroeconomic information, given the fact that any analysis for forecasting energy demand necessarily requires linkages between energy consumption and the level of activity in the branch being dealt with.

Precisely due to the diversity of activities encompassed herein, this is an especially difficult sector in which to determine an indicative variable for the level of activity, in order to best explain the characteristics of energy consumption.

But no matter what the method used in future analyses for forecasting, it seems highly convenient to define the subsectors on the basis of an international classification which all of the countries can respect in their information systems. For that purpose, just as in the case of the industrial sector, the proposal is to base the sector breakdown on the ISIC classification.

Even though this classification covers the wide range of activities which constitute the sector, it is necessary to point out that the information usually recorded in the statistical systems (both energy and socioeconomic) is circumscribed to formally established services and does not cover the informal activities which in some countries of the region may be relevant.

For example, in some countries a large part of the commercial activity is not tied to the formal infrastructure but takes place informally in the streets. To the extent that these activities require energy consumption, this will not usually be recorded in the information systems; its detection should therefore be one

of the aims of the database design.

Table IV.1 details the activities included in Major Divisions 4, 6, 7, 8 and 9 of the ISIC Classification- Rev. 2, which, generally speaking, constitute the Commercial, Services, and Public Sector. The inclusion of Major Division 7 responds to the fact that the Divisions, Headings and Groups comprised therein give rise to energy consumption not accounted for under other sectors, particularly under the Transportation Sector: energy consumption in offices, establishments, etc., dedicated to Transportation and Communications should be accounted for under this sector.

In Major Division 4, only Division 42 (Waterworks and Water Supplies) is considered to form part of the sector, since Division 41 (Electricity, Gas and Steam and Hot Water Supplies) should be treated within the energy-producing activities.

This is clear enough insofar as electricity and gas (Groups 4101 and 4102), but with respect to Group 4103 (Steam and Hot Water Supplies), it should be noted that, when this service exists, both the distributed steam and hot water should be treated as just another secondary source, for the purposes of the balance

According to the definition of useful energy in the Base Document, the process of energy consumption by the end-user usually consists of two consecutive stages: production of useful forms of energy, and their subsequent use, with the intermediate energy demand serving as the link between these two stages.

To the extent that the useful forms of energy (steam, hot water) are not produced by the end-user but rather integrated into a transformation center, intermediate demand becomes confused with the final demand for a new energy source: steam or hot water.

In addition to the potable water service, included under Division 42, the energy consumption derived from Public Lighting should be made explicit, because these do not correspond directly to any Heading or Group under the ISIC Classification, but are included under Division 91, together with the rest of Public Administration and Defense.

As a function of these considerations and in an attempt to reduce to a minimum the number of subsectors, what is proposed is the disaggregation of the sector as shown in Table IV.2.

The same table also shows the correspondence between the proposed subsectors and the headings of the ISIC.

The criteria on which the groupings or disaggregation of the activities were fundamentally decided are as follows:

- relative homogeneity insofar as the type of energy used in each subsector.

- disaggregation of those activities whose relative evolution

TABLE IV.1

ISIC CLASSIFICATION OF THE COMMERCIAL-SERVICES-PUBLIC SECTOR

Divis.		Group	Activity
41	410		Electricity, Gas and Water
		4101	Electric Light and Power
		4102	Production and Distribution of Gas
		4103	Supply of steam and Hot Water
42	420	4200	Waterworks and Water Supplies
61	610	6100	Wholesaling
62	620	6200	Retailing
63			Restaurants and Hotels
	631	6310	Restaurants, cafes and other establishments which expend food and beverages
	632	6320	Hotels, boarding-houses, camps and others
71			Transportation and Storage
72			Communications
81	810		Financial Establishments
		8101	Monetary institutions
		8102	Other financial establishments
		8103	Financial services
82	820	8200	Insurance
83			Real Estate and Services Rendered to Companies
	831	8310	Real estate
	832		Services rendered to companies, except for rental of machinery and equipment
		8321	Legal services
		8322	Accounting, auditing and bookkeeping services
		8324	Technical and architectural services
		8325	Other services rendered to companies, except for rental of machinery and equipment
	833	8330	Rental of machinery and equipment
91	910	9100	Administration and Public Defense
92	920	9200	Health Services and Similar

TABLE IV.1 (continuation)

ISIC CLASSIFICATION OF THE COMMERCIAL-SERVICES-PUBLIC SECTOR

Divis.	Grping	Group	Activity
93			Social Services and Other Related Community Services
	931	9310	Public instruction
	932	9320	Research and scientific institutions
	933		Medical and odontological services and other veterinary services
		9331	Medical and odontological services and other health services
		9332	Veterinary services
	934	9340	Social welfare institutions
	935	9350	Business, professional and labor associations
	939		Other social services and related community services
		9391	Religious organizations
		9399	Social services and related community services
94			Entertainment Services and Other Amusements
	941		Cinema and other amusements
		9411	Cinematographic production
		9412	Distribution and exhibition of films
		9413	Radio and television broadcasts
		9414	Theater producers and amusement services
		9415	Authors, composers and other independent performers
	942	9420	Libraries, museums, botanical gardens and zoos and other cultural services
	949	9490	Entertainment and amusement services
95			Personal Household Services and Repair Services
	951		
		9511	Repair of shoes and other leather articles
		9512	Electrical repair shops
		9513	Automobile and motorcycle repair
		9514	Watch and jewelry repair
			Other repair services
	952	9520	Laundries and laundry services, cleaning and dying establishments
	959		Direct personal services
		9591	Barber shops and beauty salons
		9592	Photographic studios, including commercial photography
		9599	Personal services otherwise unspecified
96	960	9600	International organizations and other extra-territorial organizations

TABLE IV.2

COMMERCIAL-SERVICES-PUBLIC SECTOR

DISAGGREGATION IN SUBSECTORS
CORRESPONDENCE WITH THE ISIC CLASSIFICATION

Groups Balance	Correspondence with ISIC	Name of the Sector
1	42 + Public Lighting	Public Services
2	61 + 62 + 71 + 72	Wholesaling and Retailing Transportation, Storage and Communications
3	631	Restaurants
4	632	Hotels
5	81 + 82 + 83	Financial Establishments, Insurance, Real Estate and Services to Companies
6	91 - Public Lighting	Public Administration, Defense and Government
7	933	Public Health
8	92 + 931 + 932 + 934 + 935 +939 + 94 + 95 + 96	Other Services

in relation to the sector can vary substantially, according to the type of policy which is applied.

- consideration of the possibilities for obtaining direct information on the formation of a database, primarily with reference to the sample design.

The fact that the proposed level of disaggregation may or may not prove sufficient for a good analysis of demand forecasting will depend on the degree of complexity of the sector in the countries, as well as on the importance of the sector in each countrys total energy consumption.

Along general lines, the disaggregation in the proposed eight subsectors can be considered sufficient, with Subsector 8, corresponding to "Other Services", being the most heterogeneous.

This situation should be kept in mind especially in the sample design for the preparation of sectoral balances.

2. Disaggregation by End-Uses

From the energy standpoint, the activities that are considered under each one of the subsectors represent very different end-uses, ranging, for example, from the predominance of caloric uses (cooking, water heating) under groups 3 and 4 of the balance, (Restaurants and Hotels), to the predominance of uses such as lighting and air conditioning in groups 2, 5 and 6, (Businesses, Financial Establishments and Public Administration, respectively). Furthermore, there are activities which have one single use and one single source, as in the case of Public Lighting.

For the purposes of elaboration of the balance, it is proposed that the following uses be considered:

- Heating
- Cooking
- Water Heating

- Air Conditioning/Ventilation
- Refrigeration
- Mechanical Force

- Others

These end-uses, or purposes, for which energy is used in the sector are similar to those of the Residential Sector.

However, in the case of the Commerical, Services and Public Sector, the features and types of equipment used in the category "Other Uses" vary widely among the different activities which comprise the sector.

In most cases, they are fundamentally caloric end-uses such as dry cleaning, sterilization, etc., in activities such as public health (hospitals).

In some cases, the production of useful forms of energy can serve more than one energy end-use or purpose; for instance, one single boiler can be used for space heating and for water heating for sanitary purposes.

This is a situation similar to the one discussed under the Industrial Sector, in connection with the production of steam in a boiler for different purposes or end-uses (supplying the steam requirements of production processes, electric power auto-production, mechanical force).

Consequently, just as in the productive sectors, it will be necessary to determine the flows of hot water (useful form of energy produced in the boiler) destined both for water heating and space heating.

Unlike the productive sectors, where the energy needs or useful demand of the user is always determined by production processes, in the case of the Commercial, Services and Public Sector, the useful demand of the user in many cases is associated with the level of comfort or mechanization of the different activities.

To the extent that human energy is not included in the energy balances, considerable disparity can appear in the useful demand for mechanical force. This fact demands special care in the sample design.

Useful demand in the Commercial, Services and Public Sector therefore depends on two factors:

- the level of comfort and/or mechanization and

- the efficiency with which the equipment is used.

In this regard, there is great similarity between this sector and the Residential Sector.

3. Final Energy, Useful Energy and Efficiencies

Following the conceptual scheme set forth in the definition of useful energy in the Base Document, which consists of observing the energy consumption process in two stages:

- production of heat, cold, mechanical force, etc., on the basis of energy sources and

- use made of heat, cold, mechanical force, etc., in each activity

The overall efficiency of energy end-use will be given by the product of the efficiency of each one of these stages (efficiency of production and efficiency of use).

In the case of space conditioning (whether heating or air conditioning/ventilation), the two stages are clear and correspond to:

- the production of the necessary heat or cold and

- the degree of utilization of that heat or cold, given the insulation of the spaces.

To preserve food or medicine through refrigeration, the degree of utilization of the cold produced is also associated with environmental conditions, given that the efficiency of the cold-producing equipment varies with ambient temperature and the frequency with which the doors of the equipment are opened and closed.

Although efficiency of end-use is very difficult to measure, and given the heterogeneity of the universe, it would not seem appropriate to propose, a priori, that it be quantified by means of an energy audit (of the industrial type). Some countries in which the consumption of heating or air conditioning is important have implemented information-gathering systems at the level of building insulation, not only for the Commercial, Services and Public Sector, but also for the Residential Sector.

As described in the Base Document, in a first stage of preparation of BEEU, only the efficiencies of production of the different end-uses are accounted for; the elements conducive to evaluating the efficiencies of use are not included.

In any case, and only for those end-uses which represent an important consumption and in which efficiency of use is much less than the unit, it is recommended that the different methods which would lead to an estimate of that efficiency be analyzed.

Table IV.3 presents some efficiencies of production compiled by the Institute of Energy Economics (IDEE), which were used in the preparation of a Regional BEEU.

TABLE IV.3

EFFICIENCY OF PRODUCTION IN THE

COMMERCIAL-SERVICES-PUBLIC SECTOR
(%)

USES	LE	CV	GL	GN	KE	EE	AL	FO	DO	GO
1-COOKING EQUIPMENT										
a) Clay Oven	20									
b) Economic Stove	20	25								
c) Hearths	10	15								
d) Spits	5	8								
e) Grills	3	5								
f) Stove-Heater			45	50	35	80				
2-WATER HEATING EQUIPMENT										
a) Tank			45	50		90	35			
b) Thermotank	24		50	55		95				
3-HEATING EQUIPMENT										
a) Open hearth	5									
b) Closed hearth	20									
c) Stoves			50	60	40	80			40	
d) Boilers			65	65				60	60	
4-LIGHTING EQUIPMENT										
a) Oil lamp			2.5		2					
b) Wick lamp					1.6					
c) Incandescent						4.5				
d) Mercury						11				
e) Fluorescent						15				
f) Sodium						18.5				
5-AIR CONDITIONING EQUIPMENT										
a) Ventilator-fan						90				
b) Air conditioner						90				

TABLE IV.3 (Cont.)

EFFICIENCY OF PRODUCTION IN THE

COMMERCIAL-SERVICES-PUBLIC SECTOR
(%)

USES	LE	CV	GL	GN	KE	EE	AL	FO	DO	NF
1-OTHERS EQUIPMENT										
a) Transistor Electr.						100				
b) Lamp Electronics						25				
c) Iron	11	20	36		28	80				
d) Electric Motors						80				
e) Commercial Boilers				75				65	65	
f) Commercial Ovens				65				40	40	
7-WATER PUMPING						70			20	15

Source: Balance Energético, Tomo III "Planeamiento Energético Global de Largo Plazo para la Provincia de Entre Ríos" CFI Bs. As. Argentina, 1980. Prepared by the Institute of Energy Economics (IDEE).

CHAPTER II

DATABASE FORMATION

1. Data-Collecting Form

The contents of a data-gathering sheet should be gauged according to the particularities of each country. The contents of the form which is presented herewith can be used for the sake of reference, since it is of a more or less general nature; and corrections can eventually be made in the end-uses under consideration.

For warm countries in which the use of heating is marginal or non-existent, or in the sectors where cooking does not take part, etc., such uses should not be included.

The form is divided into five chapters. Chapter I refers to general data on the establishment: type of activity, location, surface area, economic data and regimen of activities, number of employees, etc.

Chapter II details the information on electric power to be recorded: origin, types of equipment for auto-production, sales to third parties, etc. The same procedure is used for fuels in the following chapter.

Chapter IV disaggregates consumption by uses, details types of equipment, and reviews the terminology for each case.

Finally, the last chapter refers to the control and revision of surveys.

It is necessary to note that, in many cases, it may be convenient to add the brand name of the equipment when power output or capacity is difficult to register.

2. Analysis of Existing Information

The type of form discussed above will fundamentally depend on the sample design which must be implemented, and on a diagnostic of the existing information.

The information on energy consumption in this sector, at least what is presented in the BEEF-OLADE, appears aggregated with the consumption of the Residential Sector, under the name Residential, Commercial and Public Sector.

This presentation does not mean that some countries cannot maintain the information for each sector separately. If this has not been done, it should be disaggregated.

If on the basis of the methodology presented herein the consumption of the Residential Sector has been quantified prior to the consumption of the Commercial-Services-Public Sector, the formers consumption will have been defined.

If the aim is to determine the total consumption of this sector, prior to launching the proposed survey on uses detailed under the following point, a more numerous survey should be undertaken, the objective of which would be to quantify the energy consumption of the sector (and/or subsector).

The survey on total consumption should contain only Chapters II and III of the sheet presented above, concerning the consumption of electricity and fuels. This survey should have as a frame of reference the type of sample used for censuses in the Services Sector, or other type of sample surveys normally done in the sector.

Even though the record of information on electricity is included, it can be omitted for a large number of establishments since its origin is Public Service; consumption by subsector can be obtained from the records of the firms which render services.

The same thing occurs with some fuels, as in the case of natural gas or piped gas, which are billable sources with consumption records for the sector and/or subsector in the producing and/or distributing firms.

The major problem lies in commercial sources whose distribution is not through fixed networks (e.g.,liquefied gas, gas oil, etc.) and in non-commercial sources.

In any case, this type of survey should have broad coverage; it is very simple to carry out and is usually inexpensive.

As for the information which should be available to define the universe of reference, i.e., the energy consumption of the Commercial, Services and Public Sector, and the number of establishments in each subsector, work begins with a fairly logical assumption, which is knowledge about this last piece of information. The state of energy information can offer the following variations:

- Energy consumption by subsector is not known, but energy consumption for the entire sector is.

- The consumption of electricity supplied by Public Services is known, but the amount of fuels for each subsector is not.

- Energy consumption by subsector is known.

The third case may be the least frequent for the countries of Latin America; a more frequent case would be the second; and the most common would be the first, as long as there are records on total sectoral consumption (either because they were already available or because the above-mentioned survey on total consumption in the sector has been conducted).

The second case implies the existence of records on the basis of which the electricity billed to each subsector can be known, together with some information on fuel sales made to certain establishments in the sector. These records constitute invaluable information for the sample design, especially in the case of electricity, which in turn constitutes a basic element of control for the expansion of the sample done on energy end-uses.

