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USEFUL ENERGY BALANCE-SHEETS

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I INTRODUCTION

The energy balance-sheets currently published in the Community are of the 'primary input' type using coal as a reference. They are drawn up by converting the various sources of energy into their energy equivalents at the primary input level. This system means that the quantities consumed are expressed in terms of the calorific value of the energy needed at the primary input level to meet final consumption requirements. The result is that when one form of energy is transformed into another, losses during transformation are not recorded. Compiling the balance-sheets in this way no longer seems to meet the needs of economic analysis fully. Recent trends in energy policy in the wake of the 1973 oil crisis call for a more detailed knowledge of the amount of energy actually used for transformation and by final consumers. Work on energy-saving and demand analyses and forecasts has made it necessary to know the exact losses of energy which occur during the various stages of transformation and consumption and thus the actual energy consumed, i.e. 'useful energy'.

For these purposes the present balance-sheets - drawn up and valid purely from the primary input standpoint - have several drawbacks. They tackle the problem solely from the producers' point of view, thereby failing to take account of the importance of consumption, obscuring losses, favouring certain forms of energy because of the equivalence conversion method and using a unit of measurement of thermal equivalence which has a variable and non-transitive definition.

An endeavour must therefore be made to improve the above system and to overcome these drawbacks if the new analysis requirements are to be met more effectively. The aim is to calculate 'useful energy', i.e. to record the amount of energy actually used by the final consumer to cover his requirements.

In order to achieve this, the present primary input balance-sheets must first be converted into 'energy supplied' balance-sheets, i.e. calculate energy actually delivered to the final consumers'door. Useful energy is then calculated by multiplying this quantity by the efficiency of the final apparatus used by the final consumer.

This entails the observation of a number of principles.

II PRINCIPLES

It is necessary to :

- observe the First Law of Thermodynamics, which states that the energy in a closed system remains constant, i.e. the equation : input = output + losses. A consumer cannot obtain more energy than that contained in the resources placed at his disposal;

- treat all sources of energy on an equal footing, which means applying precise equivalents and conversion factors to them and using the same balance system for all of them in order to make it possible to add the totals together and to obtain a better picture of the effects of substitutions;

- use a unit of measure which is neutral, general and transitive, and therefore suitable for the measurement of all forms of energy (heat, motion, radiation, etc.) and all energy sources (coal, oil, gas, electricity, etc.) in order to obtain addable figures;

- monitor all energy flows from creation to final use, showing all intermediate operations;

- record, in addition to losses, the quantities of energy required for all operations throughout the energy flow, in other words show separately energy used in the extraction, production, preparation and transformation of energy sources and possibly their transportation to the final consumer;

- consider operations within given limits of time and space. This means applying the principle of territoriality, according to which operations which take place within the geographical limits of the country in question are included in the balance-sheets irrespective of the nationality or objectives of the economic agents. Any loss which occurs before or after the frontier is crossed is thus not included in the balance-sheet of the country under consideration.

- consider all the countries on an equal footing so that comparisons can be drawn internationally and an overall Community balance-sheet compiled. This once again means identical recording of all energy sources (without which comparisons between two countries with different energy source structures would be invalid)and also consistency in foreign trade (in particular, no change in the calorific power of an energy source when a frontier is crossed);

- obtain a set of statistics which can be computer-processed: this requires the consistency of all the vertical and horizontal lines of the balance-sheet as well as the elimination of non-sequiturs and loops, which are often rejected by the computer.

A balance-sheet based on these principles will make it possible to :

a) describe the actual situation, without making any a priori assumptions;
b) proceed from production to final use of the energy by the final consumer, without gap, and conversely to work backwards as far as primary input;
c) calculate the losses for each of the possible sub-flows throught the energy flow;
d) compare losses and efficiencies at any level and determine the values of any substitutions;
e) present the results with a view to rational utilization of energy;
f) incorporate any new source of energy without destroying the

coherence of the system and without requiring any changes other than in presentation;

g) provide a sort of concrete economic model, thus facilitating the observation of the effects produced by varying one or more values.

III PRESENTATION

The general presentation of these balance-sheets is modelled on that of double-entry tables. The columns show the various sources of energy by type of product. The rows show all the operations to which these sources are subjected, and thus correspond to the balance-sheet system, which describes the energy flow. The number of columns may vary according to the sources of energy used in a given country, whereas the number of lines is in principle constant and corresponds to the system adopted, which is the same for all the countries.

The results are aggregated in the overall-balance-sheet table, expressed in a common unit and addable in both directions. This overall balance-sheet is supplemented by tables in specific units relating to each source of energy, which can thus be added by columns only.

Transformations raise a problem of presentation, because, by definition, the products obtained are different from those fed in. Inputs and outputs are therefore shown in different columns of the tables and, as several products may be shown as inputs and/or outputs, it becomes difficult to reconstruct the transformation process.

The simplest solution is to draw up subsidiary transformation balance-sheets, one for each transformer of energy. These balance-sheets show, for each transformer, all inputs and outputs, together with the losses occurring during the operation.

In addition, the quantities of energy needed for the transformation process are shown incidentally (this corresponds to a certain proportion of the consumption of the energy sector). The transformation balance-sheets are expressed in specific units and in a common energy unit.

The balance-sheet of the process can only be ensured and checked and losses calculated on the basis of the energy unit (this again means using a fully transitive unit). It thus becomes possible to calculate percentage losses and to obtain a wide variety of technical coefficients, which will subsequently be very useful for the purposes of monitoring the various branches in the energy flow, together with their respective efficiencies.

Other tables derived from the overall balance-sheets are presented separately for reasons of convenience, e.g. a crossed table showing the consumption of the energy sector and a table which gives a detailed breakdown of final consumption. The important thing is that all these tables fit together to form a coherent and practical whole.

IV BREAKDOWN BY SOURCE OF ENERGY

As the sources of energy have an effect on the results, particularly on losses and useful energy, the breakdown must be as complete and objective as possible.

Initially, the following breakdown is proposed:

- hard coal (including recoveries and low-grade products)
- patent fuel
- coke (hard coke, gas works coke and coke breeze)
- lignite (black lignite or brown coal)
- brown coal briquettes (including lignite coke and dried brown coal)
- tar, pitch and benzol (coking plant by-products)
- crude oil (including semi-refined petroleum)
- refinery gas
- liquefied petroleum gases (propane, butane)
- motor spirits (including aviation spirit)
- kerosines and jet fuels
- naphthas
- gas diesel oil ($<$ 115" Redwood)
- residual fuel oils ($\geq$ 115" Redwood)
- petroleum coke
- other refined petroleum products (white spirit, industrial spirits, lubricants, bitumen, waxes, paraffins, etc.)
- natural gas (including methane and sewage gas)
- coke-oven gas
- blast-furnace gas
- gasworks gas (including water gas)
- other fuels (household refuse and waste)
- heat
- electricity.

Some of these energy sources are primary sources (as found in the natural state), others are secondary (the result of a transformation).

The distinction between these two categories is shown in the balance-sheet grid (rows). Some products may be both primary and secondary; for example, there are natural spirits similar to those obtained by refining crude oil. Heat can also be primary, if the source is geothermic, or secondary if steam or hot water is recovered in a thermal power station. The breakdown by energy source is based therefore on the nature of the product, irrespective of its origin or use.

Other sources of energy may subsequently be added to this list, depending on the statistical possibilities, e.g. :

- peat
- wood and wood chips
- radioactive ores or nuclear fuel
- hydroelectric power
- geothermal power

  etc.

The first four would require additional columns, whereas geothermal power would be included as a matter of course in the 'heat' column. The introduction of the last three sources would mean that all electical energy would be considered as a secondary source, which is in fact the case. In this study, nuclear energy has been treated in the following way :

- the gross production of electricity from nuclear reactors is entered on the appropriate row relating to transformation output (in the electricity column)
- the heat released by nuclear fission in the reactors is recorded under transformation input (heat column)
- this same quantity of heat is entered under "resources" in the "heat" balance-sheet either as an import or as a primary product, depending on the origin of the uranium which has undergone fission and from which this energy production in the form of heat is derived.

The heat thus entered in the balance corresponds to a quantity of available energy obtained from the fission of uranium during the year under consideration. The snag in this procedure is that it disregards stock variations. Uranium which has been transformed into electricity via heat might actually have been produced or imported in a previous year and kept in store until its use in a nuclear reactor. This procedure, which has the advantage of simplicity, could be replaced by a more detailed statistical treatment of nuclear fuels when a solution is found.

The inclusion of one of the new types of energy poses some problems, however, namely heat pumps, which are likely to be developed in the near future. A heat pump with a compressor driven by an electric motor has a mechanical efficiency of 95% for the motor and 93% for the heat-conveying fluid system, i.e. 88% overall. However, the measured useful energy produced by the apparatus turns out to be greater than the energy input, i.e. consumed during operation (Kelvin's paradox). The coefficient of performance is thus 200-300% (1) , the principle being based on a transfer of calories between a cold external source and a hot internal source (thermodynamically, the system is not closed).

In order to take this into account, it is proposed that the heat transferred be entered under primary production in the 'heat' column of the balance-sheet, since it is a calorific energy drawn from natural sources, i.e. ambient water or air.

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(1) A consumption of 100 kJ for operation of a heat pump gives 200-300 kJ in the form of heat which can be used for heating, for example.

V THE BALANCE-SHEET SYSTEM

As stated above, the aim of the balance-sheet system is to make it possible to describe energy flows by enumerating the operations to which the energy sources are subjected. Before going any further, four main functions may be distinguished in this respect :

1) Extraction function : creation of the primary energy sources (drawn from nature)

2) Transformation function : physical or chemical modification of the energy sources to make them more suitable for transport or consumption

3) Distribution function : movement of the energy sources in time and space in order to make them available for use (storage and transport)

4) Utilization function : final transformation of the energy sources by the final consumer.