One last alternative with respect to the state of information is that for any of the eight subsectors considered there are records for some of the activities presented; thus, for example, in Subsector 7, "Public Health," there may be records on energy consumption by sources in hospitals or public and/or private aid institutions, as may occur for the financial establishments of the States, public or private schools, etc.

One particular case of analysis is constituted by the so-called INFORMAL SERVICES, about which little is recorded from both the energy and non-energy points of view. In general, it can be affirmed that:

a) The number of "establishments" or "employees" is not known; therefore, the universe is unknown, thus implying the impossibility of any sample whatsoever.

b) Most of these types of services are devoted to the sale of finished products, not generating any type of energy consumption, in which case the failure to consider them does not create any problem.

c) There may be some services, such as the sale of foodstuffs which have to be cooked, the energy consumption of which will have to be estimated. Given the characteristics of this type of activity, the most advisable thing to do is to have the survey in the Residential Sector capture that consumption (actually, the form presented in this sector foresees this type of problem), since that survey will surely be able to do so much more reliably than the one designed for this sector.

   If such consumption is detected, it should be accounted for under the Commercial, Services and Public Sector, and subtracted from the Residential Sector.

d) Other types of informal services such as portable market stands, in which the products are transported to the place of sale, thereby generating the consumption of commercial energy, should be captured under the transportation sector, on the basis of surveys designed for freight transportation.

e) Even though the level of "informal activity" in some countries can reach important magnitudes in the general level of

economic activity, this does not seem to occur from the energy standpoint, since its incidence is quite marginal or non-existent.

Finally, by taking the consumption of commercial sources in the legally formal activities, i.e., in the establishments in this sector which contribute to the formation of the gross domestic product, it can be observed that in many activities there is a relative concentration of consumption in establishments which can be considered "large" but, unlike in other sectors such as the Industrial Sector, for example, the curve of distribution inequality or asymmetric proportion can approach the diagonal more.

3. Guidelines for Sample Design

The guidelines for designing a consumption sample by END-USES will be based on the assumption that sectoral energy consumption is known and that the number of establishments per subsector is known, together with the most relevant economic variables: value added, number of employees, etc.

In dividing the population under study into subsectors which, from the energy standpoint, have a certain degree of homogeneity, and in presenting a certain concentration of consumption in those establishments considered "large," it is proposed that a stratified sample be done.

Before going on to the formation of strata, it is necessary to specify that there will be certain activities in some subsectors which will not form part of the sample. Such is the case of PUBLIC LIGHTING included in Subsector 1, since electricity consumption can be obtained directly from the energy companies, or from those public or private establishments for which energy consumption is known by sources (schools, hospitals, public administration, etc.); and the case of DEFENSE, including Subsector 5, the consumption of which is usually highly confidential. In this case, it is most probable that this consumption will figure in the Sector OTHERS or in Adjustments.

Keeping in mind the observations made under point 1, regarding the heterogeneity of activities, and given the need for a variable correlated with consumption to stratify the population, it has been thought convenient to adopt the number of employees as a stratification variable, since this is the most closely representative variable in energy consumption. However, there may be others such as surface area of the establishment, to be correlated with consumption in lighting and climatization (heating or air conditioning); the number of beds in a hospital, to be correlated with total hospital consumption; value added, etc.

The formation of the strata will include:

Stratum (A), of obligatory inclusion in the sample, made up of the large energy-consuming establishments, working from the hypothesis that large energy consumers will be those whose number of employees will surpass a given figure (400, 600, etc.).

The remaining strata, in which there will be a division according to subsectors, i.e., there will be a series of new strata (Bi) containing a considerable number of establishments.

Given that one of the working hypotheses is lack of knowledge about subsectoral consumption, in order to complete the design it will be necessary to sample in each one of the 20 or 30 strata into which the population was divided. The universe of reference will no longer be the establishments in each group, but rather the 20 or 30 subpopulations, for which average consumption will be estimated for each source of energy. Within each stratum, the same simple or systematic random sample may be taken, for example, of 1% of the components of the subpopulation. If the variances in the estimators prove unacceptable, there are two possible approaches for continuing the process:

i) to increase the size of the sample, keeping the same stratification.

ii) to make stratification more refined, with a range of variation smaller than the stratification variable utilized.

Later on, the estimators for each activity are calculated, according to the formulas provided by the stratified sample, and they are treated jointly with the estimators for the stratum of obligatory inclusion (A); from this will result in a second analysis of the variations to ascertain the soundness of the estimate.

4. Guidelines for Data Processing and Sample Expansion

No details will be given with respect to data management in terms of: errors in data-gathering, data loads, errors in data handling, consistency of information, etc.

In the processing of the sector surveys, some cases of shared end-uses, i.e., consumptions covered by one same source and device, may appear. Even though this case does not occur in many countries or activities, it is necessary to clarify that it may arise in the end-uses of hot water and heating produced by a boiler.

The way to match energy consumption to these shared end-uses is based on determination of the flows of hot water (useful form of energy produced in the boiler) earmarked for water heating and space heating.

If these measurements are not available, one practical way of solving this allocation is through monthly or seasonal consumption records, according to the specifications of Chapter

III of the survey form presented.

Using statistical inference, the sample is expanded to the population on the basis of the analyzed estimators. This expansion will depend on the type of sample taken and on the properties of the estimators.

Since the aim of the study is to measure useful energy consumption by end-uses, in every case it will be necessary to determine a matrix for the average share of each source in each end-use in each subsector.

This matrix is prepared by considering the sample averages as estimators of the populations' expectation parameters, These estimates, on the basis of their variances, will give a certain idea of heterogeneity within each stratum considered.

The determination of whether or not there is heterogeneity is equivalent to testing the variances of the sample averages obtained for each stratum, by testing the hypotheses to be defined in each case.

One of the objectives of the stratified sample is to form strata which are as homogeneous as possible from within, but heterogeneous among themselves. Hence, it is expected that, on the basis of a good design, the matrix of the sources' participation in end-uses will have a certain homogeneity in each subsector under consideration.

By applying the matrix for shares in subsectoral final consumption, final consumption will be obtained by end-uses and by sources. When related to efficiencies of production (measured or adopted) for each source in each end-use, this will yield useful intermediate consumption by source and by end-use, measured at the level of efficiencies of production.

In the event that energy audits are done to provide efficiencies of use, these should be related to useful intermediate consumption, so as to obtain overall efficiencies of use.

SURVEY FORM

COMMERCIAL, SERVICES AND PUBLIC SECTOR

SURVEY FORM

COMMERCIAL, SERVICES AND PUBLIC SECTOR

1. GENERAL DATA

1.1 Activity

Restaurant ___ Beauty Salon ___
Hotel ___ Hospital or Sanitarium ___
Bar or Cafeteria ___ School ___
Rotisserie ___ Public Office ___
Laundry or Dry Cleaner ___

1.2 Address

Street: ____________ Number: ____ City: ____________
Phone: ____________

1.3 Characteristics of the Building

No. of rooms ____ Area ________

Does the establishment have running water? Is it connected to the sewage disposal system?

YES ____ NO ____ YES ____ NO ____

1.4 Economic Data and Regimen of Activities

No. of persons employed: Permanently ____
Temporarily ____
Total ____

No. of persons served (complete the information for each activity)

- Clients per day ____ students ____
  patients: internal ____
  external ____

- Gross income __________

- Regimen of activities

  * No. of months worked per year ____
  * Specify months not worked ________________________
  ____

Days per week ____ Schedule ________________

2. ELECTRICITY

- Is the energy used exclusively auto-generated?

NO ____ YES ____

- Supplier
  - Provincial firm ____
  - Municipal firm ____
  - Private firm ____

- Power contracted in KW __________

- What type of feed system is there? One-phase ____ Three-phase ____

- Is there generating equipment? YES ____ NO ____

- Frequency of use __________

2.1 Type of Generator

TYPE OF GENERATOR	FUEL CONSUMED			PRODUCTION 1979 (kWh)	INSTALLED CAPACITY	
	TYPE	UNIT MEAS.	AMOUNT		AMOUNT	UNIT
Diesel						
Gasoline						

2.2 Energy Sales to Third Parties

- Do you sell electricity to third parties? YES ___ NO ___

- Units sold: public service __________kWh
  other consumer __________

2.3 Electricity Consumption (kWh)

Billing is monthly _____ biannual _____

Period	1	2	3	4	5	6	TOTAL 1/
Gen:							
Bought							
Auto-Generated							
Period	**7**	**8**	**9**	**10**	**11**	**12**	**TOTAL**
Gen:							

1/ Complete this column only if billing is biannual (every six months); in this case cross out the second half of the chart. If billing is monthly, cross out this column and complete the second half of the chart.

3. FUEL CONSUMPTION (EXCLUSING THAT CONSUMED IN TRANSPORTATION AND AUTO-GENERATION)

3.1 Type and Amount of Fuel Used

TYPE	UNIT	CONSUMPTION		OBSERVATIONS
		ANNUAL	MONTHLY	
-Liquefied Gas	number	-------	-------	
a) Cylinders	number	-------	-------	
b) 15-Kg tanks	number	-------	-------	
c) 12-Kg tanks	number	-------	-------	
d) 10-Kg tanks	number	-------	-------	
e) Others	------	-------	-------	Which?
- Kerosene	liters	-------	-------	
- Gasoline	liters	-------	-------	
- Diesel Oil	liters	-------	-------	
- Fuel Oil	liters	-------	-------	
- Firewood	tons	-------	-------	
- Others	------	-------	-------	Which?

4. USES

4.1 Lighting

DEVICE	SOURCE	CAPACITY (WATTS)	AMOUNT (No.)	UTILIZATION (hrs./day) 2/	OBSERVATIONS
Incandescent Lamps	electricity	25			
	electricity	40			
	electricity	60			
	electricity	75			
	electricity	100			
Flourescent Lamps	electricity	20			
	electricity	40			
	electricity				
	electricity				
	electricity				
Lamps	kerosene				
Lamps					

2/ Complete this column only if the lamps are used permanently. Otherwise, expain frequency under "Observations".

4.2 Cooking

DEVICE	SOURCE	CAPACITY (WATTS)	AMOUNT (No.)	UTILIZATION (hrs./day)	OBSERVATIONS
Household Cooking					
Industr. Cooking					
Ordinary Oven					
Microwave Oven					
Grill					
Spit					
Deep Fryer					
Pots					
Pancake Grill					
Waffle Iron					
Toaster Oven					
Coffee-maker					

4.3 Water Heating (only for washing and hygiene)

DEVICE	SOURCE	CAPACITY (WATTS)	AMOUNT (No.)	UTILIZATION (hrs./day)	OBSERVATIONS
Boiler 3/					
Thermo-tank					
Tank					
Stove					

3/ Ask about the characteristics and consumption of the pumps to raise hot water.

4.4 Heating

DEVICE		ENERGY SOURCE	AMOUNT (No.)	CAPACITY	UTILIZATION (hrs./day)	OBSERVATIONS
-BOILER	Radiant ___					
	Radiators ___					
	Air circulation ___					
-Resistance ___						
-Quartz ___						
-Radiator ___						
-Portable ___						
-Balanced-draft ___						
-Infra-red ___						
-Wick ___						
-Drop ___						
-Pressure ___						
Salamander						
Open Hearth						
Spit						
Stove						
Heater						
Air Conditioner						

NOTE: Ask about characteristics and consumption of the pumps used to circulate hot water or air.

CHAPTER III

APPLICATIONS

1. The Case of El Salvador

The case of El Salvador, where most of the surveys presented in the preceding pages have been carried out, is included as as example of the application of the methodology discussed in this document.

For the sake of example, see Tables IV.4, corresponding to the disaggregation of final consumption by sources in the different subsectors, and IV.5, corresponding to the disaggregation of electricity consumption by end-uses and subsectors.

TABLE IV.4

COMMERCIAL-SERVICES-PUBLIC SECTOR

FINAL POPULATION CONSUMPTION - EL SALVADOR

YEAR: 1984 UNIT: BOE

	GENERAL COMMERCE	RESTAURANTS	HOTELS	FINANCIAL ESTABLISHMENTS	COMMUNITY INSTITUTIONS	TOTAL
Electricity	42.47	7.57	10.26	27.61	57.90	145.81
Liquefied Gas (LPG)	-	4.77	1.86	-	11.04	17.67
Diesel Oil	-	-	2.50	-	3.12	5.62
Fuel Oil	-	-	3.67	-	0.61	4.28
TOTAL	42.47	12.34	18.29	27.61	72.67	173.38

TABLE IV.5

COMMERCIAL-SERVICES-PUBLIC SECTOR

MATRIX OF SHARES IN ELECTRICITY

YEAR: 1984 UNIT: BOE

	HOT WATER	MECHANICAL FORCE	AIR CONDITIONING	REFRIGERATION	LIGHTING	COOKING	ELECTRICAL APPLIANCES	OTHERS
Commerce	0.00	5.62	55.14	2.16	28.92	0.24	1.88	6.04
Restaurants	0.14	1.89	29.25	28.18	8.15	23.58	5.39	3.42
Hotels	0.57	11.97	56.26	5.21	18.10	0.62	5.21	2.06
Financial	0.00	3.63	61.84	0.97	19.62	0.04	0.82	13.08
Community	0.27	13.47	36.06	5.05	22.72	0.90	0.62	20.86

SECTORAL APPENDIX V

AGRICULTURE-FISHING-MINING SECTOR

INDEX

AGRICULTURE-FISHING-MINING SECTOR

CHAPTER I

DEFINITIONS AND BASIC CONCEPTS

1. Disaggregation by Subsectors

This sector groups the activities related to the primary production corresponding to the Major Divisions 1 and 2 of the ISIC Classification: on the one hand, Agriculture, Hunting, Forestry and Fishing and, on the other, Exploitation of Mines and Quarries, the divisions and headings for which are presented in Table V.1.

Table V.2 presents the proposed classification for disaggregation of the three subsectors to be incorporated into the present methodology, as well as the codes for the headings to be considered under each subsector.

Just as in the industrial sector, it is necessary to refine certain activities which might be accounted for under other matrices of the energy balance (supply) or included in other consumption sectors, or to include consumption from other sectors.

This sector will only include direct energy consumption, i.e., not the energy content of the inputs, equipment and materials used in the units of exploitation, since these are accounted for under the Industrial Sector. For example, the energy equivalent of inorganic fertilizers incorporated into agriculture will not be counted, nor will the explosives used in mining.

This sector is perhaps one of the most controversial in terms of the problem of assignation of energy consumption among sectors, since the information concerning many of the productive activities does not in principle seem to be duly separated as to what is strictly primary (and therefore attributable to Agriculture, Fishing and Mining) and what undergoes a process of transformation (attributable to the Industrial Sector). For the sake of example, let us cite: the mining-metallurgy complexes; the extraction of wood combined with the manufacture of paper pulp; fishing and processing of fish products, etc.

In addition to this problem of distribution of consumption among sectors, there are others regarding the treatment of information (specifically the universe of reference of the sample frame).

On the basis of groups, the ISIC classification considers the possibility of determining the principal activity or groups of principal activities. However, in practice there is vertical integration of activities (examples given previously), which makes it impossible to obtain information (value added, number of employees, etc.) for each product, service or group.

Therefore, "the establishment or unit according to the type of activity should be classified in the group of the ISIC which includes the goods or services that constitute the bulk of the gross product. Thus, for example, an establishment which combines the cutting of trees with a sawmill will be classified as a sawmill and the clay quarry combined with a brick factory will be classified as a brick factory." (*)

According to this criterion, the energy consumption associated with the activities of establishments which cannot be separated:

- agriculture from agroindustries
- fishing from the fishing industry
- mining from metallurgy

should be considered in the pertinent subsector corresponding to the Industrial Sector.