On the basis of these functions, the following balance-sheet system was chosen :

- primary production	(1)
- imports (primary (secondary	(3)
- exports	(3)
- stocks movements *	(3)
- transformation input	(2)
- transformation output	(2)
- exchanges and transfers	(3)
- losses during distribution	(3)
- bunkers	(3)(4)
- energy sector consumption	(4)
- non-energy consumption	(4)
- final energy consumption	(4)
(energy supplied (useful energy	(1)...(4)functions

* (+) decrease in stock, (-) increase in stock

The results must be inserted in this system according to functional or technical criteria and not institutional or legal criteria. It is the actual operation conducted on the energy source which must serve as a guide and not the nature of the operator. This means that any quantity of primary source energy extracted must be entered in the "primary production" row, even if this production is not the work of a professional producer. In this way, all coking plants and electric power stations, for example, must be considered as energy transformers (for such is their technical function), even if the plants themselves belong to an oil producer, a branch of the steel industry or to any other private or public undertaking whose main activity is not energy transformation.

In the overall balance-sheet, production from secondary sources is entered under transformation output. In the specific balance-sheets, secondary production can take the place of the first row.

Final energy consumption is broken down by major sectors (industry, transport, households and equivalent) and further broken down by types of appliance or technologies in order to facilitate calculation of the useful energy.

A variety of intermediate totals are obviously possible, notably working from the top to obtain "availabilities" and from the bottom to obtain "total consumption", any difference between the two giving the statistical difference.

Losses are shown : 1) by the difference between transformation inputs and outputs; 2) during distribution; 3) by the difference between "energy supplied" and useful energy. In addition, the "energy sector" row shows the energy consumed to produce or to transform the energy. All the data relating to the energy budget are thus available.

Transformation inputs and outputs are broken down according to the number of transformers operating in the country in question.

Certain rows of the balance-sheet require some explanation. Primary production means any extraction of energy from natural sources : coal, gas or oil deposits, sensible heat contained in the ground, water or air, radioactive ores, water or tidal power, wood, wind, solar radiation.

Provisionally, and by way of exception to the definitions, electrical energy of hydraulic, nuclear and geothermal origin is regarded as primary energy. Recovered waste (e.g. household refuse) is classed as a primary source, like coal or crude oil, because it appears in the energy balance for the first time. Under imports and exports all movements of energy sources across the frontiers of the country concerned, apart from direct transit without transformation, are to be recorded. These data refer therefore to general trade and not to the special trade of customs statistics.

The "stocks" row records, as far as possible, the changes in the stocks held by producers, transformers, importers, dealers and other agents, and consumers. "Exchanges and transfers" record mixtures of energy sources without transformation. The row "available for consumption" is derived from the algebraic sum of all the above rows. It is calculated excluding distribution losses in the network. It therefore gives the actual energy made available to consumers.

"Bunkers" refers to the quantities stored on board sea-going vessels, whatever their flag, for consumption purposes. Aircraft tanks are included in final energy consumption. The quantities of energy stored in ships'bunkers may, depending on the point of view, be either regarded as exports or classed as consumption.

The consumption of the energy sector covers the energy consumption of producers and transformers of energy for operating their plants; it naturally covers not only the energy produced by these consumers themselves but also the energy they receive.

Non-energy consumption eliminates from the balance sheet all uses of a non-energy nature, e.g. lubrication, road surfacing and charges for chemical synthesis, the efficiency of which is not calculated because it is regarded as being outside the energy budget as such. **On the other hand, the energy consumption of the chemical industry is definitely part of the final energy consumption shown in the balance sheet.**
The row "final consumption of energy as supplied to the final consumer" records the energy flow before the final transformation at final consumer level. The row "final consumption in terms of useful energy" records the energy obtained after the final transformation by the final consumer.

In two cases only **can there be** equilibrium in practice between the energy supplied to the final consumer and useful energy. These relate firstly to natural heat (e.g. geothermic heat) used as such and secondly to heat recovered in electric power stations and supplied as such to the consumer.

This type of balance sheet system respects the basic principles set out in chapter II.

VI UNITS OF MEASUREMENT

The specific balance-sheets of energy source are presented in the unit of measure currently used for commercial transactions, thus facilitating statistical returns and checking of the veracity of the results. Except in rare cases, this should not involve any conversion calculation.
The specific balance-sheets relating to solid or liquid fuels are thus presented in metric tonnes, regardless of the quality of the energy provided by the product. Electricity is recorded in kwh and gases should be given in m3. This is very important from a practical point of view if accurate basic data are to be obtained. The calculations for conversion to the common unit **with a** view to constructing the overall balance-sheet can only be carried out when the specific unit balance-sheet is considered correct and balanced.

This means discontinuing basic balance-sheets expressed in tce or tpe, which already include conversion calculations and which are difficult to check and use (in this study it was not possible to use the coal balance-sheets expressed in tce). Conversion to the common unit must be carried out from these sound bases.

According to the principles stated in chapter II, the common unit of energy must be neutral, general and transitive. The joule fulfils these conditions and also complies with Council Directive No 71/354/EEC of 18 October 1971.

The kilojoule ist defined as follows:

the work produced by one sthene when its point of application moves by 1 m in the axis of the force (1 sthene : force which imparts to a mass of 1 t an acceleration of 1 m/sec^2) (i.e. 1 joule : 1 watt/sec).

From this the following equivalents may be deduced:

	kJoule	kcal	kWh	1 000 kgm
kJoule	1	0.2390	0.0002777	0.102
kcal	4.186	1	0.00 116	0.426
kWh	3.600	860	1	367.20
1 000 kgm	9.81	2.34	0.00272	1

VII CONVERSION COEFFICIENTS

The foregoing shows that the coefficients of conversion from specific units to the common unit are important for the success of an overall energy balance-sheet. A table of conversion coefficients is given in the annex. They are calculated in accordance with methods which are outlined briefly below.

The starting point was the actual calorific value of each energy source at the time of consumption, since the calorific value of a product is only known at the time it is used, either for transformation or for final consumption. Most analyses are carried out at this stage. This procedure corresponds to the consumers viewpoint, which is the most suitable for the purposes of useful energy. The calorific values recorded reflect therefore the state in which the product is delivered to the consumer.

It is never therefore a pure product but a commodity containing water, inert matter and other impurities. This is also in line with the way in which quantities are measured or weighed in the basic statistics expressed in specific units.

With the same view in mind, all the conversion coefficients were calculated on the basis of the net calorific value (NCV), which is nearer to the energy which can actually be used than the gross calorific value (GCV). The difference between the two may be as much as 10%. In the case of coal, the "NCV as delivered" was used.

Generally speaking, the products have a stable chemical composition, with a constant calorific value. On the other hand, certain primary sources (coal, lignite, crude oil) have variable characteristics and therefore a fluctuating calorific value. This problem was solved in the simplest and most pragmatic way possible.

80 % of coal, 95 % of lignite and 100 % of crude oil are transformed and the calorific value is always monitored during the transformation operation, either on input of the raw material or on output of the derived products.

A few additional data are therefore all that is needed to determine, by weighted average, the calorific value of the primary sources involved. This does not require a special survey and ensures the coherence of the balance-sheets (endogenous variable). The calorific value of changes in stocks is determined by the calorific value of the product normally used by the holder. Thus, the calorific value of coking coal is applied to changes in stocks held at coking plants, etc.

These methods lead, without ambiguity or difficulty, to actual calorific values for each product and for each type of use in the case of a primary product of variable quality, and give conversion coefficients which ensure the coherence of the overall balance-sheet.

VIII METHOD OF CONSTRUCTING THE BALANCE-SHEET

The balance-sheets in specific units for each energy source constitute the starting point. These balance-sheets were checked and considered correct, after the statistical difference had been reduced to the minimum. In order to complete the next stage (conversion to the common unit), subsidiary transformation balance-sheets must first be drawn up. Approximately 80 % of the energy used is transformed. The drawing up of transformation balance-sheets therefore provides the essential key to the subsequent stages. These balance-sheets make it possible to ensure that inputs and outputs tally, to check the calorific values and therefore the conversion coefficients, to calculate losses and check their accuracy, and to trace the connection between the various sources of energy which are derived from one another.

This work is of prime importance and points to an important conclusion regarding methodology: an overall energy balance-sheet should not be drawn up unless complete and accurate transformation balance-sheets have been drawn up first. It is evident that current statistical surveys are scarcely conducted along these lines. They favour information on one source of energy without relating it to other sources, with the result that it is very difficult to reconstruct the transformation operations. In future, priority should be given to returns relating to transformation. Balance-sheets for final consumption cannot be drawn up until all the transformation balance-sheets have been completed.

These balance-sheets, drawn up for each transformer, are shown in tabular form in the annex, with appropriate explanations. By "transformer" is meant any undertaking which effects a physical or chemical change on an energy source before its supply to the final consumer. Transformers are therefore intermediaries in the energy flow.

Consequently, the final energy transformation which takes place at final consumer level (coal burnt in a boiler, petrol consumed in a motor car etc.) is not the intermediate activity of a "transformer". This results from the principles and general definitions of the balance sheet and is compatible with the system described in chapter V.

In order to obtain a coherent result, the following procedure is therefore followed: specific balance-sheets - transformation balance-sheets - overall balance-sheet in a common unit. Once the transformation balance-sheet stage has been completed, the rest of the work consists mainly in applying the conversion coefficients, a purely arithmetical task which does not present any difficulty.

As the conversion coefficients are based on the actual energy content of the products as delivered to the consumer, this gives rise to the concept of "supplied energy".

Thus, for example, the energy value of 1 t of coke is not equal to that of 1 t of coal, the energy value of 1 t of fuel oil is not equal to that of 1 t of crude oil, the energy value of 1 GWh of electricity is not calculated on the basis of the calories burnt to produce 1 GWh, etc. It is on this point that the balance-sheet diverges from those of the primary input type, which equated the energy value of the derived products with that of the primary inputs.

Once the 'supplied energy' results have been obtained, the next stage is to record operations involving the final transformation of the energy by the final consumer, which means calculating consumption efficiencies. This is a completely new and difficult field requiring highly developed methods, which are presented in the following chapters.

IX EFFICIENCY AT THE FINAL CONSUMER STAGE

Taking account of the precise but fairly restrictive definition given for useful energy, the efficiency to be calculated and recorded in the balance sheet will correspond to that of the final transformation of the energy at final consumer stage.

This study is limited by choice to the energy flows and makes no attempt to record efficiencies and losses in all the flows of non-energy goods and services. It is clear that the efficiencies and losses which occur at this later stage influence the demand and consumption of energy. It is also clear that energy can also be saved at this stage by improving the systems of production, distribution and consumption of the non-energy goods and services. This should be the subject of supplementary studies, the results of which cannot be included in a true energy balance sheet. To cite a concrete example, this study takes account of the efficiency and therefore the losses of heating boilers since these are quite definitely energy appliances in which the final transformation of the energy takes place.

On the other hand, it does not take account of calorific losses due to the poor insulation of dwellings although such losses influence the demand for energy and can be reduced in order to economize. Dwellings are not considered as energy-transforming energy appliances. On the contrary, the dwelling is a non-energy product and service which consumes energy by means of appliances such as boilers, motors, electric bulbs etc., in order to fulfil its function of housing the population.

As the objectives of the balance-sheet are economic and statistical, the energy situation must always be regarded from a practical and realistic point of view. It is not a question of applying theoretical efficiencies but of recording actual efficiencies. Having said this, the concept of efficiency is specifically linked to an 'appliance' which uses energy for a certain purpose.

It is thus the appliance which will have a certain efficiency and from which it will be possible to measure energy inputs and outputs. If there is no appliance, the concept of efficiency becomes theoretical, abstract and devoid of economic and statistical significance. Useful energy is thus the energy produced by an appliance, recovered by the consumer and used for the purpose for which the appliance is designed and used.

In order to determine useful energy it is therefore necessary to :

1) know the main appliances used by final consumers of energy
2) discern the quantities of energy supplied to each of these various appliances
3) know the efficiency of these appliances.

Initially, 30 or so 'appliances' may give a good approximation of the useful energy, without raising too many difficulties for the statistical breakdown of the quantities delivered.

The efficiencies selected for these appliances are shown in a table in the annex. They are average efficiencies, valid for the whole of the range, and therefore applicable to the total figure for quantities delivered. The fact that this average efficiency conceals divergencies of varying magnitude does not affect the calculation of useful energy.

These efficiencies allow for the fact that the appliances do not operate continuously at their optimum rating. They are therefore working efficiencies observed during use over a long period of time and lower than the maximum efficiencies often indicated by manufacturers. This means that losses due to the regulation or faulty adjustment of the appliances have been taken into account. These efficiencies are the result of studies published recently by energy technicians and engineers. Sensible heat (e.g. of smoke or ash) was included in the losses, and therefore deducted from the efficiency, even though it may be recovered. 'Free heat', as it is frequently called, was not included in useful energy. Free heat means here the heat unavoidably given off by an appliance not intended for heating purposes. Three examples will serve to illustrate this point. An electric bulb, the purpose of which is to provide light, also gives off calories. A cooker used for cooking food helps to heat the room. A refrigerator gives off heat in order to be able to produce cold.

It is still extremely difficult to calculate the rate of recovery of this free heat and this may lead to many arguments. However, this rate of recovery seems low, because firstly, current models are not equipped for recovery of this type; secondly, free heat often leads to unintentional overheating which entails extra ventilation, which in its turn causes a drop in the efficiency of the heating system for the whole of the building; thirdly, free heat often arises at the wrong time, e.g. a refrigerator gives off more heat in summer than in winter.

It is considered therefore that most free heat is given off into the atmosphere and thus regarded as lost from the point of view of useful energy.

To give a few examples of practical efficiency, a figure of 65% was selected for a domestic coal-fired central-heating boiler (small boiler without automatic adjustment of charging), the losses (35%) coming from:

sensible heat of smoke and ash		10-15%
unburnt residue	approx.	1%
radiation		2- 5%
pipes		8-10%
incorrect adjustment	approx.	10%

A figure of 95% was chosen for an electric motor-which may appear to be rather high-the losses coming from the magnetic field, ventilation, heating of the coils, and friction of the moving mechanical parts (heating of bearings).

These efficiencies lead to a calculation of the useful energy yielded by the appliances which in no way prejudges the wastage which may occur subsequently. The balance-sheets thus give the results in terms of useful energy in the transport sector as it is, although a certain amount of transportation may be superfluous; similarly, the balance-sheets show the useful energy of domestic heating installations as they are used, without taking into account the wastage due to poor insulation of the buildings, excessive temperatures or losses via 'thermal bridges' or open windows. Useful energy and wasteful use of energy must not therefore be confused. They are two problems to be studies separately. The problem of the justification of consumption or of the quest for the optimum economic level of consumption is to a great extent outside the sphere of thermodynamics.

X BREAKDOWN OF USEFUL ENERGY

The way in which useful energy must be calculated automatically gives a breakdown by 'appliance', which differs from the breakdown presented in the primary input balance-sheets. This should not be surprising since the situation is being considered from a different point of view and a new field is being entered into. It is an adjustment to a new situation.

In theory, useful energy can also be broken down :

- by technological procedures
- by uses
- by sectors or branches of economic activity.

These breakdowns, however, present considerable difficulties of practical application which have not yet been solved. It was not possible to give a breakdown by technological procedure since this concept proved difficult to define in concrete terms. Furthermore, the procedures can be applied only to a part of industry and the breakdown would not have been homogeneous with transport and domestic households. Finally, the procedures often overlap the sectors and branches of economic activity in industry.

It was not possible to give a breakdown by use or ultimate intended purpose or a breakdown by economic sector or sub-sector. The reasons for and implications of this are outlined below.
The concept of finality in the use made of an appliance remains too hazy and is of no help either for understanding useful energy or for the calculations. An electric motor can obviously be used for various purposes without any change in its own efficiency. To give a few examples, an electric motor can be used to drive a machine tool (mechanical work), pull a train (locomotion), turn a fan (displacement of air which may be used for refrigeration), drive a compressor (increase in the pressure of gas with simultaneous production of heat, e.g. for the synthesis

of ammonia), make a refrigerator work (production of cold), drive a pump which may in turn feed a burner (for heating), or make a crusher work (with 5 % mechanical effect and 95 % thermal effect). These examples show that the ultimate uses of an appliance are many and varied, difficult to classify and sometimes inextricably interlinked.

In particular, it proves to be almost impossible to distinguish between the apparently simple concepts of thermal use and mechanical use, on account of the laws of thermodynamics. Furthermore, there are cases where the same appliance serves several purposes and conversely where the same job is carried out by various appliances: this makes distribution calculations somewhat difficult.

As the efficiencies are linked to the appliances and the appliances are scattered over various economic sectors, it is immediately apparent that a breakdown by sector is difficult and does not provide any additional information on the useful energy. It is obvious that the efficiency of motors of the same design or of electric bulbs remains the same whether they are installed in a textile mill, a foodstuffs factory, public offices or a private house. The useful energy or efficiency of an industrial sector depends on the degree of integration of the installations and on the often very variable proportion of machines with different efficiencies. To take just one example, taken from the best-known and most easily examinable sector, the efficiency of the iron and steel sector depends on :

1) the level of integration of the various phases which contribute to production : blast furnace, foundry, melting shop, hot - or cold-rolling mills and possibly ore-sintering plant and even power station. These last three installations are not part of the iron and steel sector according to the nomanclatures currently in force, but their inclusions in the production process will modify the overall efficiency of the iron and steel sector. Thermodynamic systems thus do not correspond to the economic sectors, which poses problems which cannot be solved at the present time;

2) the proportion of the various types of equipment installed and their degree of utilization, when they have different efficiencies. A steelworks installation producing cold-rolled flats obviously has a far larger number of high-powered electric motors than an installation which produced only non-rolled products. Since the efficiency of electric motors (95 %) is higher than that of all the other types of appliance, the former installation will have a higher useful-energy yield than the latter, although this does not necessarily mean greater productivity.

3) the arrangement and combination of the various energy appliances. This can vary in terms of the techniques and procedures used for manufacturing a non-energy product (e.g. steel sheet). In concrete terms, the overall efficiency of the production installations will clearly differ depending on whether the energy appliances are arranged in series or in parallel.

These observations show that the overall efficiency of the iron and steel sector is obtained from weighted averages for all combinations of installations, taking account of the degrees of utilization; this involved complicated calculations and leads to results which are difficult to interpret. The statistical apparatus is not geared **to deal with such complex and detailed problems.**

The useful energy calculated by appliance is thus an analytical and not a synthetic approach to the problem. But at least it constitutes a step forward and does not lead to a dead end. No breakdown of the appliances by use and by procedure has been possible.

However, it has been possible to break down the useful energy by three major consumer sectors :

- industry
- transport
- households and equivalent.

These three sectors correspond to the quantities delivered to the consumer and form a sort of crossroads. From this point, two parallel breakdowns are possible : one by sector in terms of 'energy supplied', the other by appliance in terms of 'useful energy'.

The limits of these three sectors tally with the definitions currently in force. 'Households and equivalent' includes, apart from households as such, wholesale and retail trade, crafts, general government and private institutions, small-scale industry, agriculture and fishing.

This grouping, which poses a difficulty for analyses by economic sector, is paradoxically an advantage for the calculation of useful energy. The appliances used in small-scale industry are generally different in size, technology and efficiency from those installed in large-scale industry. Their efficiencies, and therefore the useful energy released, seem more or less on a par with those of the appliances used in wholesale and retail trade, crafts and households. Their classification in a single sector therefore makes the calculations easier.

XI CALCULATION OF LOSSES AND ENERGY SECTOR

One of the advantages of a useful-energy balance-sheet is that it shows the losses throughout the energy chain. In this connection, it must first be stated that the present balance-sheet does not take into consideration the possible rate of extraction of primary energy in relation to the potential (or natural resources) contained in the deposit. Nor does it take account of reinjections into the deposits (crude oil and natural gas).
The starting point for the balance-sheet is gross actual production. In the case of electricity it underestimates the losses, since hydroelectric sources are regarded as primary sources.