However, given that from an energy standpoint-- e.g., substitution among sources, projection of consumption and energy conservation-- the designation of this consumption has very dissimilar characteristics depending on the sector to which it is assigned, the following reordering is proposed at the subsectoral level:

a) Agriculture Subsector

This will include the activities of Divisions 11 and 12 of the ISIC Classification, with the following clarifications:

- Heading 121 (Silviculture), related to "exploitation of forests; sapling nurseries; planting, repopulation and conservation of forests, etc.," contemplates the possibility of including charcoal production when it is done within the forest. It would be convenient to separate such production and to include that consumption under the pertinent Transformation Center.

- Heading 122 (Wood Extraction) of the Agriculture Subsector will contain exclusively "sawmilling camps, lumberjack contractors and lumberyards devoted mainly to cutting wood and producing logs...etc." (*)

  "The operations of lumber and firewood extraction carried out in combination with sawmills, pulp factories and other transformation establishments which cannot be stated separately, are classified in Groups 3311 (Sawmills), 3411 (Wood Pulp, Paper and Cardboard) or 3511 (Manufacture of Basic Industrial Chemicals), respectively." (**)

(*) See United Nations Office of Statistics. Statistical Reports. Series M No. 4, ISIC Rev. 2, page 16.

(**) See United Nations Office of Statistics. Statistical Reports. Series M No. 4, ISIC Rev. 2, pp. 16-17.

Therefore, in order to account for the energy consumption associated with Group 122, it will be necessary to subtract that accounted for in the above-mentioned industrial groups.

b) Fishing Subsector

In some countries this subsector is quite difficult to express. In such a case it is proposed that it not be disaggregated from the Agriculture Subsector.

It will cover energy consumption in commercial fishing, including that done by the processing ships and fleets devoted to fishing and elaboration of fish products.

The ISIC classification establishes that: "the processing ships that are devoted exclusively to the elaboration of fish products and that can be considered as isolated establishments are classified under Group 3114 (elaboration of fish, shellfish,...)", so that if this is the case of a given country, the respective energy consumption is accounted for under the Industrial Sector. In practice, it can prove extremely complex to separate the activities of capture and manufacturing and, therefore, the energy consumption related to each one of these stages.

In the event that these stages cannot be separated, it would be convenient for the consumption originated by these to be included within this subsector.

c) Mining Subsector

The exploitation of mines and quarries includes the extraction, preparation and enrichment of minerals, as well as complementary activities (crushing, cribbing, lixiviation, fusion, etc.) to prepare and enrich ores and other raw minerales, in order to facilitate their later marketing.

In mining activity, the stage of extraction culminates with the obtention of the ore for which purpose, in certain cases, it is necessary to remove variable amounts of sterile products. The ore treated in the enrichment plants makes it possible to obtain concentrates; the percentage of mineral increases in different concentration ratios according to later treatment (metallurgy).

In addition, different types of establishments can be presented, generally classified under Large Mining, Medium-size Mining and Small Mining, devoted to mining-metallurgy activities which can cover different stages of the production process.

EXTRACTION-------[ENRICHMENT----------[METALLURGY

Thus, whereas in Large Mining most of the establishments have integrated processes including the three stages, in Medium-size and Small Mining the first two can appear together or separately.

Thus, it clearly appears that for integrated establishments, it will prove extremely difficult to disaggregate energy consumption between what is strictly Mining and what is strictly Industrial (Metallurgy).

Therefore, in addition to the energy consumption pertinent to this subsector, it is proposed:

- to include all of the energy consumption of the integrated complexes.
- to exclude the iron and steel industry (incorporated into the Industrial Sector)
- to exclude metal refining, recovery and forging, as well as the production of ingots, bars, billets, tubes, etc., in isolated (non-integrated) establishments included in Division 372 (copper, aluminum, lead, etc.) of the Industrial Sector.

Furthermore, Divisions 21 (Exploitation of Coal Mines) and 22 (Production of Crude Oil and Natural Gas) will be excluded, because the energy consumption associated with these activities is accounted for under the Energy Sector (supply).

2. Disaggregation by End-Uses

2.1 Subsectoral

The disaggregation of energy consumption into end-uses presents such different features-- according to the subsector, technology, equipment and source being dealt with-- that it is necessary to detail the production processes or tasks of each subsector in order to quantify the useful energy resulting from each end-use.

2.1.1 Agriculture Subsector

This includes all of the tasks carried out in agriculture for farming, livestock-raising and forestry. The principal tasks are detailed below:

i) Farming activities: these correspond to preparation of the soil (plowing, disking, hoeing, etc.), planting, clearing, supervision, protection and harvesting. Depending on the production methods used, these tasks can be carried out using only hand labor, by combining hand labor with animals or with farm machinery, or by combining hand labor, animals, and farm machinery.

The type of equipment includes tractors, harvesters, planters, etc., i.e., primarily motor-driven farm machinery which consumes mostly conventional fuels.

ii) Irrigation: the use of water (from surface or subsurface sources) for irrigation can be through motorpumps run on fuel or electricity, windmills, manual pumps, animal force, waterwheels or simply by gravity.

iii) Water pumping: for livestock troughs. The alternative end-uses are listed under ii).

iv) Livestock-raising activities, workshops, and lighting: these refer to the breeding and fattening of livestock in specific installations, as well as the extraction, cooling and treatment of milk prior to commercialization or domestic industrialization; and to the repair of machinery and tools in the unit of production. These activities may require direct energy consumption in motors and specific equipment, and in lighting for the facilities.

v) Support transport for production: this is what is needed for productive processes, whether through automotive vehicles, pack animals or manpower.

vi) Support transport for marketing: this is what occurs between the unit of production and the centers of storage or sale, whether through automotive vehicles or manpower.

vii) Inorganic fertilizer: this is the incorporation of inorganic nutrients into the soil. The energy consumption of this activity is included under i) and v).

viii) Organic enrichers: this is the organic matter incorporated into the soil through crop residues and animal excrements.

The residues and excrements may come from the crops and livestock on the farm into whose soil they are incorporated. In this case, the energy consumption for that incorporation (e.g., through plowing) is included under a) and no energy consumption should therefore be added in.

ix) Treatment with agrochemicals: this is the use of pesticides, herbicides, insecticides, etc., in pre- and post-planting on farms and plantations and in livestock-raising. Energy consumption is included in i) except for that related to aerial fumigation carried out by the unit itself.

Thus, the end-uses associated with these tasks would be:

- Movable Mechanical Force (Tractors and Farm Machinery)
- Stationary Mechanical Force (Stationary Motors)
- Irrigation
- Water Pumping
- Refrigeration
- Thermics
  . Heating
  . Water Heating
  . Drying

- Lighting
- Transportation
- Fumigation

It is proposed that this list be grouped as follows:

- Tractors and Farm Machinery
- Irrigation and Water Pumping
- Transportation and Fumigation
- Others
  . Lighting
  . Refrigeration
  . Drying
  . Water Heating and Space Heating
  . Mechanical Force

2.1.2 <u>Fishing Subsector</u>

The energy end-uses to be accounted for under this subsector may be broken down according to whether or not the ships are devoted only to fishing or if they also do processing.

In the first case, the end-uses will be:

. Mechanical Force (cranes, mills, etc.)
. Transportation (displacement to and from the place of capture)

In the second case, it will also be necessary to add:

. Steam (sterilization, etc.)
. Refrigeration (refrigerators, freezers, etc.)
. Direct heat (water heating, drying, cooking)

2.1.3 <u>Mining Subsector</u>

The activities carried out in the productive process of this subsector demand the consideration of different end-uses according to the stages of extraction, enrichment, and metallurgy in reference. In the case of TRANSPORTATION, it is necessary to clarify that the movement of minerals and/or materials within the mine will be accounted for as Mechanical Force (conveyor belts, rails, etc.); on the other hand, transport through pipelines from the mines storage area to the outside will be accounted for under the Transportation Sector.

i) Extraction

- Mechanical Force (drills, mechanical shovels, rakes, conveyor belts and rails, elevators, pumps, etc.)

- Lighting (electric, batteries, carbide, etc.)

- Ventilation (extractors and ventilators)

ii) Enrichment

- Mechanical Force (crushers, grinders, vibrators, miscellaneous transporters, centrifugators, pumps, etc.)

- Lighting

- Steam (dryers, etc.)

- Ventilation (extractors and ventilators)

iii) Metallurgy

It is proposed that the same classification adopted for the Industrial Sector be used.

2.2 Sectoral

According to points 2.1.1 to 2.1.3, the energy end-uses considered in this sector are quite varied, and some of them appear in the different subsectors. In order to present the end-uses that can concentrate a large percentage of the sectoral consumption, as well as to take into account the particular subsectoral features, the following classification is proposed:

- Mechanical Force
- Steam
- Direct Heat
- Pumping and Irrigation
- Others
  . Caloric
  . Lighting
  . Refrigeration
  . Electrolysis
  . Others

3. Final Energy, Useful Energy and Efficiencies

The foregoing description of the different end-uses and the stages of the productive process which gives them origin, just as described in the Base Document (Chapter I), permits treatment of the concepts of final energy, useful energy, and efficiency. It will thus be necessary to specify the efficiencies of production for each subsector and each end-use, as suggested for the first stage of application, and the efficiencies of use which determine overall efficiency.

If it is necessary to quantify "measured efficiencies" both for production and use, by means of audits to implement energy conservation mechanisms, it is logical to think that there will be certain activities of those described above for which it will not be necessary to carry out an audit, either because consumption is marginal or because there are combinations of uses, sources, and equipment which cannot be disassociated or substi-

TABLE V.1

DIVISIONS AND GROUPINGS UNDER MAJOR DIVISION 1 AND 2

Division	Grouping	Title
		Major Division 1. Agriculture, Hunting, Forestry and Fishing
11		Agriculture and hunting
	111	Farming
	112	Agricultural services
	113	Ordinary hunting and using traps, repopulation of animals
12		Silviculture and lumbering
	121	Silviculture
	122	Lumbering
13	130	Fishing
		Major Division 2. Exploitation of Mines and Quarries
21	210	Exploitation of coal mines
22	220	Production of crude oil and natural gas
23	230	Extraction of metallic minerals
29	290	Extraction of other minerals

TABLE V.2

Disaggregation of the Agriculture-Fishing-Mining in Subsectors and Their Corresponding ISIC Classification

	SUBSECTOR NAME OLADE METHODOL.	ISIC DIVISION	TITLE
1.	Agriculture	11	Agriculture and Hunting
		12	Silviculture and Lumbering
2.	Fishing	13	Fishing
3.	Mining	23	Extraction of Metal Minerals
		29	Extraction of Other Minerals

tuted for (wind energy in windmills for pumping drinking water to animal troughs).

Furthermore, the efforts to carry out energy audits should concentrate on those stages of the productive process for which there are no specific uses for a source, as well as on the energy-intensive nature of the product.

To measure efficiency of use, it will be necessary to analyze the stages of the productive process of the three subsectors considered, which can be sumamrized as follows:

- Mining and Fishing Subsectors:

  Evidently, it will be more important to consider efficiency of use in integrated processes such as mining and metallurgy and fishing and the fishing industry than in small mining (low degree of mechanization and, therefore, very low energy consumption of inanimate sources) or in fishing. In the two cases cited for integrated processes, the type of measurement to be taken is identical to an industrial audit, since the end-uses under consideration are similar.

  In the case of transportation in fishing per se, there is no practical significance for measuring efficiency of use since it has been included under the Transportation Sector.

- Agriculture Subsector

  In this case, an attempt is made to separate FARM MACHINERY AND TRACTORS from the rest of the end-uses, since they constitute the principal consumer of direct energy in this subsector and since the rest of the end-uses (refrigeration, drying, water heating, etc., i.e., the "process" uses) merit a treatment similar to that of any industrial process.

  Just as in the Transportation Sector, quantification of overall efficiency in the case of the use of FARM MACHINERY AND TRACTORS deserves come clarifications related to the concept of work and the end-use of mechanical force corresponding to farming activities. An attempt is made to provide a method for quantifying EFFICIENCY OF USE, for which purpose the analysis will be limited to the case of tractors used in plowing.

i) The drag developed by the tractor is known as "traction" and the unit of measure will be kg of force. The farming activity which can best serve to illustrate the different factors which have a bearing on traction force is plowing. Specialized literature discusses the concept of the "tilling coefficient" which refers to the traction needed per unit of surface area of the plowed section (kg/dm2 or kg/cm2). This coefficient is determined experimentally in each country or region and is usually tabulated for different types of soil.

For the sake of example, some values are presented in Table V.4.

The tilling coefficient depends, first of all, on soil conditions; it is higher in soils which are irrigated by infiltration than in those irrigated by aspersion. Other factors which influence the value of this coefficient are the specific weight of the soil, the weight of the plow, the speed of plowing, the humidity of the soil and the design of the plow.

Therefore, if what is desired is to measure the traction required by a plow with four 12" disks plowing 15 cm deep in a soil whose tilling coefficient is 0.6 kg/cm2:

- tilling width

  4 x 12" = 4 x 0.30 cm = 1.20 m

- surface area of plowed section:

  120 cm x 15 cm = 1800 cm2

- traction

  F = 1800 cm2 x 0.6 kg/cm2 = 1080 kg

ii) As in the case of the Transportation Sector, the work here would be:

$$T = Fdx \qquad (1)$$

In the example above, if the surface to be plowed were one hectare (ha), then:

- the distance covered in plowing one hectare with a width of 1.20 m is d = 10 000 m2/1.20 m = 8333.3 m

- T = 1080 kg x 8333.3 m = 9 x 106 kgm = 33,3 CVh

This is the work that would be required in the drawbar.

iii) The value for F can also be calculated on the basis of motor output (P), mechanical efficiency (R_1) and plowing speed (V):

$$F = \frac{P \cdot R_1}{V} \qquad (2)$$

Expression (2), in technical units, takes the form:

$$F_{(kg)} = \frac{P_{(cv)} \cdot R_1}{V_{(km/h)} \cdot 0.0037\ (CVh/kgm)} \qquad (2)$$

In referring to the output of a tractor, it is necessary to specify clearly what is being dealt with: motor output, measurements of the pulley or force intake or the measurements of the drawbar. The difference between the first and the second is due to: a) losses due to friction in the tractor transmission; b) rolling resistance and c) skidding.

The rolling resistance of the tractor is the power it needs to keep itself in movement at a given speed, without a load. It depends on: a) the type and state of the soils; b) the load of the axis (the larger the load, the greater the resistance); c) the pressure in the tires (in compacted roads resistance is inversely proportional to pressure, but on worked land it is directly proportional) and d) the size of the wheels, since the greater their diameter, the lesser the resistance (see Table V.3).

Skidding causes losses of power because it reduces the space covered. The greater the traction capacity, the lesser the skidding. The traction force is: 1) directly proportional to the weight of the wheels with drive; 2) direclty proportional to the diameter and width of the tires; 3) inversely proportional to the pressure of the tires on soft soil and 4) dependent on the type of tread.

The relation between the power of the bar and that of the motor is known as the mechanical efficiency of the tractor or traction efficiency and it constitutes what was termed R_1 in the foregoing expression:

$$R_1 = \frac{\text{Power in the bar}}{\text{Power in the motor}} \qquad (3)$$

iv) This efficiency can well be considered as an EFFICIENCY OF USE since it is a function of the conditions of utilization. Table V.3 shows, as an example, some of the values for R_1 for different types of soil; it can be seen that, as the rolling resistance coefficient increases, the mechanical efficiency decreases for average traction.

Continuing with the example, the energy required in the motor will be a function of R_1. Suppose a new field (R_1 = 0.75), the energy required in the motor will be:

$$E(CVh/ha) = \frac{1080\ kg \times 0.037\ (CVh/kgm)}{1.20\ m \times 0.75} = 44.4\ CVh/ha$$

v) The total force along the way will then be the work Fdx equal to useful energy, which could be defined as "the work

needed to accelerate and keep in movement the tractor and farm machinery dragged along behind it, plus the work which comes into play due to the drag force developed by the tractor."