Despite these shortcomings, which can be remedied in future, the recording of losses is better than in a primary input balance-sheet or even in an 'energy supplied' balance-sheet. A few words of explanation about losses will facilitate better interpretation and utilization of the balance-sheets. Transformation losses are, by their very nature, linked to the transformer and not to the energy sources; this may cause difficulties if the intention is to ascribe the losses to a certain product and to analyse a particular branch of the energy flow-chart. The solution is to apply the appropriate percentage loss as shown in the transformation balance-sheet so as to make it possible to deduce correctly the successive links in the chain of transformation.

Another aspect of losses needs to be noted, namely the losses occurring during the transportation and distribution of gas and electricity in particular. Losses during transportation (loss in weight, leaks, evaporation) of the other energy sources are negligible and are not shown in the balance. However, an energy which sustains heavy losses during transport requires practically no expenditure of energy for transport purposes, whereas the transport of coal or oil without loss requires a certain energy consumption. This constitutes a disparity in the treatment of energy sources which ought to be corrected. To do this properly, it would be necessary to include in the balance-sheet energy used to transport energy, on the same basis as the energy used to extract or transform energy. An attempted calculation along these lines is given below in the analysis of results.

Apart from these considerations, showing the losses as such fulfils a dual purpose :

1) to show the relationship between useful energy and waste energy, of interest for various analyses, e.g. comparison and substitution of different types of energy, energy saving;

2) to provide an estimate of pollution.

This second concern is of more recent origin. Losses occur most frequently in the form of heat unintentionally dissipated into the environment (radiation, sensible heat of smoke and exhaust gases, burning of flares, hot-water springs, etc.). The only exceptions to these heat losses are losses by leakage, evaporation or loss of weight (as well as magnetic losses). In all cases, the energy lost causes pollution, either thermal or chemical. The total loss, shown in the balance-sheet as waste energy, can thus provide an indication of the pollution caused by energy consumption.

As well as losses, mention must also be made of the consumption of the energy sector, which also represents a reduction in the quantities of energy which reach the final consumer. The crossed table given in the annex makes it possible to ascribe either to each energy source or to each transformer or producer of energy the energy used to produce or transform energy.

This can also play a part in the calculation of energy sub-flows and substitutions (choice between production or imports, for example). Consumption for the transport of energy should be treated, for the purposes of analysis, in the same way as the consumption of the energy sector.

XII FUTURE IMPROVEMENTS AND CONCLUSION

This study, together with a trial useful-energy balance-sheet, was drawn up on the basis of the information available, without the help of a special survey. Progress may be achieved in future by adapting the statistical apparatus to this new objective. A few guidelines can already be laid down with a view to improving the useful-energy balance-sheets.

It has already been stated, in chapter VIII, that the statistical returns should be centred on transformations of energy; this could be done by, for example, modifying the questionnaires used in the Community along these lines.

A second way of improving the balance-sheets would be to obtain more precise figures for the efficiencies of the appliances by means of technical studies. Another way would be to obtain more information on and to extend the classification of the equipment (or technologies) used in industry.

Obviously, a more detailed classification is only of interest if the efficiencies of the appliances listed differ appreciably. Still in the industrial sector, it might prove useful, for the purposes of economic analysis and forecasting, to separate consumption for heating premises from consumption for manufacturing. The function 'heating of premises' depends on the climate, which is an exogenous random variable, independent of the manufacturing process, whereas the energy consumed for manufacturing purposes is independent of the climate but is related to industrial activity (output or hours worked). This would require a number of special surveys, using the sampling method which seems most suitable for this purpose.

Finally, and this is most important, this balance sheet must be supplemented by studies which further investigate the possibilities of energy economy, as indicated in chapter IX.

In order to try and clarify the situation, five topics can be considered in the analysis of energy :

1) primary input of energy

2) transformation of energy sources

3) consumption of energy as supplied to final consumer

4) useful energy obtained by final consumer

5) energy content of the non-energy goods and services.

The present balance sheet covers only the first four topics, deliberately excluding the last, although the importance of the latter is incontestable.

It is clear that possible energy savings can come from :

a) improvement of productivity in the energy sector itself, i.e. by reducing the losses and own consumption of the energy producers, transformers and distributors. In other words, maximizing the amount of energy supplied to the final consumer on the basis of a given primary input.

b) from the best use made of the energy appliances at final consumer level. This means trying to obtain as much useful energy as possible.

c) from adjusting consumption methods in order to reduce the energy required for producing, distributing and using the non-energy goods and services. This means minimizing the energy content of the non-energy goods and services.

The first two points above can be analyzed using the balance sheets proposed in this study. The last point depends upon an analysis of the specific consumption and input-output matrixes: it therefore goes beyond the framework of the energy balance-sheets.

One general conclusion emerges from these various guidelines: balance-sheets of the 'energy supplied' type constitute the basis and kingpin of the entire statistical system relating to energy. Indeed, the 'energy supplied' balance sheet makes it possible either to work back to production and primary resources and make an exact calculation of requirements in terms of primary input, or to proceed in the direction of consumption, as far as useful energy, or to compile studies on the different levels of specific consumption.

A balance-sheet of the 'energy supplied' type, possibly supplemented by information on useful energy and specific consumption, constitutes the only correct basis for analyzing energy consumption and thus the only platform on which to base forecast calculations - for forecasts are always based on the projection of consumption in the future.

If no historic basis expressed at 'energy supplied' level is used, the coefficients of elasticity will be biased, as shown by past experience in energy forecasting. Finally, it is at the 'energy supplied' and 'useful energy' levels that valid price comparisons can be drawn at consumer level and value studies carried out.

XIII ANALYSIS OF RESULTS – FRANCE-GERMANY 1975

A first attempt at a balance-sheet based on the new methods was drawn up for the Federal Republic of Germany for the year 1975. A number of comments may be made on the results. The first analysis concerns comparison of the results between 'primary input', 'energy supplied' and 'useful-energy' balance-sheets. A table in the annex shows the extent of the differences, both by major consumer sector and by energy source.

Compared to the 'energy supplied' balance-sheet, the primary input balance-sheet overestimates final energy consumption by 23 %, industrial consumption by 33 % and electricity consumption by 165 %, and it underestmates the transport sector and petroleum products (this is particulary apparent in the breakdown of consumption). The breakdown by energy source is considerably modified by this, to the advantage of petroleum products and the detriment of electricity. The difference between these two types of balance-sheet stems from the losses due to transformation, distribution and consumption of the energy sector. This explains indirectly the differences in the breakdown between industry and transport. The energy content of deliveries to the transport sector is greater than that of deliveries to industry (mainly motor spirit as against residual fuel oils), whereas the primary input balance-sheet equated the grades of products in terms of crude oil equivalent.

The 'useful-energy' balance-sheet presents another angle by including losses occurring during final consumption. This gives a different picture again, depending on the efficiencies of the appliances used by final consumers.

It is no surprise, in view of the low efficiency of internal combustion engines, to note the considerable reduction in useful energy in the transport sector. On the other hand, the high efficiencies generally observed in electric or gas appliances increase the proportion of useful energy produced by these two sources.

However, the excellent performance of most electric appliances does not make up for the losses arising during transformation in thermal power stations. This shows one of the fundamental aspects of the German economy, to which hydro-electric power continues to make a minimal contribution. Losses during final consumption, expressed as the difference between the 'energy supplied' and useful energy, are as follows:

solid fuels	29%
liquid fuels	44%
gas	26%
electricity	24%
Total for all sources of energy	36%

These general comparisons bring out the extent of losses throughout the energy chain from extraction (primary input) to final consumption (useful energy). A graph shows the overall flow of energy in 1975 in the Federal Republic of Germany. Useful energy account for 47% and lost energy for 53% of availabilities.
The energy lost is broken down as follows:
50% during consumption
36% during transformation
13% consumption of the energy sector
1% during distribution.

A table in the annex gives a more detailed breakdown of these losses by energy source. The main losses occur with oil and electricity, the former because of the considerable volume concerned, the latter because of the low efficiency of transformations in thermal power stations.

A second graph illustrates the energy flow by source.

It shows that the more transformations of energy there are, the greater the losses and the more the overall efficiency tends to decrease. This highlights the advantages of natural gas, a primary energy source, generally used without intermediate transformation. More accurate determination of the losses throughout the energy chain is thus of great importance for the purposes of analysis. Where losses are calculated in the form of percentages, it is possible to apply various types of "technical coefficients" to each possible "sub-flow" in the energy flow-chart. The percentages of intermediate losses are taken from the subsidiary transformation balance-sheets; consumption of the energy sector and any losses during distribution of gas and electricity must be added to these.

The "technical coefficients" of lost energy may be summarized as follows :

Losses during transformation :

patent fuel plants	9 %	of the input
coking plants	1.5 %	" "
brown coal briquette works	5.6 %	" "
blast furnaces	3.5 %	" "
thermal power stations (electricity)	62.6 %	" "
power stations (heat)	15 %	" "
nuclear reactors	65.8 %	" "
oil refineries	0.6 %	" "
gas works	3.3 %	" "

Consumptions of producers and transformers of energy :

	% input	% production
coal mines (with patent fuel plants)	-	2,5
brown coal mines (with briquetting works)	-	1,1
production of natural gas	-	4,8
coking plants	9,8	13,1 (coke)
oil refineries	8,6	8,7
gasworks	10,8	11,2
thermal power stations	2,3	6,3
nuclear reactors	1,8	5,4
hydroelectric power stations	-	1,5

These specific consumptions represent the energy (either from own production or bought) used to extract or transform the energy (1). These percentages were calculated directly from the units in Joules, at 'energy supplied' level, i.e. without going back to the primary input level (e.g. for electrical energy). Non-energy output (often unavoidable) was not included in the losses. It leaves the energy balance-sheet at the line "non-energy consumption". This is in line with economics, since the non-energy products are transferred to other sectors where they are used.

With the percentage losses or "technical coefficients", it is possible to construct various special sub-flows in the energy flow-chart and to observe the progressive disappearance of the energy up to final consumption. The simplest way of illustrating this is in the form of a graph, as given in the annex, showing a few typical examples.

For the heating of domestic and similar premises, the sub-flow-charts show that solid and liquid fuels have the same overall efficiency. The greater efficiency of oil-fired boilers offsets the losses or consumption of energy during refining.