Given that there is no heat engine which absorbs heat from a light bulb at one same temperature and transforms it completely into mechanical force, there will be an efficiency of production to be quantified in order to evaluate the resulting final energy.

Accepting that the final energy which is really used in the farming under consideration is:

$$C\ K\ dx \qquad (4)$$

where:

- C - specific consumption (lt/km)
- K - calorific value of the fuel (Kcal/lt)
- dx - tractor displacement (m)

overall efficiency will be:

$$R = \frac{Fdx}{CKdx} \qquad (5)$$

where F will be:

$$F = \frac{P\ R_1\ R_2}{V} \qquad (6)$$

On the basis of points i) through v), particularly point iv), it is possible to deduce that in the case of the agricultural sector, the efficiencies of use cannot always be measured for farm machinery and tractors, since the efficiency (Rl) is basically determined by soil conditions, which can be modified very little and do not lend themselves to any implementation of energy conservation whatsoever.

Only in uses other than mechanical force, basically in the caloric uses or processes described under point 2.1.1 of this chapter, it is feasible to take into account the measurement of the efficiencies of use, in which case an indispensable condition will be to analyze the importance that energy consumption has for the end-uses in consideration.

4. BEEU Applied to a Unit

Of the three subsectors analyzed, Mining is perhaps the one which entails the greatest difficulty in terms of allocation of consumption, for its later transfer into the energy balance. Hence, the application of flow diagrams for designing balances for one productive firm or unit is presented below only in the case of the Mining subsector.

In order to make this treatment general, let us begin by assuming that a mining plant-- particularly mining-metallurgical complexes-- can buy and produce energy, whether primary or secondary, for transformation into useful forms (steam, direct heat, mechanical force, etc.). These sources can be disaggregated according to the ones represented in the general summary matrix of the OLADE Energy Balance.

The concept of Net Energy Input (NEI) responds to the energy that enters the establishment, disaggregated by sources. In many cases, the NEI will be equivalent to purchases but, in order to generalize the treatment, the two following situations should be kept in mind:

- that the establishment may sell energy, in which case that energy should be subtracted from the purchases. If there is auto-produced electricity sold to third parties or delivered to the public grid, it may occur that the NEI will be negative. A similar situation may arise with steam.

- that the establishment may auto-produce electricity by means of a hydraulic generator, in which case, although the energy is not bought, it should be accounted for in the balance.

Once the NEI has been determined, the flows for each source should be identified according to the scheme presented in Figure V.1. The first destination of the energy that enters can be Direct Auto-Production of electricity through steam, whether in hydraulic generators, diesel groups or gas turbines. In this case, the hydroenergy and the corresponding energy sources should be subtracted and the electricity bought should be added to that purchased.

Another example of the NEI may be the indirect auto-production through electricity based on steam. This steam comes from recycling in the boiler to feed into the steam turbogenerators; it is therefore necessary to do a boiler balance previously. In the flow diagram, this balance appears afterwards in order to be able to express the steam in terms of the fuels that produce it, subtracting them from the respective NEI and adding the auto-produced electric power to the NEI.

The fuels used in means of transportation outside the mining complex will be accounted for in the Transportation Sector. However, the energy used to move freight or passengers within the mining complex will be accounted for under "Mechanical Force" in this subsector.

Final consumption by sources will thus result from adding to, or subtracting from, the NEI, as necessary:

- direct auto-production
- indirect auto-production
- transportation outside the complex.

This final consumption, when added by sources, can be lower than the NEI; the difference is explained by the fact that part of these flows should form part of supply (case of auto-production) or part of another consumption sector (in this case, the Transportation Sector).

Table V.5 shows a type of auxiliary data sheet in line with the disaggregation of energy sources in the OLADE methodology, and contains details on final consumption and a series of data for calculating useful energy.

On the basis of these auxiliary sheets for each establishment, it is possible to generate final consumption and useful consumption by sources and end-uses in the subsector.

TABLE V.3

ROLLING RESISTANCE COEFFICIENTS AND MECHANICAL EFFICIENCIES ON HORIZONTAL SURFACES, FOR VEHICLES WITH PNEUMATIC TREAD

SOIL	CRR[1]	η[2]	CRR/η
Pavement or good dirt road	0.03	0.85	0.035
Fairly good dirt road	0.05*	0.80*	0.062
Field or flat natural pasture	0.06	0.75	0.080
Bumpy terrain	0.10*	0.60	0.167
Soil plowed in terraces, with packed soil	0.25	0.50	0.500
Soil recently plowed or losse sand	0.35	0.40	0.875

* Own estimate.

1 Average values from McKibben, Eugene and J. Brownlee Davidson. "Transport Wheels for Agricultural Machines." Agr. Eng. 20 (12): 469-473. 1939. Keep in mind that the CRR is directly proportional to the inflation pressure, on loose soils, and inversely proportional on firm soils it is inversely proportional to wheel diameter (the data in this table refer to wheels measuring 6.00 x 16 and similar dimensions) and it is directly proportional to the weight borne by the wheels.

2 Values cited from De Dios. Carlos A. "Potencia y energía absorbidas por máquinas de labranza y siembra". Estac. Exp. Agr. Pergamino. INTA, page 8, 1972. These values refer to average traction.

SOURCE: Frank R "Costo y Administacion de la Maquinaria Agrícola"; Editorial Hemisferio Sur; Bs. As. 1977, page 356.

TABLE V.4

ENERGY REQUIRED IN THE TRACTOR ENGINE, FOR PLOWING, AS A FUNCTION OF THE TILLING COEFFICIENT AND DEPTH OF WORK

(Cvh/Ha)

Tilling Coefficient (kg/cm^2)	For mechanical efficiencies of					
	= 0.75 (natural field or pasture) Depth of work (cm)			= 0.50 (plowed soil) Depth of work (cm)		
	10	15	20	10	15	20
0.20	10	15	20	15	22	30
0.40	20	30	39	30	44	59
0.60	30	44	59	44	67	89
0.80	39	59	79	59	89	118
1.00	49	74	99	74	111	148

Reference values for the tilling coefficient for different types of soils:

sandy (e.g., west of the Province of Buenos Aires)	0.30 kg/cm^2
firm (e.g., region of Junin)	0.45 kg/cm^2
firm-claylike (e.g., region of Pergamino)	0.60 kg/cm^2
claylike (e.g., east of the Prov. of Buenos Aires)	0.80 kg/cm^2

For one same soil, the tilling coefficient is inversely proportional to the humidity of the soil and directly proportional to speed (the data given above respond to speeds of > 8 km/h).

SOURCE: Frank. R. op. cit., page 326.

TABLE V.5

AGRICULTURE-FISHING-MINING SECTOR

AUXILIARY DATA SHEET FOR CALCULATING THE CONSUMPTION

OF FINAL AND USEFUL ENERGY IN A UNIT

SOURCES	ENERGY INPUT	AUTOPRODUCTION		EXTERNAL TRANS-PORT	FINAL CONSUMP. BY SOURCES	FINAL CONS.SOURCES & USES				SOURCE EFFICIENCY IN USES			
		DIRECT	INDIRC. STEAM			NET STEAM	DIREC HEAT	MECHAN FORCE	OTHER USES	NET STEAM	DIRECT HEAT	MECHAN. FORCE	OTHER USES
HE													
GN													
CM													
LE													
RV													
EE													
GL													
GM													
KJ													
DO													
FO													
CQ													
CV													
TOTAL													
INTERMEDIATE CONSUMPTION (Production of Useful Forms)													
EFFICIENCIES OF USE													
USEFUL CONSUMPTION													
LOSSES													

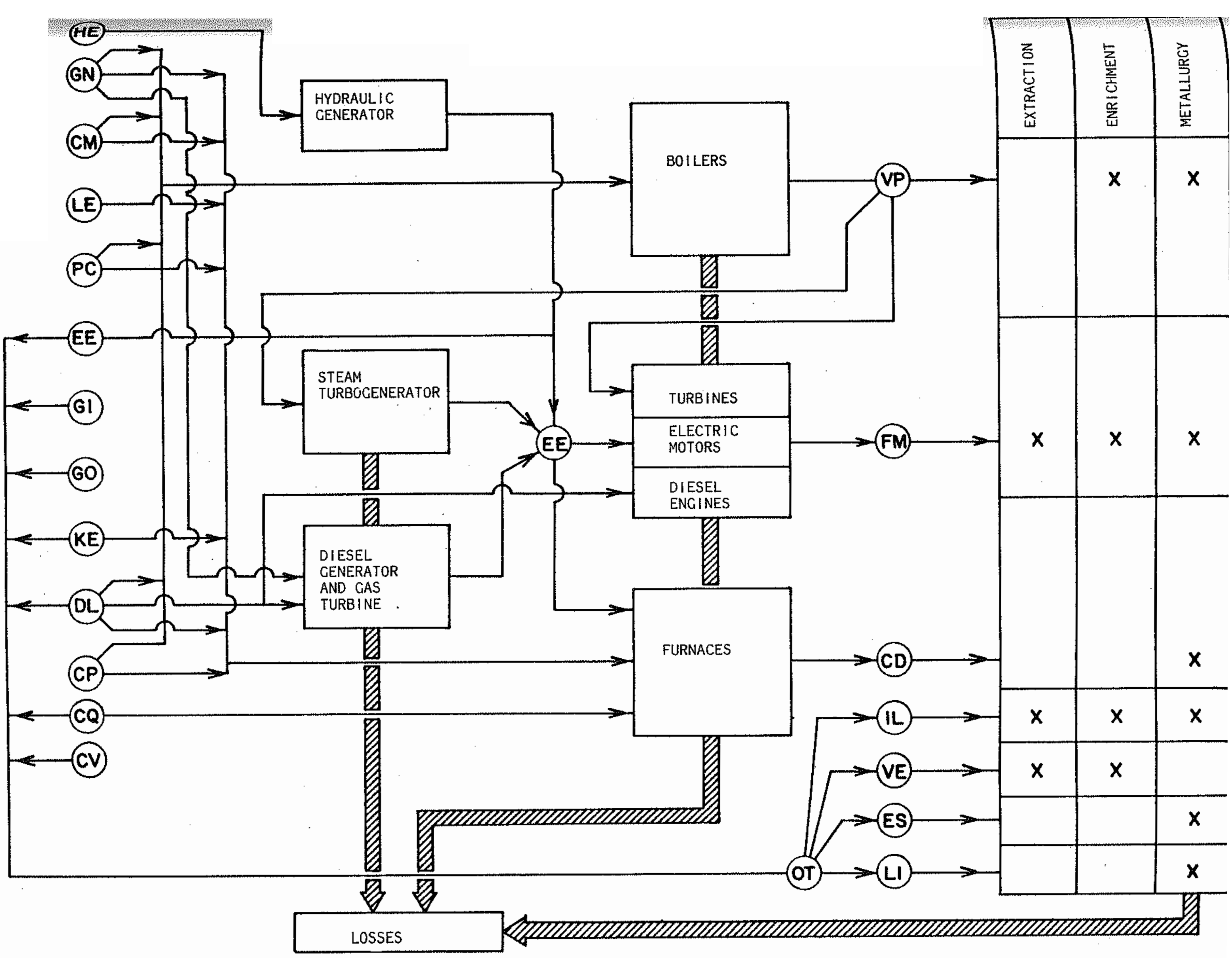

FIGURE VI - ENERGY BALANCE FOR MINING

CHAPTER II

DATABASE FORMATION

1. Data-Collecting Form

In the case of the Agriculture-Fishing-Mining Sector, according to the preceding points, it will be necessary to prepare different information-gathering sheets, given the particular features noted for each one of the subsectors.

In general, it can be said that the contents of the surveys forms are geared to obtaining information on energy consumption by sources and end-uses, and at the same time to detecting the types of equipment associated with that consumption.

It also proves imperative to obtain information on "non-energy" variables for use later in statistical treatments in order to relate energy consumption to the level of activity developed in the subsector, as well as in the treatment of the design, processing and expansion of the sample.

The contents of the sheets for the Agriculture and Mining subsectors will be detailed below; the Fishing subsector has not been included since, from the energy standpoint, it will basically cover the information contained in Modules III to VII of the form for the Industrial Sector.

1.1 Agriculture Subsector

The contents of the questionnaires for this subsector will be substantially different, depending on the activity dealt with, i.e., livestock-raising (*), farming or forestry. In fact, the information to be compiled on the different end-uses and equipment, as well as on non-energy variables, will be quite different depending on products such as coffee, bananas, poultry, milk, etc.

Even though the survey forms should be adapted to the reality of each country, what is presented is a questionnaire which can serve as a reference for agricultural and livestock activities in general.

As for the survey form on agricultural/livestock activities, unlike other sectors, in the unit of information (establishment) there are not different sections with data recorded for each stage of the production process.

(*) See "Survey on Energy Consumption in the Livestock Sector," Energy Sector Division, Costa Rica, December 1985.

The contents of the reference survey comprise three modules. The first two refer to non-energy data such as location, surface area destined to production and under irrigation; volume of production by type of crop for a normal year (if the year of the survey was not a normal year); production of animal and vegetable residues and their destination; livestock production; labor employed and time worked.

The third records energy consumption by end-uses and sources in the different types of equipment that can appear for each use. Unlike in the industrial sector, efficiency values are not included. However, power capacities and hours of use of the different types of equipment must be assigned.

With respect to hours of use, the record does not offer any major drawbacks in equipment using mechanical force, for example tractors and farm machinery. There may, however, be difficulties in estimating hours for some end-uses such as irrigation. In this case questions should be specified on: months of duration of the irrigation, flow, water consumption, etc., from which, in referring to a given crop, given soil conditions and a given power capacity, hours of use can be calculated.

The possibility of recording the consumption of aerial fumigation is included in point 5 of this module (other uses); it should be stressed that this consumption will always be accounted for when not contracted out to third parties.

1.2 Mining Subsector

The contents of the survey for this subsector are divided into five modules, of which the first refers to general data and productive activity.

Modules II to IV records information on energy consumption by sources and end-uses. The disaggregation proposed for these is worthy of mention:

- Description of equipment in the mine and enrichment plant.

- Electricity and fuels consumed in the mine and enrichment plant.

- Fuels used for electricity auto-production.

Furthermore, there is the possibility of recording information on the stages of industrialization or metallurgy mentioned under point 2.1.3 of the previous chapter, for the case in which the surveyed establishment is integrated and energy consumption is included in this subsector. Thus, the following are incorporated:

- Fuels used in steam production and amount of steam produced.
- Direct heat.

- Mechanical force.
- Other uses.

The end-uses incorporated in this case will therefore be those already described in Modules IV and VII of the Industrial Sector.

2. Analysis of Existing Information and Guidelines for Sample Design

To do an assessment of existing information obviously constitutes the first stage of any sample design. This diagnostic should be based on the analysis of information provided by agricultural censuses, general censuses on economic activity (including the Fishing and Mining subsectors), surveys usually done in these subsectors, special studies (even though partial), etc.

The situation that may arise in terms of basic information, which is understood as the information which constitutes the Universe of Reference, varies according to what has been recorded in the countries but, even more, it varies according to the importance that the three subsectors analyzed herein have in the national economy and according to the modes of production detected in each subsector.

The basic information to which reference is made is constituted by the total energy consumption of each subsector, the number of productive establishments for the Agriculture and Mining subsectors, and the establishments as well as the fishing fleet and processing ships in the Fishing subsector.

As for total energy consumption in the subsectors, certain situations may arise because:

- subsectoral consumption is aggregated and usually included in the Industrial Sector.

- energy consumption is known for only one of the subsectors.

- subsectoral consumption is disaggregated into three subsectors.

In the third case, total energy consumption will coincide with that of the universe of reference, in which case a design will have to be made to disaggregate total consumption by sources and end-uses.