(1) This means, for example, that to produce 1000 kJ of natural gas requires a consumption of 48 kJ; to refine 1 000 kJ of crude oil requires a consumption of 86 kJ, etc.

The high efficiency of natural-gas-fired heating is also brought out. On the other hand, electric heating with electricity from thermal sources has an overall efficiency equal to half that of solid or liquid-fuel types of heating.

As regards motive power, it does not matter, from the point of view of the overall yields of useful energy, whether a diesel engine or an electric motor driven by electricity of thermal origin is used. On the other hand, the sub-flow-charts bring out the high efficiency of hydroelectricity, but this is the least common source of energy in Germany. In all cases, lighting has the lowest efficiency but technologists have, as yet, found no substitute. These sub-flow-charts confirm that transformations reduce the overall efficiencies, since the increase in efficiency during use brought about by a better developed form of energy does not offset the losses and consumption of energy during the transformation operation.

The volume of thermal pollution caused by the production and use of energy can be estimated on the basis of losses. This gives a total of the order of 4 300 000 tJoules, not including distribution losses and the consumption of the energy sector. This figure represents more than 1 million Tcal, i.e. a sufficient quantity of heat to raise the temperature of a volume of 100 000 million m^3 of water by 10° C. For comparison, this figure is of the same magnitude as the annual flow of all the surface water collected in the Federal Republic of Germany.

Moreover, the balance-sheet also makes it possible to obtain a breakdown of consumption by main types of appliance and by major sector. A table in the annex gives the percentage breakdown of consumption, in terms of both 'energy supplied' and useful energy. A few comments may be added to this. Lighting always plays a secondary, even negligible, part. Its poor efficiency has therefore practically no effect on the energy budget as a whole. Its role appears least negligible in the tertiary sector (street lighting and lighting of offices, government buildings and shops).

On the other hand, space heating, at around 80% of consumption, constitutes a major part of the households and equivalent sector, while the transport sector is dominated to a great extent by internal-combustion engines with 90% of 'energy supplied' consumption and 80% of the useful-energy consumption. In industry, the range of appliances appears much wider, although there is a preponderance of furnaces and boilers. The table also makes it possible to estimate the distribution of appliances in households as such. Out of a total of 2 990 992 tJoule ('energy supplied') in the sector comprising households, handicraft, public authorities, small industry, agriculture and fishing, the consumption of households as such may be put at around 1 680 000 tJoules, as follows:

1 400 000 tJ	for space heating	83.3%
90 000 tJ	for cooking	5.4%
70 000 tJ	for hot water	4.2%
18 000 tJ	for lighting	1.1%
102 000 tJ	for various electrical appliances	6.0%
		100%

These observations give a clear indication of the lines along which future studies and research should proceed, with a view both to energy saving and to improving the balance-sheets (better knowledge of the equipment used in industry, for example).

A final feature of this type of balance-sheet concerns primary input, the analysis of which can be improved by working upwards from 'energy supplied'. On the basis of the subsidiary balance-sheets, i.e. the various transformation losses and the consumption of the energy sector, it is possible to calculate the actual substitutions between production and imports on the one hand and primary and secondary energy on the other. Importing a tonne of coke is not the same as importing a tonne of coal, nor is producing electricity by thermal means the same as producing it from water. The various possible substitutions have effects which may be shown by the balance-sheet. As it stands now, the balance-sheet is a sort of practical economic model, on the basis of which it is possible, hypothetically, to modify certain values and calculate the consequences thereof.

The scope of this type of calculation is vast. A few examples will suffice to show its potential. What would happen if net production of hydroelectricity were reduced by 36 000 tJoules (a reduction of 10 000 GWh) ? As consumption would remain the same, production of electricity from thermal sources, e.g. based on fuel oils, would have to be increased. To obtain 36 000 tJoules of net electricity in a conventional thermal power station requires a gross output of 38 430 tJoules. This needs a charge of 102 600 tJ, i.e. approximately 2 565 000 t of heavy fuel oil. This results in an increase in oil refining. Thus, to obtain 102 600 tJ of a petroleum product (fuel oil) requires an input of 103 215 tJ of crude oil, allowing for losses during refining, to which must be added the refineries' own consumption at 8 870 tJ (8.6 % of the charge). Altogether, a decrease of 36 000 tJoules in the output of hydroelectricity requires approximately 112 000 tJoules of alternative energy. This is an example of substitution at the primary input.

Another example entails examination of the choice between importing 1 t of coke or the primary equivalent in the form of coal. The coking plant transformation balance shows that, in terms of specific units 1.3 t of coal is required to produce 1 t of coke, allowing for losses and the unavoidable production of gas, benzol, pitch and tars. In addition, coking requires a specific consumption of around 1 % of the charge. In terms of energy, the substitution is thus as follows :

1 t of coke	28 500 000 kJoules
gas	7 220 000 "
other by-products	1 710 000 "
losses	570 000 "
charge	38 000 000 kJoules (= 1.3 t of coal)
consumption of the coking plant (1)	380 000 kJoules

(1) Taken from the unavoidable production of coke-oven gas

A final point to be clarified concerns the energy required for the transportation and distribution of solid and liquid fuels. The energy consumed for this purpose was not shown separately in the balance-sheet but is included in the final consumption of the transport sector. For the purposes of the energy budget it is useful, however, to know this consumption, compared to the consumption of the energy sector and losses during distribution of gas and electricity. The transport statistics provide a basis for calculation (tkm of traffic and specific consumptions). The following estimate is obtained :

Consumption for transport	Rail	Inland waterway	Road	Pipeline	tJ Total
Solid fuels	4 170	870	1 100	-	6 140
Liquid fuels	1 800	930	11 300	1 500	15 530
Total	5 970	1 800	12 400	1 500	21 670

These figures are very low, even negligible, compared to the quantities of fuels transported either to transformers (power stations, etc.) or to final consumers. The consumption of energy used to power the lorries, boats, wagons and pipelines may be estimated at 0.3 % of the quantity of energy transported. This figure is very low in comparison with the distribution losses for the electricity network (4.8 %).

From the useful-energy point of view it therefore appears more economical to transport fuels in their natural state to the points of consumption rather than to convert them on the spot to electricity and then transport the electrical energy to the consumers. These calculations also show that it is not necessary to enter the energy required for transport in the 'distribution losses' line of the balance-sheet, as this has no effect on the overall results.

XIV ANALYSIS OF RESULTS – FRANCE 1975

A first attempt at an 'energy supplied' and a useful-energy balance-sheet was drawn up for France on the basis of the results for 1975. The same general conclusions may be drawn as for Germany.

In the first place, the difference in the results obtained with the three types of energy balance-sheet - primary input, energy supplied and useful-energy (see table) - is very noticeable. Compared to the 'energy supplied' balance-sheet, the primary input balance-sheet overestimates final energy consumption by more than 18 %. This also has a considerable effect on the breakdown by major consumer sector. The primary input balance-sheet overestimates the final energy consumption of industry by 28 % and that of households by 20 %. On the other hand, it underestimates that of the transport sector. The breakdown by energy source also appears in a different light when the actual energy content of deliveries to consumers is taken into account. Electricity's share is reduced by half, whereas that of all the other energy sources is increased (very considerably in the case of petroleum products). These differences are obviously the result of transformation and distribution losses. The 'energy supplied' balance-sheet gives a better picture of the energy value which can be used by the final consumer, and forms the essential basis for the next step, which is to determine the useful energy produced during final transformation. The different efficiencies of the appliances modify the results considerably. The useful energy produced in industry is far greater than that produced in the sector comprising households, wholesale and retail trade, handicraft, trades and agriculture. The useful energy produced in the transport sector appears extremely small. The different efficiencies of the appliances modify the results by energy source to the advantage of electricity and gas and to the detriment of petroleum products. However, the better performance of electrical appliances does not make up for the losses arising during distribution and during transformation in thermal power stations, even through one third of all electricity produced in France is of hydroelectric origin.

The percentage losses occurring during final consumption, expressed as the difference between energy delivered to the consumer and the useful energy yield, are as follows :

solid fuels	32 %
petroleum products	48 %
gas	29 %
electricity	28 %
Total for all sources of energy	42 %

If all the losses occurring upstream of consumption, during distribution and transformation, including the consumption of the energy sector, are added to these losses, an overall picture is obtained of the energy losses throughout the flow from primary extraction to final utilization. This flow is illustrated by a graph, which shows that useful **energy accounts for only 46% and lost** or wasted energy for 54 % of availabilities.

The losses are broken down as follows :

61 %	during final consumption
26 %	during transformation
11 %	for the energy sector's own consumption
2 %	during distribution
100%	

A table in the annex gives a more detailed breakdown of these losses, in particular by energy source.

It can be seen that, next to final consumption, the greatest volume of losses occurs as a result of transformations. It would therefore be useful to analyse this aspect in greater detail and in particular to give the percentage loss or 'technical coefficient' arising with each transformer of energy.

These percentages are taken from the subsidiary transformation balance sheets.

- Percentage losses during transformation :

	% of the input	% of secondary production
patent fuel plants	8,4	9.2
Coking plants	4,1	4.3
Blast furnaces	6.8	7.3
Oil refineries	1.7	1.75
Gasworks	6.35	6.8
Thermal power stations	60.3	151.3
Nuclear reactors	71.2	247.1

These losses include flare burn-off, leaks and the heat dissipated by radiation, in smoke or in waste water, during the transformation process. They do not include the unavoidable production of by-products used for non-energy purposes.

Added to these losses is the energy used to extract and transform the energy (energy sector). This too may be expressed in the form of a percentage related to the charge or the quantity extracted or produced.

- Energy consumed by producers and transformers :

	% of the input	% of the output
Coalmines (with patent fuel plants)	-	2.6
Brown coal mines	-	0.4
Production of natural gas	-	3.2
Coking plants	10.0	13.5 (coke)
Oil refineries	6.1	6.2
Gasworks	17.4	18.6
Thermal power stations	2.1	5.3
Hydroelectric power stations	-	2.25
Nuclear reactors	1.4	4.7

These percentages were calculated on the basis of 'energy supplied' expressed in Joules.(1)This means that to extract 100 tJoule of coal requires an energy consumption of 2.6 tJ, or the produce 100 tJ of coke requires 13.5 tJ of energy.

By and large, these percentages are similar to those calculated for Germany. However, differences may arise as a result of the type of processing (in the case of gasworks, for example) or of the quality of the fuels extracted (approximately the same amount of energy must be used to extract a tonne of anthracite or a tonne of low-grade coal).

By applying the coefficients of efficiency of the appliances used by final consumers, the percentage losses during distribution and transformation, and the rates of consumption of the energy sector, it is thus possible to work upwards from useful energy to primary input or in the opposite direction, tracing all the possible sub-flows. The various sub-flows calculated on the basis of the figures for France lead to the same results and conclusions as for Germany.

Heat losses arising as a result of the use of energy can be estimated at 3 000 000 terajoules i.e. less than in Germany. This is nonetheless an important cause of pollution.

The balance-sheet also gives a breakdown of consumption by type of appliance and by major sector, in terms of both'energy supplied' and useful energy, thus making it possible to identify the important areas and to pinpoint losses.

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(1) In terms of, for example, the amount of electricity needed for the transformation and not in terms of the amount of primary input (coal, fuel-oil etc) needed to give that amount of electricity.

Of total final energy consumption, more than 3/4 of the energy delivered to the consumer is absorbed by three main types of appliances, namely :

- space heating boilers, with approximately	1 500 000 TJ
- combustion engines (piston-driven), with	1 143 000 TJ
- industrial furnaces and boilers, with	1 120 000 TJ

The remainder is spread over a wide variety of appliances used for more specific purposes. Overall, lighting and electric motors appear to play a secondary part.

This shows what steps must be taken in the field of statistical analysis to obtain a clearer picture of the situation and in the field of technological research to ensure better utilization of energy.

On the basis of the statistics on the breakdown of final energy consumption it is also possible to add a few more details and give separate figures for households as such, excluding wholesale and retail trade, public authorities, handicraft, trades, agriculture and small-scale industry.

Approximately 1 351 000 TJ (energy supplied) may thus be attributed to households as such, broken down as follows :

	1 000 TJ	%
Space heating	1 100	81.4
Cooking	107	7.9
Water heating	57	4.2
Lighting and television	38	2.8
Miscellaneous electric appliances (1)	49	3.6
	1 351	100

(1) Miscellaneous electric appliances include: washing machines, dish washers, vacuum cleaners, refrigerators, freezers, hair dryers, toasters, mixers, etc.

It can be seen that this breakdown differs from that for Germany, with heating having a smaller and cooking a larger share of the total - a reflection of consumer habits and climatic factors. With the 'energy supplied' balance-sheet, it is possible to go back as far as primary input. There are several possible methods. The percentages or technical coefficients described above, relating to losses and energy for producers' and transformers' consumption, may be applied to each energy source. An overall result may also be obtained from the totals for all energy sources together. The result is then given directly on the overall energy flow chart.

6 193 467 TJ are used for energy purposes and 422 992 TJ for non-energy purposes, i.e. a total of 6 616 459 TJ for the primary input equivalent of actual energy consumption and associated non-energy consumption. Translated into tonnes of coal equivalent, this represents 226 million tce. This figure is lower than given in the primary input balance-sheets currently calculated and published, which give a gross inland consumption of 235 million tce for France in 1975. The difference is due to the basic approach. The 'energy supplied' balances describe the situation as it actually is and therefore show actual supply, without making any assumptions which modify the facts, whereas the present primary input balance-sheets are based on the assumption whereby conventional thermal power is substituted for hydroelectric power. The implied losses from this theoretical output must therefore be added.

The calculation is simple :

transformation losses in a conventional thermal power station to produce the equivalent of hydroelectric power (151 % of gross output) = 329 378 TJ

additional consumption of related services (energy sector) (5,3% of gross output) = 11 560 TJ

i.e. a total of 340 938 TJ, equivalent to 11.6 million tce, i.e. approximately the same difference as noted above.

The slight difference still remaining is the result of more precise consideration of the energy values of the products in the 'energy supplied' balance-sheet (particulary in the case of solid and liquid fuels). It may be concluded that the primary input balance-sheets greatly overestimate energy losses and do not permit correct analysis at consumer level.

In France, it is also possible to estimate the quantity of energy used to transport solid and liquid fuels, which in principle is to be added to the consumption of the energy sector, as is the energy used for the distribution of gas and electricity.

Using the transport statistics (NST) in tonne-kilometres and specific consumptions as a basis, the following estimate is obtained :

Consumption for transport of:	Rail	Inland waterway	Road	Pipeline	TJ Total
Solid fuels	1 563	287	806	-	2 656
Liquid fuels	1 958	853	8 719	5 196	16 726
Total	3 521	1 140	9 525	5 196	19 382

This figure of 19 382 TJ for the transport of fuels is much lower than the losses on the gas and electricity networks (77 651 TJ).

The energy used for this purpose represents 0.3 % of the total energy available on the domestic market and 0.4 % of total energy delivered to the consumer.

A comparison of the fuels in question gives the following figures :

- solid fuels $\frac{2\ 656 \text{ TJ}}{491\ 869 \text{ TJ (1)}} = 0.5\ \%$

- liquid fuels $\frac{16\ 726 \text{ TJ}}{3\ 223\ 550 \text{ TJ (1)}} = 0.5\ \%$

(1) energy supplied

These calculations show that the quantities of energy required for the transport of solid or liquid fuels are very small and negligible in relation to a country's overall energy budget.

XV COMPARISON OF RESULTS – GERMANY-FRANCE 1975

The foregoing analyses result in identical general conclusions for the two countries and do not reveal any inconsistency.

However, there are a number of differences between Germany and France which need to be clarified and if possible explained.

The first obvious difference is the lower efficiency of the energy budget in France, where useful energy accounts for a slightly lower percentage of the total energy available.

The levels at which this difference occurs are shown by the following calculation :

	FR of Germany		France	
	TJ	%	TJ	%
Energy available on the domestic market	9 468 126	100	6 193 467	100
Consumption of the energy sector	635 088	6.7	383 110	6.2
Transformation losses	1 828 027	19.3	862 249	13.9
Distribution losses	69 023	0.7	77 656	1.2
Consumption losses	2 495 278	26.4	2 030 586	32.8
Useful energy	4 440 710	46.9	2 839 866	45.9

There are two adverse factors in Germany, namely the consumption of the energy sector and transformation losses, and two in France, namely distribution and consumption losses.

The energy sector is more developed in Germany owing to greater production from primary sources of fossil origin and to the size of transformer installations (coking plants and thermal power stations). It is therefore natural that, for operating purposes, this sector consumes a slightly higher proportion of the available energy than in France.

The difference between the two countries regarding transformation losses is the result of a number of counteracting factors.

Transformation losses in refineries are usually higher in France because this country refines on the spot the quantities of crude oil required to cover domestic requirements (with even a slight surplus for export), whereas German refineries can cover only a fraction of requirements, the remainder being imported in the form of refined products.

Naturally, transformation losses during refining occur in countries which process crude oil on behalf of Germany (mainly the Netherlands, Italy and France). Losses in coking plants, blast furnaces and gasworks appear higher in France, where flare burn-off is apparently greater.
On the other hand, there is a considerable difference in respect of transformation losses in power stations, to the detriment of the FR of Germany (losses almost three times greater than in France : 1 583 983 TJ against 582 143 TJ). Almost all the electricity produced in Germany is of thermal origin - which gives rise to considerable losses - whereas in France 33 % of the electricity is generated by natural water power, which does not give rise to any transformation losses.
This structural difference tips the scales in favour of France and explains why total transformation losses are ultimately higher in Germany, in both absolute and relative terms.
Distribution losses (gas and electricity) are higher in France, owing to the size of the territory and the lower population density, geographical characteristics which necessitate a more extensive network. For the same reasons, more energy has to be

used in France for the transport and delivery of solid and liquid fuels. The transport statistics show that the average distances covered are much greater in France.

Finally, there is a considerable difference in respect of consumption losses between energy supplied and useful energy. Consumption losses totalled 42 % in France, compared with 36 % in Germany. A difference of this order warrants closer examination. The reason lies in the actual structure of final energy consumption. The transport sector is highly developed in France, but it has the lowest energy efficiency. This is further reinforced by the preponderance of road transport in France over other modes of transport, particularly railways and inland waterways; it is precisely road transport which has the lowest efficiency.

In the household and associated sectors, there is in France a not inconsiderable number of heating stoves, which still have a poor level of efficiency, whereas German appliances - almost all of which are central heating installations - are more modern.

In the industry sector, the efficiency of the various appliances is identical in both countries, but the breakdown of consumption by type of appliance is different. Processes with low-efficiency appliances are used more in France. That is cement kilns, glassworks radiation furnaces and electrolysis. Thus, electrolysis absorbs 20 % of the electricity consumed in industry in France, compared with 14 % in Germany.

There are other factors in addition to these structural factors of energy demand. The type of fuel can also play a part. Thus, natural gas, which gives rise to few losses because it is used without transformation, accounts for a greater proportion of consumption in Germany than in France.

The 'energy supplied' balance-sheets also give more precise additional information which helps to explain the results. For example, in France certain primary energy products have a lower calorific value per unit of weight. Overall, the coal extracted in France seems to be of poorer quality than that produced in the FR of Germany; this obviously does not benefit the efficiency of the energy sector. The crude oil imported into France has an average calorific value of 42 102 KJ/kg NCV, compared with 42 340 KJ/kg NCV in the FR of Germany. This tallies with the grades of crude oil imported, as the FR of Germany buys a considerable number of light grades from Africa, whereas France purchases large quantities of heavy oil from the Persian Gulf which have a lower energy content. Although the difference in calorific value appears slight at first sight, it nevertheless affects the results of the balance-sheets and the degree of energy dependence, since the quantities involved are enormous, of the order of a hundred million tonnes.

Overall, many factors are conducive to greater efficiency of the energy budget in the FR of Germany, compared to France. This conclusion applies to the whole analysis, including useful energy, i.e. the quantities of energy produced by the appliances during the final stage of transformation by the final consumer. This analysis does not apply to the specific energy consumption required to produce non-energy goods and services. This field is outside the scope of the energy budget and its study can lead to other developments and other conclusions.