The second case is what occurs in countries such as Chile and Peru (perhaps Bolivia also), where there are records on total energy consumption in the Mining Subsector or mining-metallurgy; in the case of Peru also in the Fishing Subsector or fishing industry; in the case of Uruguay in the Agriculture Subsector, etc., records which appear in the publication of the respective national balances.

The presentation of the BEEF prepared by the different countries that show aggregate consumption in these subsectors (which would be the first case presented above) does not necessarily mean that records will not be available with the corresponding disaggregation. For those cases in which consumption seems to be aggregated, and therefore usually included in the Industrial Sector, it is inevitably necessary to proceed with disaggregation prior to the preparation of useful-energy balances.

Necessarily, sectoral and/or subsectoral consumption must be known previously for application of a survey on END-USES, since what is definitely wanted is to quantify the SHARE of each SOURCE in each END-USE for each SUBSECTOR. Actually, as will be seen in greater detail under the next point, the measurement of useful energy consumption in physical quantities (TOE) consists of multiplying total subsectoral consumption (in absolute terms) by a matrix of participation coefficients (%).

Therefore, if records were not available on subsector consumption, the first step would be to quantify it through a survey much more numerous than the survey on end-uses. The design of a sample to quantify total consumption and consumption by sources in these three subsectors depends on the features of each country, basically insofar as the importance of the subsector in the GDP, the type of activities developed in each subsector, etc. Likewise, the survey form will contain only questions referring to the consumption of commercial sources, of the type which figure in points III.6 for the Agriculture subsector and III. for the Mining subsector.

It is also necessary to point out that, according to the information existing on the characteristics of the activity of each subsector and on the modes of production used, there can be more than one type of sample. Therefore, it can be affirmed that there will be experimental samples according to the universe of reference and the activities of each subsector; for example, there can be MECHANIZED and UNMECHANIZED; for the Agriculture subsector, IRRIGATED and UNIRRIGATED, etc., which means having different sampling alternatives.

However, the guidelines for sample design which are proposed below for a survey on end-uses are valid if there is information on energy consumption by subsector, in addition to the non-energy information for each subsector which characterizes the level of economic activity.

The foregoing is also generally valid for the Industrial Sector in terms of the LAW OF ASYMMETRIC PROPORTIONS, in which a very low percentage of establishments accounts for a large percentage of consumption.

On this basis, what is proposed is to do a stratified sample, considering each subsector separately and, within these, to stratify according to their particular characteristics(*). Actually, not only the importance of the participation of END-USES in the total consumption of each subsector is different, but also its nature.

Thus, there is a clear differentiation insofar as the composition of strata in the three subsectors:

- Mining subsector: there are two strata to be considered, depending on whether the establishments are integrated or not. In other words, small and/or medium-size mining is separated from large mining, since the latter (of obligatory inclusion in the sample) will surely not concentrate a substantial percentage of the energy consumption of this subsector, but will present a structure of end-uses very different from that of small and/or medium-size mining. Furthermore, the establishments devoted solely to extraction tasks using unmechanized energy (usually, hand labor for extraction and pack animals for transporting the production), as in the case of certain limestone quarries, etc., will not form part of the universe.

- In the Fishing subsector, it is possible to present two different modes of production, which generate two types of sample designs:

  i) where the activity is "centralized," i.e., that there us a legal entity (establishment or firm) of production, in which case what is proposed is a stratified sample or census if the activity is concentrated in a small number of firms. Stratification will consist of considering the establishments according to the capacity and importance of the fishing fleet and/or according to whether the ships are devoted merely to fishing per se or are processing ships.

  ii) where the activity is "artesanal," in which case there will not be records on establishments but there may be records on ships dedicated to this activity. In this case, a random sample can be done, on the basis of the shipping records available in port offices (naval prefects). In this case, the only energy end-use to be considered will be transportation, since the rest of the end-uses (mechanical force, in particular) is manpower.

  It will not include artesanal fishing using manpower as the only source of energy.

  In order not to repeat the concepts referring to quality of the sample, soundness of the estimators, etc., suffice it to say that for the entire Mining subsector

----

(*) This is valid for the Mining and Agriculture subsectors; however, for the Fishing subsector, and in particular for artesanal fishing, another type of sampling is proposed.

  and for variant a) of the Fishing subsector, all of the conclusions for the sample design of the Industrial Sector are valid.

  iii) For the Agriculture subsector, certain criteria on which to base the design are presented below. For most countries there is information, with a greater or lesser degree of disaggregation, the source of which is: agricultural surveys, specialized surveys, information records from agricultural extension organizations, information records from international organizations (FAO), etc.

This information refers to:

- Personnel occupied on farms and wood plantations.

- For agricultural products, number of farms by size.

- For each crop, number of farms and surface area of lands cultivated with and without irrigation.

- Physical output by crop and efficiencies of production.

- Livestock by size and type of farm.

- Number and power of tractors and farm machinery by size of farm.

All of this information is provided by the Agricultural Census; it can even be disaggregated by biogeographical areas (or natural areas) , whereas the agricultural extension organizations or other public offices (Ministries, Secretaries or Departments of State, etc.) and/or private institutions (cattleraisers association, etc.) can provide part of this information.

What is important to determine in this part of the work is which information will be used for stratification and what the stratification will consist of.

First of all, due to the specifications of this subsector, a dual stratification is proposed, with two categories referring to the type of "activity" and another referring to farm size.

Type of "activity" is understood to be a group of products (crops) normally used in the studies on agrarian economy and also in those on rural energy, with the aim of mainfesting their importance in the value added of the subsector and presenting certain homogeneity from the energy standpoint. Thus, the subsector can be grouped into three principal "activities":

- <u>Annual crops</u> such as cotton, rice, corn, beans, potatoes, wheat, barley, etc.

- <u>Perennial crops</u> such as sugarcane, coffee, etc.

- Livestock-raising, breeding, products of animal origin, e.g., eggs, milk, etc.

The relative importance of each one of these categories depends on the production structure of each country and will obviously be reflected in the energy consumption structure of this subsector.

The second level of stratification is a function of farm size. Even though in the specialized literature the size of the farm refers to whether it is a multi-family, single-family or subsistence farm, it is also necessary to categorize farms according to size:

- surface area under exploitation, for annual and perennial crops. Number of tons produced can also be taken, but this variable is closely correlated to surface area.

- number of heads or productive units in livestock production.

For this second level of stratification, it is difficult to determine the number of strata to be considered, since it will depend on each individual case. There may be cases in which good representativity of the universe may be obtained by taking the three categories all together: let us suppose the number of establishments corresponding to large, medium-size and small farms. There will be some cases in which this division will be insufficient, and others in which it will be excessive.

According to the existing information, it will be possible to determine the number of establishments that account for an important percentage of the value added of each one of the activities. These establishments will be of obligatory inclusion in the sampling and will form a stratum for each one of the three activities. For the rest of the strata, it will be convenient to analyze the products of each activity, according to the reality of each country, thus shaping new strata (let us suppose H) which will represent an important number of establishments. According to the quality of the existing information, the sampling may lead to different variants which are difficult to generalize about.

However, perhaps the most common case may be that of not knowing about the consumption of the products considered under each activity, in which case there will be "H" subuniverses for which the average consumption of each form of energy will be inferred. By doing a simple random sample in each stratum "H", and from the analysis of the variances in the estimators, it will be opted:

- to accept the estimates.
- not to accept the estimates, in which case it will be necessary to increase the sample size or else to reformulate the stratification of the "H" strata.

If regionalization contributes concrete elements to the reduction of variances in estimates, it should form part of the stratification. This will also depend on each study since, whereas

accuracy may increase, costs will also be higher.

3. Guidelines for Data Processing and Sample Expansion

The guidelines for data processing will not be reiterated here, since they are discussed in detail in Chapter 4 of the Base Document, in terms of: software, database, errors in data management, errors in data collection, tests on information consistency, etc.

As for expansion of the sample, this will depend on the type of sampling done and on the properties of the estimators, i.e.:

- if the stratified sample is done with proportional allocation, which is equivalent to saying that the sampling fraction is the same for all of the strata, or if the sample is self-weighted.

- if the sample in the stratum is done on the basis of a simple random sample.

- how the sample size has been determined.

- analysis of the variance in the estimators.

Assuming that all of these clarification have been made, the expansion will depend on each particular case, but in all cases it will be necessary to determine a matrix of average participation for each sources in each end-use for each subsector.

This participation calls for an analysis of expected values (or means) in the sample, such as estimators of the populations expected parameters. These estiamtes will be accepted as long as the estimated variance is acceptable or not rejected on the basis of the tests usually done in these cases.

Not to reject the variability found on the basis of hypothesis testing-- that is, to say that the variance in the estimators is not significant-- implies accepting (always from the statistical point of view) a certain homogeneity in the set of variables dealt with.

In reality, given the stratification proposed for the different subsectors, in principle there should be no major problems insofar as being able to characterize a matrix of shares with minimal variance. In fact, in the Mining subsector, when the integrated complexes are separated from small and medium-size mining enterprises, the consumption of the latter will basically be in mechanical force, whereas integrated industry will practically be of obligatory inclusion.

In the Fishing subsector, with a stratification according to "artesanal" or "centralized" activities, and within these between fishing per se and processing, there will also be separation into strata by end-uses.

Finally, in the Agriculture subsector, the dominant end-use of "annual crops" and "perennial crops" is in mecahnical force for farm machinery, although in some cases its use for irrigation purposes may be important. As for livestock-raising, it is possible to have a certain amount of heterogeneity in end-uses, but it will depend on how diversified the activity is.

Once the participation matrix has been determined, for the calculation of useful energy, it should be kept in mind whether efficiencies of use are available or only efficiencies of production, whether measured or adopted.

In any case, when the shares of the sources under the end-uses are related to efficiencies and strata consumption, the useful consumption of the sources will be obtained.

SURVEY FORM

AGRICULTURAL SUBSECTOR

SURVEY FORM

AGRICULTURAL SUBSECTOR

ACTIVITY: MIXED FARMING

I. GENERAL DATA

a) Name of the establishment ....
....

b) Geographical Location

Landmark ____ Mailing Address ____
Locality ____ Department ____
Municipality ____

II. FARM

1. Rural Farm

a) Farming season (*) ....years
b) Total area under exploitation ....has.
c) Area under cultivation ....has.
d) Area in pasturelands ....has.
e) Area in forestlands ....has.
f) Area under irrigation ....has.
g) Area lying fallow or unutilized ....has.

2. Volume of Agricultural Production

a) Farming season(*): YEAR: ______

b) Was it normal from an agricultural standpoint?
YES ____ NO ____

c) If it was not normal (droughts, excessive rains, lack of labor, etc.), indicated the last normal farming season. YEAR: _____

d) Indicate the area planted, cultivated and harvested for the last farming season or for the last normal farming season, if the last farming season was not normal.

The data in the following chart refer to:

- Last season _____ - Last normal season _____

(*) This is the period to which the survey data will refer.

FARMING SEASON (*)	CROP	AREA PLANTED		AREA CULTIVATED		AREA HARVESTED		VOLUME OF PRODUCTION	
		Unit	Amt.	Unit	Amt.	Unit	Amt.	Unit	Amt.
Year of survey ______(*)	- - - -								
TOTAL									
Normal year ______(*)	- - - -								
TOTAL									

3. Livestock-Raising

a) Is there livestock-raising activity on the farm?
YES ____ NO ____

(Continue with the survey only if the response was "yes".)

b) Indicate if the last year was normal or not from the standpoint of livestock-raising.

Last year normal ____ Last year not normal ____
YEAR: ____

c) How large was the area devoted to livestock-raising last year? ....
....

d) What was the livestock production?

Year of the data in the chart. YEAR: ____

(*) Indicate again the year of the farming season in reference, either "the last" or "the normal".

BREED OF LIVESTOCK	STOCK No. of Heads		AVERAGE WEIGHT on hoof (KG)	
	Survey year ____	Normal year	Survey year ____	Normal year
CATTLE ( ) ( )				
PIGS ( ) ( )				

4. Labor Employed

	Persons Employed	Days per week	Weeks per month	Months per year
AGRICULTURE				
LIVESTOCK				

Shifts Worked: indicate ....

III. ENERGY CONSUMPTION FOR PRODUCTION

1. Farm Machinery

	No.	Make and Model (yr.)	Power cap. (HP)	Hrs. of work/ year	Activity(*)		Fuel Consumption		
					Agro %	Lvstk %	Type	Unit	Amt.
TRACTOR 1									
TRACTOR 2 ______									
HARVESTER 1									
HARVESTER 2 ______									

(*) For agricultural products, indicate % of time for each crop.

2. Irrigation

EQUIP- MENT	AMOUNT	POWER CAP		PUMP FLOW (m^3/h)	HOURS OF USE/ YEAR	ENERGY CONSUMPTION		
		HP	KW			Type	Unit	Amount

3. Water Pumping for Uses Other than Irrigation

EQUIP- MENT	AMOUNT	POWER CAP		PUMP FLOW (m^3/h)	HOURS OF USE/ YEAR	ENERGY CONSUMPTION		
		HP	KW			Type	Unit	Amount

4. Grain Drying and Storage

4.1 Part of the production subject to drying and storage: crop 1 _____ crop 2 _____ crop n _____

4.2 Operating capacity of dryers or silos (m^3)

4.3 Months of operation

4.4 Energy consumption

EQUIP- MENT	POWER CAP		HOURS OF USE/ YEAR	SPECIFIC CONSUMPTION by hour	ENERGY CONSUMPTION		
	HP	KW			Type	Unit	Amount

5. Other End-Uses

EQUIPMENT DESCRIPTION	POWER CAP		HOURS OF USE/ YEAR	ENERGY CONSUMPTION			TYPE OF END-USES Descrip.
	HP	KW		Type	Unit	Amount	

6. Total Energy Purchased

TYPE	UNIT	AMOUNT

SURVEY FORM

MINING SUBSECTOR

SURVEY FORM

MINING SUBSECTOR

BRANCH: Metal___ Non-Metal___ Application Rocks ___

1. GENERAL DATA

1. Name of the establishment ....
....

2. Address ....
....

3. Productive activity

EXTRACTION	ENRICHMENT
a) PRODUCT AMOUNT UNIT	PRODUCT AMOUNT UNIT
b) Do you work on holidays? YES ____ NO ____	Do you work on holidays? YES ____ NO ____
c) Work schedule - Holidays and weekends - Workdays	Work schedule - Holidays and weekends - Workdays
d) Number of employees ______	Number of employees ______

2. EQUIPMENT IN THE MINE AND ENRICHMENT PLANT

TYPE OF EQUIP.	AMT.	CAPACITY		PROD. CAP.		REGIMEN OF USE			FUEL OR ELEC.		
		KW	HP	UNIT	AMT.	DAY (hr)	MONTH (wk)	YEAR (mo)	TYPE	CONSUMP.	
										UNIT	AMT.
Com-pres-sor											
Drill											
Shovel											
Rake											
Buoy											
Mixer											

3. ENERGY PURCHASED AND AUTO-PRODUCED

FUEL	UNIT	AMOUNT	PAID FOR IN YEAR
Natural Gas			
Coal			
Firewood			
Electricity Bought			
Electricity Auto-Produced			
Electricity Sold			
TOTAL Electricity			
Liquefied Gas			
Diesel Oil			
Fuel Oil			

4. FUELS USED FOR AUTO-PRODUCTION

EQUIPMENT	AMOUNT	INSTALLED CAPACITY	ELECTRICITY PRODUCED	FUEL CONSUMPTION		
				TYPE	UNIT	AMOUNT
Diesel Engines						
Gas Turbines						
Steam Turbines						
Others						

5. IN THE CASE OF AN INTEGRATED COMPLEX

5.1 Fuels Used To Produce Steam and Amount of Steam Produced

FUEL	UNIT	AMOUNT
Natural Gas		
Coal		
Vegetable Waste		
Diesel Oil		
Fuel Oil		
Others		

	AMOUNT	PRESSURE	TEMPERATURE
High			
Medium			
Low			
Total Steam in Kcal			

EQUIPMENT IN BOILERS	TYPE	CAPACITY	EFFICIENCY

5.2 Direct Heat

FUEL	UNIT	AMOUNT
Natural Gas		
Coal		
Firewood		
Vegetable Waste		
Electricity		
Kerosene		
Diesel Oil		
Fuel Oil		
EQUIPMENT IN FURNACES - TYPE	CAPACITY	EFFICIENCY

5.3 Mechanical Force

FUEL	UNIT		AMOUNT
Electricity			
Diesel Oil			
Steam			
EQUIPMENT IN MOTORS AND TURBINES	Installed Capacity	Efficiency	Hours of Utilization
Electric Engines			
Diesel Engines			
Steam Turbines			

5.4 Other Uses

FUEL (UNIT)	LIGHTING TRANSPORT	ELECTROLYSIS FEEDSTOCK	OTHERS (SPECIFY)
Natural Gas ( )			
Electricity ( )			
Liquefied Gas ( )			
Gasoline ( )			
Kerosene ( )			
Diesel Oil ( )			
Coke ( )			
Coal ( )			

SECTORAL APPENDIX VI

AUTO-CONSUMPTION SECTOR

INDEX

AUTO-CONSUMPTION SECTOR

CHAPTER I

DEFINITIONS AND BASIC CONCEPTS

The treatment of the auto-consumption sector in the elaboration of useful-energy balances (BEEU) has some particular features of its own, with respect to the other sectors, since within the BEEU the others cover demand, whereas this one forms part of supply.

To facilitate treatment, two netly differentiated parts should be distinguished: (1) TRANSFORMATION and (2) AUTO-CONSUMPTION.

With respect to transformation, the OLADE methodology-- and actually any other methodology-- treats the conversion centers as a balance of input and output flows, out of which automatically emerge transformation losses and efficiencies. In energy planning, these transformation centers are dealt with as a typical problem of supply, with techniques such as simulation or optimization. Since efficiencies and losses are inherent to planning of energy supply, no additional concept such as useful energy is needed to delve into greater depth. Nonetheless, there can be a better disaggregation of efficiencies and an improvement of the database in order to permit suitable estimates, since it would not make sense to be concerned with better energy utilization at the level of consumption sectors without paying due attention to what happens in the transformation centers. However, no matter how important it is, it is a traditional instrument for perfecting balances and does not require new concepts for its implementation.

As for auto-consumption, the situation is different. From a methodological standpoint, auto-consumption can correspond to supply, given that projection techniques correspond to supply models. When a refinery or a gas or oil well development site is designed, auto-consumption is the result of a selection of conversion and production technologies, and has little to do with the techniques for projecting final demand. However, from the point of view of the energy balance, the auto-consumption sector (especially for oil and gas) is a large consumer and the guidelines for end-use do not differ in any way from those of the industrial or mining sector. Auto-consumption is thus of a dual nature, and the concept of useful energy is applicable in its role as a consumption sector. The present methodology has adopted the convention of including the energy sectorš own consumption as a consumption sector, as can be seen in the summary matrix of the balance.

Insofar as the energy sector, the function of this methodology can be visualized as follows: to provide a more detailed treatment of transformation and to apply to auto-consumption a treatment analagous to that of industry or mining.

In order to complete this discussion, it is worthwhile to clarify another aspect which frequently leads to confusion: the flows entering the conversion units are considered as feedstock, as "what is transformed". For its part, auto-consumption (whether from a conversion center or not) is considered as "what is consumed". Therefore, it lends itself to being treated in terms of useful energy with the corresponding losses during use.

1. Disaggregation by Subsectors

The energy sectorš auto-consumption occurs in different stages, one of which is transformation itself. There are important amounts of auto-consumption associated with conversion centers.

Another stage which can be a large consumer is production of primary sources.

The transport of some energy products-- especially fuels-- also accounts for large amounts of consumption. However, it must be kept in mind that the OLADE methodology does not consider hydrocarbon transportation by road, rail or water within the energy sector, but rather within the transportation sector, since it would otherwise be necessary to separate the freight-carrying fleet by type of products; this would require an enormous database effort, which would not make a highly relevant contribution to information and knowledge. In the case of hydrocarbons, only the pipelines are left; these constitute extremely specific means of transportation within the energy sector, and it is obvious that auto-consumption in the pumping stations and pipeline heating systems should form part of this section of the useful-energy balance.

The transmission of electricity does not entail auto-consumption since this form of energy moves freely along the tension lines, except usually for very small consumption in certain electrical control mechanisms which are sometimes installed in the lines. It is evident that the transmission of electricity implies large losses, just as the transportation of fuel in pipelines, ships and trucks also entails losses, although smaller ones than those in the case of electric power. But such losses-- which are included under another part of the balance-- should not be confused with auto-consumption; the concept of useful energy is not applicable to them since they are not associated with a given use or type of equipment. With respect to the balance, these losses function in the same way as the transformation losses. Energy prospecting also has auto-consumption, from a theoretical standpoint; however, given its small magnitude, it does not deserve to be considered as such.

On the basis of the aforesaid, it may be concluded that:

"The consumption related to production, transformation and transportation of energy sources through pipelines is considered auto-consumption."

Therefore, the subsectors are:

- Transformation
- Production
- Pipelines

Production and pipelines may be combined in countries where the latter are not very important.

It should be clarified that fuel storage is generally associated with some one of the three subsectors defined above and cannot therefore be considered as a subsector in itself.

The transformation subsector is automatically subdivided by type of transformation center, and it is desirable to do the same disaggregation under auto-consumption, i.e.:

- Petroleum refineries
- Public power plants
- Auto-producing power plants
- Gas treatment plants
- Charcoal plants
- Coke plants
- Alcohol distilleries
- Other transformation centers
- Other transformations

Public power plants should in turn be divided into the following types:

- Hydro
- Conventional steam turbines
- Gas turbines
- Diesel groups
- Nuclear
- Others

and the auto-producing plants into:

- Hydro
- Conventional steam turbines
- Gas turbines
- Diesel groups

Further breakdown of the electric power balance by type of plant is undoubtedly necessary in the OLADE balance, but it proves imperative for BEEU, which should put the conversion technologies in homogeneous groupings. Transformation efficiencies range from 90% in hydropower plants tapping small heads up to 16% in those with gas turbines, and it is obvious that the overall efficiency of the aggregate electric power sector lacks significance for electricity production efficiency. It is thus proposed that a sub-balance be prepared for the electric power sector, in order to resolve the uncertainty in the current methodologys interpretation of the respective flows and in order to place the countries in a homogeneous situation for the sake of comparisons.

The production (plus pipelines) subsector may be subdivided by primary sources of energy; the respective auto-consumption will thus in turn be subdivided by forms of energy, i.e.:

- Oil and gas
- Nuclear fuels
- Coal
- Others

It is evident that the three primary sources mentioned above will account for most of the auto-consumption in production and pipeline transportation. The other sources such as hydro, bagasse, firewood, etc., will register negligible or non-existent consumption and have therefore been grouped under "Others". One exception might be bagasse drying, if that technology were to come to play an important role in the future. The solar energy or fuel consumed would represent a considerable auto-consumption; but drying would not constitute a new transformation center (and neither would the preparation of nuclear fuels), since there is no clear correlation at the level of the secondary energy which could be generated on the basis of these operations.

There is a clear distinction between what is production of primary sources on the one hand and what is transformation of these into secondary sources on the other. These two processes constitute the large subsectors into which auto-consumption should be disaggregated. This treatment offers the advantage of discounting the tendency to open up new transformation centers, thereby introducing fictitious new secondary sources which are really treated primary sources. In the treatment of primary sources there may be (and there are in fact) transformations of a physical and chemical kind. This does not mean that they should be considered as transformation in the sense of the energy balance; in other words, there is a secondary source with a clearly independent entity working at the level of demand and demand forecasting.

The disaggregation of auto-consumption by energy sources (primary and secondary) is obvious, and corresponds to the columns of the OLADE balance. The most important auto-consumption will undoubtedly be found in the following products:

- Oil
- Natural gas
- Coal
- Electricity
- Diesel oil
- Fuel oil
- Coke gas
- Refinery gas

2. Disaggregation by End-Uses

As a consequence of the concepts already discussed, disaggregation by uses works only for auto-consumption and not for the feedstock used in transformation.

The following end-uses and respective types of equipment are considered:

* Steam	Boilers
* Direct Heat	Ovens
* Mechanical Force	Motors and Pumps
* Others:	
- Lighting	Lamps
- Transportation	Moving equipment
- Refrigeration	Cooling equipment
- Miscellaneous	Miscellaneous

Just as in the mining and industrial sectors, these end-uses represent the energy needs or useful demand of the user belonging to the auto-consumption sector. In the production subsector, the technologies of use are similar to those of mining, with a heavy predominance by mechanical force. Coal mining and petroleum activities will account for the largest consumption corresponding to motors and pumping equipment, used primarily for extraction, transportation and storage of these sources.

In the transformation subsector, the centers of major consumption are petroleum refineries, in which large amounts of steam, direct heat and mechanical force consumption will be found. Electric power plants will mainly register the use of mechanical force.

With respect to what has been termed "transportation" within other uses, an important clarification should be made: this use is associated with "non-specific moving equipment", i.e., those passenger and freight vehicles that circulate around the reservoirs and plants-- no matter whether the load they carry is or is not the primary source under exploitation. This use should be individualized in order to be able to subtract it from the energy sectorš auto-consumption since, methodologically speaking, it corresponds to the transportation sector. The same thing does not occur with the specific transportation equipment such as cranes or specially-designed trucks which usually cover short distances within the mining areas; these correspond to the use of mechanical force, just like conveyor belts.

The reason for this distinction is that transportation as such is not defined as a use in this methodology, but rather it is a final consumption sector characterized by a vehicle park. The only use of the transportation sector is also mechanical force; however, in the auto-consumption sector (just as in industry, agriculture, commerce and mining), there is consumption which corresponds to the transportation sector; hence, the device of individualizing it as a use in order to be able to subtract it from consumption and thus avoid double accounting.

3. Final Energy, Useful Energy and Efficiencies

According to the ideas presented so far, the consumption process in the establishments which comprise the auto-consumption sector may be visualized in two stages:

- The production of steam, heat, mechanical force, lighting, cold, etc., from energy sources.

- The use made of the useful forms produced.

The first stage is characterized by an EFFICIENCY OF PRODUCTION and the second by an EFFICIENCY OF USE. Furthermore, there will be a USEFUL ENERGY PRODUCED and a USEFUL ENERGY CONSUMED. The product of these two efficiencies yields the overall efficiency of each useful form (see Figure VI.1).

In the case of steam, the useful energy produced is measured by the enthalpy of the steam at the boiler outlet; by relating this to the enthalpy of the fuels at the burner inlet, efficiency of production is obtained, which is the efficiency of the boiler taken as a unit. The boiler acts as an external combustion engine. The steam produced must later be piped and will therefore undergo pressure reductions in the expansion valves before arriving at the processes where it is required. In its path along the pipes, losses of different types may occur; among these, mention should be made of: a) temperature reductions because of insufficient insulation of the pipes; b) pressure decreases in the pipes and valves; and c) reductions in mass. As a result, the enthalpy measured at the inlet of the processes is lower than at the boiler outlet, and this is expressed by means of efficiency of use.

FINAL ENERGY →	Systems To Produce Useful Forms of Energy EFFICIENCY OF PRODUCTION	USEFUL ENERGY PRODUCED OR INTERMEDIATE ENERGY →	Systems of Use EFFICIENCY OF USE	USEFUL ENERGY CONSUMED OR AVAILABLE ENERGY →

Figure VI.1 - Simplified BEEU

In the case of ovens and furnaces, heat is produced inside and is used either to heat materials (sensible heat) or to change their physical state (latent heat) or chemical state (reaction heat).

The efficiency of production in this case corresponds to the relation between the enthalpy of the materials at the furnace outlet and the energy content of the fuels fed into the furnace. The efficiency of use is associated with the systems of transmission and the ways in which the energy from these materials is used. Because of the diversity of processes, there is no unique, clear example like the one for boilers. One case of great interest in petroleum refining is crude oil distillation: the efficiency of production is that of the heating oven and the efficiency of use corresponds to the distillation tower.

The mechanical force produced is measured in the shaft of engines (piston or rotary) and it is the work necessary to keep the shaft moving; when it is related to the electricity (or fuel) consumed, we obtain efficiency of production. This mechanical force in the shaft is transmitted by means of different mechanisms up to the processes of utilization. For this reason, new losses occur in association with efficiency of use.

For example, again in the petroleum industry, an enormous amount of mechanical force is used by means of centrifugal pumps: to transport fluids, some of which are very viscous, the efficiency of production is in the pump itself, whereas the efficiency of use depends on the condition of the pipes.

Hence, efficiency of production is a characteristic of the equipment, whereas efficiency of use is related to the systems of transmission and the ways in which the useful energy produced is actually used.

With respect to the subject of energy transformation, it has already been stated that at this level of the balance there is no useful energy but rather primary energy or inputs and secondary energy or production and that efficiency (of transformation) comes from relating output to the respective input. From the methodological standpoint, work continues with overall efficiency in each conversion center, just as in the current balance, with the sole addition of an expanded electric power sector by type of plants, i.e., hydro, steam turbines, gas turbines, nuclear, etc., each one of which has a very different efficiency. The efficiency of large thermoelectric plants (steam turbines and nuclear) could in turn be broken down into components such as steam production (boilers and nuclear reactors), turbine, and generator. Thus, there would be an electric power sub-balance which could well be presented in an auxiliary data-sheet, to identify clearly each type of equipment and its respective efficiency.

It is also worthwhile to note that the construction of BEEU, with the identification-- even though approximate, of the efficiencies of final consumption and auto-consumption, calls for greater rigor in determining transformation efficiencies; these can no longer be mere statistical ratios between inputs and outputs, but must represent the real efficiency of the conversion technologies.

4. BEEU Applied to a Unit

The units of information in the auto-consumption sector are the centers of transformation and the reservoirs. The former are similar to industrial plants and the latter to mining facilities. In order to come up with a useful-energy balance for the auto-consumption of each unit, first of all it is necessary to define the NET ENERGY INPUT (NEI) as the energy which enters the unit, disaggregated by sources. To calculate the NEI, all of the energy inputs must be calculated and all of the outputs must be subtracted. It must be kept in mind that, given its very nature, the auto-consumption sector seldom purchases energy, but rather tends to consume its own products and, for this reason, its consumption has come to be called "auto-consumption". Nonetheless, a refinery or a reservoir area may buy electricity from the grid and even buy fuels from other refineries and/or fields. It may even sell auto-produced electricity, steam and fuels that it usually allocates for auto-consumption, such as refinery gases, heavy residues and coke. Therefore, special care must be taken in computing net input in the NEI, in order to avoid over- or under-accounting.

Once the NEI has been determined, the following must be subtracted:

- the equivalent in fuels of the auto-produced electricity and
- the fuel consumption used in transportation.

We thus arrive at FINAL CONSUMPTION BY ENERGY SOURCE in each unit. This is disaggregated by end-uses and the sum of all of the uses should be approximately equal to final consumption by sources, although it will not be exact.

Figure VI.2 presents an analytical format for these operations. The same format can be used to record efficiency of production under each flow. The sums of the flows by end-use and by source multiplied by these efficiencies permit calculation of what has been called intermediate demand , and multiplication of the latter by efficiencies of use (by use) yields useful consumption and losses.

A format such as the one in Figure VI.2 is, in turn, an excellent way to check for inconsistencies, since it makes it possible to cross-reference among flows. It also offers the advantage of being additive; several formats corresponding to several units or the auto-consumption sector in its entirety may be added together.