TABLES AND GRAPHS – FR. GERMANY 1975

1

TABLE OF CONVERSION FACTORS

(Net calorific value)

1 kcal = 4.186 kJ

Energy source	kcal/kg	kJ/kg
Hard coal (output)	variable	variable
Coking coal	7 000	29 300
Coal for power stations (1)	6 358	26 615
Coal for briquetting	7 500	31 400
Industrial coals	6 700	28 000
Household coals	7 100	29 720
Hard coke	6 800	28 500
Gas coke	6 400	26 800
Pitch and tars	9 000	37 700
Benzol	9 450	39 500
Coal briquettes	7 500	31 400
Brown coal	variable	variable
Black lignite	4 000	16 744
Brown coal briquettes	4 800	20 000
Crude oil	variable	variable
Motor spirit,white spirit, industrial spirits, naphthas	10 500	44 000
Kerosines and jet fuels	10 300	43 000
Gas-diesel oil and lubricants	10 100	42 300
Residual fuel oil	9 600	40 000
Petroleum coke	7 000	29 300
Bitumens	9 000	37 700
Paraffins, waxes, etc.	7 200	30 000
LPG	11 000	46 000
Refinery gas	14 000	58 000
	Tcal GCV	TJoules NCV
Natural gas	1	3.76740
Coke-oven gas	1	3.76740
Blast-furnace gas	1	4.18600
Gasworks gas	1	3.76740
	GWh	TJoules
Electricity	1	3.6

(1) recorded during transformation in thermal power stations

TABLE OF THE EFFICIENCIES OF APPLIANCES AT THE FINAL CONSUMPTION STAGE

Appliance	Average efficiency %
Coal-fired domestic heating boiler	65
Coal-fired stove	25
Coal-fired industrial furnaces and boilers	75
Coal-fired district heating boilers	75
Cement kilns, dry path	50
Cement kilns, wet path	30
Blast furnaces	80
Gas engine	30
Petrol engine	20
Diesel engine	35
Turbo-prop	25
Aircraft jet	30
LPG cooker	37
Oil-fired domestic heating boiler	67
Glassworks radiation furnace (fuel oil or gas)	40
Oil-fired industrial furnaces and boilers	75
Space heating with LPG	72
District heating boilers - fired with heavy fuel oil	75
Paraffin burners	75
Furnaces, boilers and technical thermal uses, small installations, handicraft, wholesale and retail trade and small-scale industry (fuel oil)	67
Gas cooker	37
Gas-fired water heater	62
Gas-fired domestic heating boiler	72
Gas-fired industrial furnaces and boilers	80
Electric cooker	75
Electric water heater	90
Electric lighting	4
Electrolysis	30
Electric motors	95
Electric rail-haulage	90
Electric heating	95
Electric furnaces	95
Steam power plants (tapping)	85
Pipe network for distribution of steam	95

FR GERMANY 1975

3

COMPARISON OF BALANCE-SHEETS

(Primary input
(Energy supplied
(Useful energy

Final energy consumption		Industry	Transports	Households, etc.	TOTAL
Primary input	TJ	3 388 366	1 389 061	3 736 152	8 513 579
balance-sheet	%	40	16	44	100
Energy supplied	TJ	2 553 827	1 391 170	2 990 992	6 935 988
balance-sheet	%	37	20	43	100
Useful energy	TJ	1 936 776	373 984	2 129 950	4 440 710
balance-sheet	%	44	8	48	100

Final energy consumption		Solid fuels	Petroleum	Gas	Electricity	Heat	TOTAL
Primary input	TJ	816 705	3 947 272	1 159 422	2 502 332	87 847	8 513 579
balance-sheet	%	10	46	14	29	1	100
Energy supplied	TJ	776 376	4 056 337	1 074 227	944 780	84 268	6 935 988
balance-sheet	%	11	58	16	14	1	100
Useful energy	TJ	553 387	2 289 781	799 236	718 251	80 055	4 440 710
balance-sheet	%	12	52	18	16	2	100

FR GERMANY 1975

4

BREAKDOWN OF WASTED ENERGY

				TJ
100 %	TOTAL	5 027 416	(consumption	2 495 278
			(transformation	1 828 028
			(energy sector	635 088
			(distribution	69 023
5,7 %	Solid fuels	285 538	(consumption	222 989
			(energy sector	31 368
			(coal briquetting *	5 396
			(coke ovens *	19 478
			(brown coal briquetting *	6 307
42,2 %	Oil	2 122 098	(consumption	1 766 556
			(energy sector	331 862
			(refining *	23 680
9,1 %	Gas	457 664	(consumption	274 991
			(energy sector	143 882
			(distribution	15 844
			(blast furnaces *	20 654(flared)
			(gasworks *	2 293
42,2 %	Electricity	2 123 979	(consumption	226 529
			(energy sector	111 780
			(distribution	53 179
			(power stations *	1 732 491
0,8 %	Heat	38 137	(consumption	4 213
			(energy sector	16 196
			(heat power stations*	17 729

(*) transformation losses

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BREAKDOWN OF CONSUMPTION BY TYPE OF APPLIANCES

%

INDUSTRY	energy supplied	useful energy
Internal combustion engines	1	0,4
Cement kilns	5	2,5
Radiation furnaces (glassworks)	1,7	0,9
Blast furnaces	17,6	18,5
Other furnaces and boilers (1)	56,7	57,9
Electric motors and furnaces	15	18,8
Electrolysis	2,5	1
Lighting	0,5	0,0
	100	100

TRANSPORTS		
Internal combustion engines	89,3	80,9
Turboprops and aircraft jets	7	7,6
Electric rail-haulage	2,3	7,6
Heating	1,4	3,8
Lighting	0,0	0,0
	100	100

HOUSEHOLDS, ETC.		
Cooking	3,2	2
Water-heaters	2,4	2,9
Space heating	79,2	82,7
District heating	1,5	1,5
Electric motors and appliances	6,5	8,6
Internal combustion engines	2,2	1,1
Technical furnaces and boilers (2)	0,8	1
Lighting	4,2	0,2
	100	100

(1) including space heating
(2) handicraft, agriculture and small-scale industry

TRANSFORMATION BALANCE-SHEET 6

COAL BRIQUETTING PLANTS

INPUT	1 000 t	TJ	OUTPUT	1 000 t	TJ
Hard coal	1 704	53 505	Coal briquettes	1 697	53 286
Coal briquettes(1)	22	691			
Pitch	119	4 486			
	1 845	58 682		1 697	53 286
LOSSES (9 % of input)					5 396

Calorific values (NCV)

	kcal/kg	kJ/kg
Hard coal	7 500	31 400
Coal briquettes	7 500	31 400
Pitch	9 000	37 700

Concumption for transformation

Coal briquettes	1 000 t
Electricity	. GWh

(1) recycled

FR GERMANY 1975

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TRANSFORMATION BALANCE-SHEET

COKING PLANTS

INPUT			OUTPUT		
	1 000 t	TJ		1 000 t	TJ
Coking coal	44 554	1 305 432	Hard coke	34 818	992 313
Hard coke (1)	174	4 959	Tars and pitch	1 280 (2)	48 256
Petroleum coke	481	14 093	Benzol	350	13 825
	45 209	1 324 484	Ammonia and miscellaneous	248	-
			Coke oven gas (3) Generator gas		250 612
				36 696	1 305 006
LOSSES (1.5 % of input)					19 478
			of which flared		3 892

Calorific values (NCV)

	kcal/kg	kJ/kg
coking coal	7 000	29 300
hard coke	6 800	28 500
tars and pitch	9 000	37 700
benzol	9 450	39 500
petroleum coke	7 000	29 300

Consumption for transformation

hard coke	24 000 t	684 TJ
coke oven gas	25 477 tcal GCV	95 981 TJ
blast furnace gas	3 719 tcal GCV	15 568 TJ
electricity	632 GWh	2 275 TJ
		114 508 TJ

(1) recycled
(2) of which 27 + 163 transferred to petroleum balance-sheet
(3) net production

FR GERMANY 1975

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TRANSFORMATION BALANCE-SHEET
BROWN COAL BRIQUETTING PLANTS

INPUT			OUTPUT		
	1 000 t	TJ		1 000 t	TJ
lignite	10 630	90 089	brown coal briquettes	5 276	105 520
own consumption (1)	2 565	21 738	water	5 354	-
		111 827		10 630	105 520
LOSSES (5.6 % of input)					6 307

Calorific values NCV

	kcal/kg	kJ/kg
brown coal	2 025	8 475
brown coal briquettes	4 800	20 000

Water content

brown coal	± 60 %
brown coal briquettes	± 18 %

Consumption for transformation

briquettes	60 000 t	1 200 TJ
electricity	. GWh	

(1) necessary to evaporate water
The reduction of water content from 60 to 18 % raises the net calorific value by 20 % approx.

9

TRANSFORMATION BALANCE-SHEET

BLAST FURNACES

INPUT			OUTPUT		
	1 000 t	TJ		tcal GCV	TJ NCV
hard coke	7 032	200 413	blast furnace gas	42 943	179 759
hard coke	10 953	312 160	gross consumption of energy for the reduction of iron ore		387 160
	17 985	512 573			
heavy fuel oil	1 875	75 000			
		587 573			566 919
LOSSES = flared (3.5 % of total input)				4 934	20 654

Calorific values

	kcal/kg	kJ/kg
hard coke	6 800	28 500
heavy fuel oil	9 600	40 000

Note GCV = NCV

Blast furnaces are considered as an "unavoidable" transformer of energy. The only loss attached to transformation is the blast furnace gas which is flared. The transformation input only includes hard coke which was converted into blast furnace gas. All other input or consumption is taken as a consumption of steel industry.

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TRANSFORMATION BALANCE-SHEET

REFINERIES

INPUT	1 000 t	TJ	OUTPUT	1 000 t	TJ
Crude oil	92 374	3 911 115	Refined products(1)	93 741	3 964 705
Semi refined petroleum	1 825	77 270			
	94 199	3 988 385		93 741	3 964 705
LOSSES (0.6 % of input)				458	23 680

Calorific values

Crude oil = semi refined petroleum = refined products
= 10 115 kcal NCV/kg
= 42 340 kJ/kg

These values result from the weighted average of the various petroleum products obtained (variable value).