One especially difficult case is undoubtedly when a petroleum refinery (and less frequently a gas treatment center) forms part of a petrochemical plant, since the latter is not included in the Auto-Consumption Sector but in the Industrial Sector. No matter how complicated it may be, an attempt should be made to apply the format in Figure VI.2, first to the refinery and then to the petrochemical units, with a careful analysis of recycling for the purpose of calculating the respective NEIs. These integrated refineries usually have steam-cracking and/or steam-reforming plants, on the basis of which the petrochemical processes for the production of aromatics or olefins begin. This is the cut-off point for the application of balances per unit, since everything that goes before these units is "refinery" and everything that comes after them is "petrochemical plant".

In the treatment of natural gas, the situation is easier since, at the same time that condensables are extracted, the ethane flows earmarked for petrochemicals are also separated; sometimes there may be a selective separation of olefins (propylene-butylene) for polymerization.

In the case of coke plants, it should be remembered that the methodology for the Industrial Sector considers furnaces in the latter and not in the Auto-Consumption Sector. Consequently, furnace gas disappears from auto-consumption, leaving coke and coke gas.

Figure VI.2

ANALYTICAL BALANCE SHEET

SOURCES	ENERGY INPUT (*)	AUTOPRODUCTION		USE IN TRANS-PORT	FINAL CONSUMP. BY SOURCES	FINAL CONS. AND (EFFICIENCY) BY SOURCES/USES			
		DIRECT + COKE	BY MEANS OF STEAM			NET STEAM	DIRECT HEAT	MECHANICAL FORCE	OTHER USES
HE									
GN									
PT									
CM									
LE									
RV									
EE									
GL									
GM									
KJ									
DO									
FO									
CQ									
CV									
RC									
TOTAL									
INTERMEDIATE CONSUMPTION (Production of Useful Forms)									
EFFICIENCIES OF USE									
USEFUL CONSUMPTION									
LOSSES									

(*) Total input minus outputs minus variations in stocks.

CHAPTER II

DATABASE FORMATION

In order to arrive at a BEEU for the Auto-Consumption Sector, as defined in this methodology, there are information difficulties of diverse kinds. First of all, it can be said that the idea of a survey or general census should be discarded because of the diversity factor; it is better to group the problems by type and to seek specific solutions.

i) Efficiency of Commercial Energy Transformation Centers

For refineries, alcohol distilleries, gas treatment plants and coke plants integrated into iron and steel plants, a materials (mass) balance should be done plant by plant and effi-ciency should be calculated as efficiency of mass and then efficiency of heat flows. The losses in these units are losses in mass expressed in caloric terms, as well as effi-ciency.

When installations are very complex, as in the case of certain petroleum refineries, it is necessary to adjust flow-accounting methods since over- and under-accounting are very frequent. Another stumbling-block is that numerous flows of intermediate products which never reach the market and which are usually destined to auto-consumption receive a variety of names which do not coincide with the ones used in the balance. Nevertheless, in a mass balance every product, as strange as it may seem, should be compared to some one of the traditional derivatives, for which purpose it is usually sufficient to compare API density or, if more precision is desired, the range of distillation as well.

In hydropower stations, efficiency is the result of relating potential energy at the site (flow x gravity x density x head) to the electricity produced in the generator bars, both expressed in the same units.

For thermoelectric plants, the best thing is to do a heat balance, assigning electricity an enthaply content of 860 Kcal per kWh. The different efficiencies can be found through checks on the enthalpy flows at the outlet of the boiler, turbine and generator.

ii) Electricity Transmission Losses

This subject could not go without mention in this methodol-ogy. As in the case of transformation losses, the electri-city transmission and distribution losses must be accurately determined. The losses which appear in a useful-energy balance should be real, since they occur in one of the fields where there are greater possibilities applying con-servation measures rather than being concerned with effi-ciency of production and use in the consumption sectors. It is also worthwhile to mention the problem of clandestine connections which are often confused with losses but which in practice result in under-billing.

There are countries in which apparent electricity transmis-sion and distriubution losses are far greater than admissi-ble technical limits, and there an effort must be made in the database, to upgrade the information without discounting the possibility of measurements in the field, or even a rigorous survey of the lines.

iii) Efficiency in Non-Commercial Energy Transformation Centers

These mainly refer to charcoal plants and coke plants on an artesanal level, where efficiency must be determined by means of surveys consisting of materials balances and meas-urements of calorific value in some selected units. There is no problem in estimating efficiency in this way, but it is much more difficult to determine installed capacity and therefore primary input and secondary production since the universe of units is usually unknown.

BEEU aid in solving this problem, for they permit a better estimate of charcoal and metallurgical coke consumption. With a sound determination of efficiency, it is possible to make a good estimate of the primary sources (firewood and coke) which feed into the charcoal and coke plants.

iv) Auto-Consumption

The magnitude of auto-consumption by sources and by subsec-tors may usually be discovered by means of an investigation of production centers, pipelines and transformation centers. The energy companies almost always have this information and attention should be paid here too to the products with non-traditional names, in order to avoid underestimates.

v) Disaggregation of Auto-Consumption by End-Uses

In order to do this, it is necessary to run industrial or mining surveys(*), as the case may be. The problem is thus not resolved within the energy sector but, on doing the industrial or mining surveys, the auto-consumption sector is included as an obligatory stratum. The intention here is not to repeat all of the statistical treatment of these surveys which are proper to industry and mining. It will simply be said that, as a result of these, the per-unit bal-ances of Figure VI.2. are obtained. Since it is assumed

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(*) For the contents related to energy, see modules II-VII of the Industrial Sector and modules III and IV of the Mining Sector.

that all of the units comprising the sector have been sampled (at least the large consumers), the balance for the sector as a whole will be the sum of the individual balances.

Given that auto-consumption is concentrated in just a few large consumers, it is not foreseen that it will be necessary to apply sampling techniques, because all of the units will be in the sample.

CHAPTER III

APPLICATIONS

This chapter presents the results obtained for the useful-energy balance of the Auto-Consumption Sector prepared for Brazil by the Ministry of Mines and Energy for 1983.

According to the conceptualization of the OLADE methodology, this useful-energy balance corresponds to energy auto-consumption in the transformation centers. In the Brazilian case, this represents a little over 7% of final energy consumption. The results presented herewith aim to serve as a reference for the proposed methodology; bibliographical references are also included for their consultation by interested countries.

For the purposes of comparisons with the other consumption sectors, the useful-energy balance for this sector basically covers the following stages:

- identification of the end-uses of the different energy sources;
- identification of the consuming equipment and its efficiency;
- evaluation of the destination of final energy, for selected end-uses;
- determination of useful energy consumption by multiplying final energy consumed by the respective efficiency (efficiency of production, according to the methodology proposed by OLADE).

The BEEU was essentially prepared using studies already avaialble in the country. At a complementary level, a survey was done on the centers of petroleum refining and electric power plants, in order to determine the destination of the final energy consumed therein.

The disaggregation by end-uses and the respective equipment was as follows:

- Mechanical force: all types of motors, electric or fuel-driven (including those used for refrigeration and pumping purposes).
- Steam: boilers
- Heating or Direct Heat: stoves and furnaces.

The results obtained in the Brazilian balance are presented in

Tables VI.1 to VI.3:

- Table VI.1

  Consolidated Balance of the Different Energy Sources, Indicating Their Values and Participation in the Consumption of Final Energy and Useful Energy and Their Respective End-Use Efficiency

- Table VI.2

  The same as above, but indicating the results at the level of selected end-uses

- Table VI.3

  Destination of Final Consumption for the Different Energy Sources and Their Respective Efficiency for Selected End-Uses.

TABLE VI.1

ENERGY SECTOR - BRAZIL

FINAL ENERGY AND USEFUL ENERGY

YEAR: 1983

SOURCES	FINAL ENERGY Tcal (1)	%	USEFUL ENERGY Tcal (2)	%	EFFICIENCY (2)/(1) %
NATURAL GAS	4320	6.6	4187	8.5	97
DIESEL	3920	5.3	3520	6.9	90
FUEL OIL	11664	15.9	10379	20.3	89
LPG	130	0.2	108	0.2	83
GAS	2160	2.9	1404	2.8	68
ELECTRICITY	2041	2.9	1836	3.6	90
BAGASSE	33091	45.0	16546	32.4	90
OTHERS	18638	21.3	12928	25.3	83
TOTAL	75964	100	50908	100	67

TABLE VI.2

ENERGY SECTOR - BRAZIL

FINAL ENERGY AND USEFUL ENERGY

YEAR: 1983

END-USES	FINAL ENERGY		USEFUL ENERGY		EFFICIENCY
	Tcal (1)	%	Tcal (2)	%	(2)/(1) %
MECHANICAL FORCE	1970	2.7	1771	3.5	90
STEAM	46669	63.5	26892	52.7	59
DIRECT HEAT	24862	33.8	22378	43.8	90
TOTAL	73461	100	51041	100	69

TABLE VI.3

ENERGY SECTOR - BRAZIL

DESTINATION OF FINAL ENERGY AND EFFICIENCY BY END-USES

(%)

YEAR: 1983

SOURCES	MECHANICAL FORCE		DIRECT HEAT		STEAM	
	PARTICI-PATION	EFFI-CIENCY	PARTICI-PATION	EFFI-CIENCY	PARTICI-PATION	EFFI-CIENCY
NATURAL GAS			77.2	90	22.8	80
DIESEL			91.0	90	9.0	89
FUEL OIL			48.4	90	51.6	88
LPG			80.8	93	19.2	43
GAS					100.0	68
ELECTRICITY	96.7	90			3.3	97
BAGASSE					100.0	90
OTHERS			75.6	90	24.4	60
TOTAL	2.7	90	33.8	90	63.5	58

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SECTOR APPENDIX VII

OTHERS SECTOR

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OTHERS SECTORS

CHAPTER I

DEFINITIONS AND BASIC CONCEPTS

1. Disaggregation by Subsectors

The energy consumption of this sector comprises that of the socioeconomic sectors not considered under previous disaggregations.

The OTHERS Sector substitutes for what was called UNIDENTIFIED CONSUMPTION in the OLADE Methodology as developed until now.

Given that the intention is to evaluate useful energy consumption and, for that purpose it is necessary to have a disaggregation by subsectors, end-uses, sources, etc., the definition of Unidentified Consumption would not allow such disaggregation; therefore, it would not be possible to calculate Useful Energy if that definition were maintained.

The definition contributed by the previous stage of the Methodology read as follows: "Includes that consumption which, given the nature of the information gathered, cannot be placed under the sectors described." (*) This reflects the impossibility of calculating efficiency of production and of end-use.

Actually, the inclusion of Unidentified Consumption may be justified in different ways: lack of fit between supply and consumption values; consumption not considered under any sector; insufficient control over the marketing destination of energy sources, etc.

Thus, it will be necessary to make the utmost effort to detect such imperfections in the current systems for recording energy information.

The new matrix presented in Figure 11 of the Base Document presents a row corresponding to ADJUSTMENTS, in which it is thought convenient to include the differences between the supply balances and the amounts allocated to consumption sectors. In this way, the destination of the primary and/or secondary sources are detected at the level of consumption sectors.

The method of expanding the sectors used in this methodology includes the consumption associated with the residential sector and the primary, secondary and tertiary sectors of the economic system of a country, except for the CONSTRUCTION sector, which corresponds to Major Division 5 of the ISIC Classification. Therefore, the sector "Others" will have the Construction subsector as one component.

(*) OLADE. Energy Balances for Latin America, February 1985. Quito, Ecuador, page 24.

There are also two additional components in the Others Sector:

- consumption associated with unspecified activities which correspond to Major Division 0 of the ISIC classification.
- unclassified consumption, i.e., that which has not been attributed to any of the previously defined sectors.

Hence, the subsectors to be considered in the Others Sector would be:

- Construction
- Major Division 0 of the ISIC
- Unclassified Consumption

The consideration of subsector "Major Division 0 of the ISIC" will be closely related to the weight that this activity holds in determining the GDP, since while the "zero" division is a component in the GDP, its corresponding value added is seldom found. The subsector "Unclassified Consumption" is made up of those energy sources whose destinations are not clearly specified. Thus, even though no strict criterion can be expressed, there will be a reference variable (sales) which will later be broken down into sectors; if there were a difference, it would be assigned to this subsector.

Finally, the "Construction" subsector is computed in determining value added:

The construction of buildings to provide housing, services, or industrial facilities (including assembly of industrial equipment), as well as public works in general, e.g., water dams, port facilities and roadways, transportation infrastructure, shipyards, distilleries, etc., and any other type of construction done by private firms or public authorities.

The work of construction, repairs and demolition carried out in auxiliary fashion by the personnel of a company for their own use is not included if the firm is considered in another economic division; for example, when excavation, clean-up, gallery or well structuring activities are carried out as part of mining activities, etc., which are classified under the Division corresponding to Exploitaton of Mines and Quarries.

According to the organization of the information system, two activities can be distinguished in the construction subsector: public construction and private construction.

Although this disaggregation would not be necessary from the energy standpoint, since there are no substantial differences for either end-uses or sources, there could be differences in terms of the formation of a database.

Thus:

- PUBLIC CONSTRUCTION accounts for the consumption associated with the activities carried out by public authorities in any of their manifestations: national, provincial or municipal governments, decentralized organs and firms (whether work carried out with their own personnel or by means of subcontracting done with private-capital companies).

- PRIVATE CONSTRUCTION accounts for the consumption associated with the activities of the private firms which operate in the country, insofar as residential buildings and other, non-public destinations.

2. Disaggregation by End-Uses

Disaggregation by end-uses depends heavily on the importance that energy consumption has in each subsector considered in each case. Nonetheless, it can be put forward that:

- the end-uses in subsector c) will not be considered, i.e., those in unclassified consumption.

- only in the case of construction, whose energy consumption can be significant, will it be possible to do some kind of expansion of the different uses.

From the energy standpoint, the activities considered in the construction subsector have very similar end-uses, with the predominance of the use of mechanical force in both cases. However, there are other uses such as lighting and direct heat, which, with some differences between public and private construction, may take on a not-so-very-negligible difference.

For the purposes of preparation of the balance, it is proposed that the following end-uses be considered:

- mechanical force
- direct heat
- lighting

These end-uses, or purposes, for which energy is used respond to inherent characteristics. Thus, for example, the use of mechanical force in the case of the Construction subsector and, particularly, in civil structures such as construction of roads, airports, etc., is tied to a special kind of machinery-- levelers, mechanical shovels, rollers, mixers, etc. In the case of private sector activitiy, it will be determined by a very small number of types of equipment, basically mixers and hoists.

As for other end-uses, the case of lighting will be of greater or lesser importance depending on the mode of production and on the conditions of the work under execution (for example, construction of an underground railway, exposed or not, or assembly of turbines and/or mounting of the powerhourse in reinforced concrete for a hydroelectric dam, etc.) Direct heat is basically

used for heating and preparation of the tar or asphalt to be used in a given project, with a relatively marginal importance.

Other types of equipment such as compressors, used for fill-ins and reinforced concrete work under pressure, are obviously included under the use of mechanical force.

Finally, one particular case which deserves mention is that of integrated trucks and mixers which, in principle, could give rise to consideration of another end-use, in this case transportation, but they will not be considered as such, since they are incorporated into the use of mechanical force.

Just as in the other productive sectors, for which the energy needs or useful demand of the user are always determined by the production process, in this case they will also be associated with the level of mechanization in the different activities.

To the extent that human energy is not included in the energy balances, a considerable scatter may appear in useful demand for the uses of mechanical force; this calls for special care in sample design.

3. Final Energy, Useful Energy and Efficiencies

Following the conceptual scheme set forth in the definition of useful energy-- which consists of observing the process of energy consumption in two stages:

- production of heat, mechanical force, etc., by means of the different types of equipment which consume different forms of energy.

- use of heat, mechanical force, etc., in each activity.

Overall efficiency will thus be given by the product of the efficiencies of each one of these stages: efficiency of production and efficiency of use.

The EFFICIENCY OF PRODUCTION will be related to the type of equipment and the source consumed under each end-use defined, whereas the EFFICIENCY OF USE will be related to the utilization process following production of this intermediate form of energy.

The importance of measuring efficiency of use lies in the fact that it constitutes a fundamental element in implementing ENERGY CONSERVATION mechanisms, and thus calls for energy audtis which permit quanitifaction of efficiency.

Furthermore, energy audits should concentrate on those energy-intensive areas for which there are no SPECIFIC USES by SOURCE.

In the case of the Others Sector, whether on the basis of the adopted disaggregation by END-USES or the fact that it is not an energy-intensive activity (considering total energy consumed by a country), it is not deemed necesary to make the effort of quantifying EFFICIENCY OF USE.

Thus, in the first stage of preparation of BEEU, an attempt will be made to quantify the efficiencies of production, for which purpose type of equipment, sources consumed, and end-uses considered will be taken into account.

This calculation will only be done for the Construction subsector. It is very likely that the calculation cannot be done for the subsector "Unspecified Activities" since there can be no universe of reference when the survey is taken, in order to be able to relate uses, sources, and equipment and then determine efficiency of production. In this case, and in the case of the subsector considering "Unclassified Consumption," useful energy will be calculated on the basis of average efficiency.

This average efficiency comes from the following calculations: on the basis of the final consumption of a given source, the subtotal obtained does not account for the subsector of "Unclassified Consumption" (A). The same procedure may be followed at the level of useful energy, in which case a subtotal (B) will be obtained; and the quotient of (B) and (A) will yield the average efficiency to be applied to the final consumption of the subsector of "Unclassified Consumption".

For the sake of example, assume two energy sources: diesel and electricity, whose disaggregated consumption will be expressed in BOE.

SECTOR / SOURCE	FINAL ENERGY DIESEL	FINAL ENERGY ELECTRICITY	USEFUL ENERGY DIESEL	USEFUL ENERGY ELECTRICITY
1. TRANSPORTATION	4,300	--	860	--
2. INDUSTRIAL	2,600	1,400	1,560	1,120
3. RESIDENTIAL	--	1,000	--	700
4. COM/SERV/PUB	700	900	420	720
5. AGRO/FISH/MIN	1,400	80	280	64
6. AUTO-CONSUMP	400	100	240	80
7. OTHERS				
7.1 CONSTRUCTION	600	200	120	160
7.2 UNCLASSIFIED UNSPECIFIED	800(*)	120(*)	a)	b)
8. SUBTOTAL	10,000	3,680	3,480	2,844
9. T O T A L	10,800	3,800	c)	d)

(*) Calculated as difference (9) - (8)

(8) = (1) to (7.1)

a) $= \frac{3,480 \times 800}{10,000} = 278.4$ b) $= \frac{2,844 \times 120}{3,680} = 92.7$

c) $= 3,480 + 278.4$ d) $= 2,844 + 92.7$

4. <u>Energy Balance Applied to A Unit</u>

The analysis of the energy balance applied to a unit is of particular importance in the cases involving construction of large projects, since the company may buy and produce energy, whether primary or secondary, and then transform this into useful forms. These sources may be disaggregated in the way indicated in the general summary matrix of the OLADE Balance.

The concept of Net Energy Input (NEI) responds to the energy which enters the establishment, disaggregated by sources. In many cases, the NEI will be equivalent to the purchases; however, for the purpose of generalizing treatment, it should be noted that there are cases in which the company generates its own electricity. Unlike other sectors, this one does not consider the alternative that the company will sell energy to third parties.

Generally speaking, auto-production in this sector is direct; in other words, through diesel groups or gas turbine sets, in which case it is necessary to subtract the fuels bought for auto-production from the purchases and to add auto-produced electricity to what is taken from the public grid.

The energy sources used in means of transportation (usually for moving materials) outside the project site should be accounted for under the Transportation Sector; however, those fuels used in internal mobilization should be considered under the use of mechanical force in this sector.

When added up by sources, final consumption may be less than the NEI; this difference is brought about by the flows which should form part of the supply due to auto-production.

Table VII.1 is a type of auxiliary data sheet in keeping with the disaggregation by sources of the OLADE Methodology, on the basis of which it is possible to calculate final consumption and a series of data needed for calculating useful energy.

From these auxiliary data sheets it is possible to generate final and useful consumption by subsector end-uses and sources for each establishment.

Finally, it can be seen that, unlike other sectors, in the lower part of Table VII.1 EFFICIENCY OF USE has not been included, since, as explained under the preceding point, it will not be considered in the Construction subsector.

TABLE VII.1

AUXILIARY DATA SHEET FOR CALCULATING THE CONSUMPTION OF FINAL AND USEFUL ENERGY IN A UNIT OF THE CONSTRUCTION SUBSECTOR

SOURCES	ENERGY INPUT	AUTOPRODUCTION	EXTERNAL TRANSPORTATION	FINAL CONSUMPTION BY SOURCES	FINAL CONS. SOURCES & USES				SOURCE EFFICIENCY IN USES			
		DIRECT			DIREC HEAT	LIGHTING	MECHAN FORCE	OTHER USES	DIRECT HEAT	LIGHTING	MECHAN. FORCE	OTHER USES
CM												
LE												
NF												
EE												
GL												
DO												
FO												
TOTAL												
INTERMEDIATE CONSUMPTION (Production of Useful Forms)												
USEFUL CONSUMPTION												
LOSSES												

CHAPTER II

DATABASE FORMATION

In relation to what has been said for the other consumption sectors, the formation of a database for the OTHERS Sector presents some differences and difficulties inherent to its particuar treatment. In fact, both the application of a data sheet to gather information as well as the design of samples and their expansion require previous knowledge about the UNIVERSE OF REFERENCE.

Thus, given the characteristics of the subsectors of Unspecified Activities and Unclassified Consumption, in terms of lack of knowledge about the universe of reference of the latter and the possible lack of knowledge about the universe of the former, it will not be possible to carry out surveys to determine the participation of the end-uses for each source and subsector involved in the calculation of useful energy consumption.

Point 3 of the previous chapter anticipated that useful energy would be calculated for the Construction subsector, by taking efficiencies of production (use-source-equipment) and that the useful energy of the other two sectors would be calculated, on the basis of the resulting average efficiency.

The formation of a database for the Construction subsector is therefore presented herewith. There are two possibilities for covering consumption:

- to take the universe of reference as the establishments, labor employed or surface area built.
- to take the equipment park or fleet.

These possibilities depend on each case of application, and the second alternative particularly depends on degree of concentration. If consumption is to be estimated on the basis of this alternative, a survey should be done on hours of use, power, and specific consumption, just as in the Agriculture subsector for farm machinery.

The formation of a database for the Construction subsector on the basis of the first alternative is presented below.

1. Data-Collecting Form

The Construction subsector offers the particular feature that, although the establishment to be surveyed may have a given location, the consumption may well not take place at that site.

The contents of a data-gathering sheet should then be worked out according to the type of activity and the specific features of the country of application. In any case, a general format is being presented here, with four modules, as can be seen in the survey form for the Construction subsector.

Module I provides general data on the establishment. Note that point c), corresponding to the location, could be substituted for by "location of the construction site(s)".

The second and third modules attempt to account for the energy bought and auto-produced, as well as to characterize the auto-producing equipment and the fuels it consumes.

Finally, Module IV disaggregates energy by END-USES.

2. Analysis of Existing Information

Before doing a sample design, it is necessary to carry out an exhaustive analysis of the existing information, and this implies preparation of a diagnostic. Such an assessment cannot be based on a common criterion which could be generalized to all of the countries. It will depend on each case of application. However, it can be said that the state of information on energy consumption in this subsector, at least as presented in the OLADE Energy Balance, appears to be either very aggregated with another sector (usually the Industrial Sector) or else corresponds to a part of the UNIDENTIFIED CONSUMPTION.

This presentation does not insist that the countries have this information for each sector separately. However, if this were not the case, it should be disaggregated or identified.

If the objective is to determine total consumption in the Construction subsector, prior to the proposed survey of end-uses which is detailed under the following point, there should be a more numerous survey, the aim of which would be to quantify the subsectors energy consumption. The frame of the survey should be the economic censuses (which normally include Construction) or another type of survey of those usually run in the subsector.

The record of information on electricity may be available since its origin is usually Public Services, and subsector consumption may be obtained from the records of the utilities companies. It should be clarified that this occurs in most cases, but there are other cases derived from auto-production (e.g., the case of the large hydroelectric dams whose construction is far away from transmission or distribution lines).

The same thing may occur with some fuels, as in the case of diesel, fuel oil, gasoline, etc., for PUBLIC CONSTRUCTION, since they may appear in the records of the Public Administration or of the private contractor hired for execution of public works.

In any case, this type of survey should have broad coverage; it is easy to carry out and is usually inexpensive.

As for the information which should be available in order to define the Universe of Reference, this is the energy consumption of Construction, and the number of establishments in each subgroup. Work starts from a fairly logical assumption, which is the knowledge about the latter. However, it is necessary to point out that usually the type of activities developed in the Construction subsector are carried on outside the establishment, so that it will be necessary to establish an information-gathering mechanism for non-energy information (basically, labor employed). As for the energy information, the following alternatives may arise:

i) Energy consumption is not known by subsector.

ii) Consumption of electricity supplied by Public Services is known, but fuel consumption in the subsector is not.

iii) Energy consumption is known.

The third case will most likely have to be discounted in the countries of Latin America, where the most common case may be the first and, to a lesser extent, the second, as long as records can be obtained on total subsector consumption (either because it is available or because the previously mentioned survey on total subsector consumption was carried out).

The second case implies the existence of records on the basis of which the electricity invoiced to each subsector is known, together with some information on fuel sales made to certain establishments in the subsector. As for electricity consumption, the mechanism for obtaining the information refers to the records on USERS SUCH AS CONSTRUCTION FIRMS, since this category of users is normally considered apart from the rest of the users (when a construction begins on a lot without a meter, the construction firm requests the connection as a construction plant user, and this status ends when the final permit for outfitting the site has been granted).

There may also be the possibility of having information on fuel consumption from the records of the distributors.

These records constitute invaluable information for the sample design, especially in the case of electricity, at the same time constituting an element of basic control for the expansion of the sample on energy end-uses.

One particular case of analysis is the construction done to expand residences, about which little is recorded both from the energy and the non-energy standpoints. It can be foreseen that the energy consumption associated with these activities would not be accounted for because:

- In most cases, the use of mechanical force is only supplied by hand labor (manpower), in which case the failure to consider it does not create any problem. There is also the possibility that it can be covered by electricity (usually accounted for in the Residential Sector), but these cases are so few and far between that they will not merit any treatment.

- The number of "establishments" or "labor employed" is unknown; therefore, the Universe is unknown. This implies the impossibility of any sampling.

3. <u>Guidelines for Sample Design and Expansion</u>

The guidelines for designing a sample on consumption by END-USES will be based on the assumption that energy consumption is known by subsector and that the number of establishments is known by type of activity (public and private), together with the most relevant economic variables (value added, labor employed, etc.)

By dividing the population under study into two activities which are homogeneous from an energy standpoint, and by observing a certain amount of concentration in the consumption of the establishments termed "large", it is proposed to carry out a stratified sample.

Before forming the strata, it is necessary to specify that there will be certain activities which will not form part of the sampling. Such is the case of PUBLIC ENTITIES, e.g., those which are devoted to road construction (at the national or provincial level), for which energy consumption is known by sources; the TRANSNATIONAL COMPANIES, which usually operate under contracts for large projects; and the aforementioned building onto existing homes, for which there are no records on surface area or consumption.

If the total surface area built is known, it should be taken as a stratification variable, the universe of reference being square meters of construction. This information, in some cases of the two subpopulations, particularly private construction, can be obtained from records in the institutions which represent this activity: builders associations, professional associations, etc.

Nonetheless, the possibility that the information on the universe of reference will not be available at the level of total m(2) built should not be overlooked. In this case, what is proposed is to adopt "labor employed" as a stratification variable.

The formation of the strata will depend on the degree of concentration presented by the two activities at the level of the contribution made to value added by the number of establishments registered. In any case, in an attempt to generalize the guidelines, it is proposed that there be a division into two strata: one of obligatory inclusion in the sample, made up by the establishments which are large energy consumers, working from the hypothesis that the large energy consumers will be those whose labor exceeds a given number of workers; and the rest of the strata, in which there will be a division according to subsectors, i.e., there will be a series of new strata which will contain a considerable number of establishments.

Given that one of the working hypotheses is the lack of knowledge about consumption needed to complete the design, it will be necessary to take samples in each one of the strata into which the population of the "Other Strata" was divided. The universe of reference will no longer be the establishments that are in each group, but rather the subpopulations, for which the average consumption for each source will be estimated, taking for each stratum a simple random sample. If the variance in the estimators proves unacceptable, the process may continue to increase the size of the sample, keeping the same stratification, or a more specific stratification can be done, with a smaller range of variation in the stratification variable utilized.

Later on, estimators are calculated per activity, according to the formulas provided by the stratified sampling; and these are dealt with jointly with the estimators for the stratum of obligatory inclusion. From this will result a second analysis of variance, in order to verify the quality of the estimation.

On the basis of statistical inference, the sample is expanded to the population, using the estimators analyzed previously. The expansion will depend on the type of sample done and on the characteristics of the estimators.

Since the objective under consideration is to measure useful energy consumption by END-USES, in every case it will be necessary to determine an average participation matrix for each source in each use for the two subsectors.

This matrix can be drawn up on the basis of the sample means for each end-use in the two subsectors, as estimators of population expectations. The estimates, based on their variance, will give a certain idea of the heterogeneity existing in each stratum considered.

To determine whether or not there is heterogeneity is equivalent to testing the variance in the sample means obtained for each stratum, by means of hypothesis testing to be defined for each case.

By applying the participation matrix to final subsector consumption, final consumption by end-uses and sources will be obtained. When this is related to the efficiencies of production (measured or adopted) for each source in each end-use, the result will be the intermediate useful energy consumption by source and by end-use, measured at the level of efficiency of production.

SURVEY FORM

CONSTRUCTION SUBSECTOR

SURVEY FORM

CONSTRUCTION SUBSECTOR

I - GENERAL DATA

a) Subsector..

b) Name of Firm ....

c) Location ....

d) Number of Employees ....

e) Work Shifts ....

f) Hours worked per year ....

II - ENERGY BOUGHT AND AUTO-PRODUCED

Fuel	Unit	Amount	$ Paid in a year
Coal			
Firewood			
Charcoal			
Electricity Bought			
Electricity Auto-Produced			
Electricity TOTAL			
Liquefied Gas			
Gas Oil			
Gasoline			
Fuel Oil			
Others			

III - FUELS USED IN AUTO-PRODUCTION IN DIESEL/TURBOGAS GROUPS

Fuel	Unit	Amount	Electricity Produced (kWh)
Diesel Oil			
Gas			
....			
....			
TOTAL			

Equipment	Power Cap.	Efficiency	Hrs. Use/year
Diesel Engines			
Gas Turbines			

IV - ENERGY CONSUMPTION BY END-USES

a) Direct Heat

Fuel	Unit	Amount
Coal		
Firewood		
Fuel Oil		
....		
....		
....		

Equipment Type	Capacity or Power	Efficiency
....	....	....
....	....	....
....	....	....

b) Mechanical Force

Equipment	Installed Capacity	Hrs. of Use/Year	Energy Consumption		Efficiency
			Unit	Amount	
Elec. Motors					
Diesel Engines					
Others					
....					
....					

c) Other Uses

Source (Unit)	Lighting	Others
Electricity ( )		
.... ( )		
.... ( )		
....		