Consumption for transformation

light fuel oil	32 068 t	)	
residual fuel oil	3 921 648 t	)	
petroleum coke	257 469 t	)	
refinery gas	3 126 202 t	)	
	7 337 387 t	)	328 032 TJ
of which power stations		)	after deducting the
(heavy fuel oil	389 000 t	)	power stations
(refinery gas	831 tcal/GCV	)	
(residues	51 tcal/GCV	)	
electricity	1 910 GWh	6 876 TJ	

Total 338 032 + 6 876 = 344 908 TJ

(1) gross production, including 183 000 t additives, excluding reprocessed lubricants and benzol

FR GERMANY 1975

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TRANSFORMATION BALANCE-SHEET

GASWORKS

INPUT	1 000 t	TJ	OUTPUT		1 000 t	TJ
Coal	1 638	47 993	gas coke		1 250	33 000
Naphtha	153	6 732	benzol		14	553
residual fuel oil	42	1 680	tar		56	2 111
coke	15	428	ammonia		13	-
			gasworks gas	tcal 4 522 NCV		18 272
			water gas	tcal 5 025 GCV		659
					1 333	55 095
LOSSES = (3.1 % of input)						1 738

	1 000 t	TJ		tcal GCV	TJ
refinery gas	26	1 508	gasworks gas	366	1 379
LPG	220(1)	10 120	gasworks gas	2 573	9 694
	246	11 628		2 939	11 073
LOSSES = (4.8 % of input)					555
TOTAL LOSSES (3.3 % of input)					2 293

Calorific values NCV

	kcal/kg	kJ/kg
Coal	7 000	29 300
naphtha	10 500	44 000
residual fuel oil	9 600	40 000
benzol	9 450	39 500
tar	9 000	37 700
gas coke	6 400	26 800
hard coke	6 800	28 500
LPG	11 000	46 000
refinery gas	14 000	58 000

Consumption for transformation

gasworks gas	1 118 tcal NCV	4 680 TJ
electricity	130 GWh	468 TJ
gas coke	84 000 t	2 251 TJ
		7 399 TJ

(1) data from Energiebilanzen Arbeitsgemeinschaft

FR GERMANY 1975

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TRANSFORMATION BALANCE-SHEET

THERMAL POWER STATIONS

INPUT			OUTPUT		
	1 000 t	TJ			TJ
Coal	(1)29 566	786 888	electricity(2)	263 293 GWh	947 855
Coke	2	57	heat (3)	24 000 tcal	100 464
Black lignite	1 188	19 892			
Brown coal	108 252	867 099			
Brown coal briquettes	926	18 607			
		1 692 543			
heavy fuel oil	6 803	272 120			
refinery gas	(249)	p.m.			
	tcal GCV				
refinery gas	3 480	13 839			
natural gas	142 933	538 487			
blast furnace gas	13 013	54 472			
coke oven gas	11 573	43 600			
	tcal NCV				
residues etc.	8 354	34 970			
		2 650 031			1 048 319
of which for heat		(118 193)			
LOSSES ELECTRICITY (62.6 % of input)					1 583 983
LOSSES HEAT (15 % of input)					17 729
			$\sum$ losses		1 601 655

Consumption for transformation

Conventional thermal power stations : 16 649 GWh = 59 936 TJ
(i.e. 6,3 % of gross production of electricity)

(1) 27 310 for electricity, 1 540 for heat, 716 for STEAG heat sent back to mines

(2) gross production

(3) of which 16 196 TJ sent back to coal mines

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TRANSFORMATION BALANCE-SHEET

NUCLEAR REACTORS

INPUT			OUTPUT		
	GWh	TJ		GWh	TJ
Heat from nuclear fission	62 650	225 541	electricity	21 398	77 033
LOSSES : 65,8 % of input					148 508

Consumption for transformation

Electricity = 1 152 GWh = 4 148 TJ

FR GERMANY 1975 TERAJOULES

CONSUMPTION OF ENERGY SECTOR

	Hard Coal	Coal briquettes	Coke	Brown coal briquettes	Petroleum products	Natural gas	Coke oven gas	Blast furnace gas	Gasworks gas	Electricity	Heat	TOTAL
Coal mines and briquetting	26 318	31	884	–	3 830	–	–	–	–	23 617	16 196	70 876
Lignite mines and briquetting	–	–	–	1 200	–	–	–	–	–	10 220	–	11 420
Coking plants	–	–	684	–	–	–	95 981	15 568	–	2 275	–	114 508
Refineries	–	–	–	–	328 032	–	–	–	–	6 876	–	334 908
Production of Natural gas	–	–	–	–	–	27 653	–	–	–	1 300	–	28 953
Gasworks	–	–	2 251		–	–	–	–	4 680	468	–	7 399
Power stations	–	–	–	–	–	–	–	–	–	65 012 (1)	–	65 012
Pumped storage Power stations	–	–	–	–	–	–	–	–	–	2 012	–	2 012
	26 318	31	3 819	1 200	331 862	27 653	95 981	15 568	4 680	111 780	16 196	635 088

(1) (conventional thermal power stations 59 936
(nuclear reactors 4 148
(hydroelectric power stations 928

FR GERMANY 1975

ENERGY BALANCE-SHEET

		HARD COAL	COAL BRIQUETTES & PATENT FUEL	COKE	BROWN COAL	BLACK LIGNITE	BROWN COAL BRIQUETTES	TARS, PITCH, BENZOL	CRUDE OIL	REFINERY GAS	LPG	MOTOR SPIRIT	KEROSINES & JETFUELS
		1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t
1	PRIMARY PRODUCTION	99 859	-	-	123 377	-	-	-	5 741	-	4	4	-
2	IMPORTS - PRIMARY	6 976	-	-	-	1 632	-	-	91 850	-	-	-	-
3	IMPORTS - DERIVED	-	4	1 294	-	-	1 102	-	-	-	254	4 422	1 234
4	EXPORTS	14 448	225	7 959	9	-	475	-	14	-	267	833	219
5	VARIATIONS OF STOCKS	-7 176	- 22	-6 465	+ 2	- 220	- 30	-	-3 186	+ 2	+ 11	- 93	+ 17
6	TRANSFORMATION INPUT	77 462	22	7 223	121 447	1 188	926	119	94 199	265	220	-	-
61	COKING PLANTS	44 554	-	174	-	-	-	-	-	-	-	-	-
62	BRIQUETTING PLANTS	1 704	22	-	13 195	-	-	119	-	-	-	-	-
63	BLAST FURNACES	-	-	7 032	-	-	-	-	-	-	-	-	-
64	REFINERIES	-	-	-	-	-	-	-	94 199	-	-	-	-
65	GASWORKS	1 638	-	15	-	-	-	-	-	26	220	-	-
66	ELECTRICAL POWER STATIONS	29 566	-	2	108 252	1 188	926	-	-	239	-	-	-
67	NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	-	-	-
7	TRANSFORMATION OUTPUT	-	1 697	36 066	-	-	5 276	1 700	-	4 053	1 978	16 473	1 308
71	COKING PLANTS	-	-	34 818	-	-	-	1 630	-	-	-	-	-
72	BRIQUETTING PLANTS	-	1 697	-	-	-	5 276	-	-	-	-	-	-
73	BLAST FURNACES	-	-	-	-	-	-	-	-	-	-	-	-
74	REFINERIES	-	-	-	-	-	-	-	-	4 053	1 978	16 473	1 308
75	GASWORKS	-	-	1 250	-	-	-	70	-	-	-	-	-
76	ELECTRICAL POWER STATIONS	-	-	-	-	-	-	-	-	-	-	-	-
77	NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	-	-	-
8	EXCHANGES AND TRANSFERS	-	-	-	-	-	-	- 396	-	-	-	+ 206	-
9	DISTRIBUTION LOSSES	-	-	-	-	-	-	-	-	-	-	-	-
10	AVAILABLE FOR CONSUMPTION	7 749	1 432	15 715	1 923	224	4 947	1 185	192	3 790	1 760	20 179	2 340
12	TOTAL CONSUMPTION	7 550	1 432	15 753	1 923	224	4 861	1 185	71	3 782	1 786	20 234	2 307
13	BUNKERS	-	-	-	-	-	-	-	-	-	-	-	-
14	ENERGY SECTOR CONSUMPTION	928	1	139	-	-	60	-	-	3 066	-	-	-
15	NON-ENERGY CONSUMPTION	-	-	647	-	-	-	1 185	71	480	778	-	-
16	FINAL ENERGY CONSUMPTION	6 622	1 431	14 967	1 923	224	4 801	-	-	236	1 008	20 234	2 307
161	INDUSTRY	3 339	4	11 799	1 909	222	530	-	-	236	347	170	62
162	TRANSPORTATION	326	-	51	-	-	43	-	-	-	8	20 064	2 245
163	HOUSEHOLDS ETC.	2 957	1 427	3 117	14	2	4 228	-	-	-	653	-	-
10-12	STATISTICAL DIFFERENCES	+ 199	-	- 38	-	-	+ 86	-	+121	+ 8	- 26	- 55	+33

NAPHTHAS 1000 t	GAS DIESEL OIL 1000 t	RESIDUAL FUEL OIL 1000 t	PETROLEUM COKE 1000 t	OTHER PETROLEUM PRODUCTS 1000 t	NATURAL GAS Tcal PCS	COKEOVEN GAS TcalPCS	BLAST FURNACE GAS TcalPCS	GASWORKS GAS TcalPCS	OTHER FUELS Tj	HEAT Tj	ELECTRICAL ENERGY Gwh		
-	-	-	-	202 (1)	160 068	-	-	-	34 970 (2)	-	15 731	1	PRIMARY PRODUCTION
-	-	-	-	-	225 932	-	-	-	-	225 541	-	2	IMPORTS - PRIMARY
4 534	19 472	4 283	1 417	1 627	-	-	-	-	-	-	17 630	3	IMPORTS - DERIVED
818	1 204	1 644	402	1 074	748	-	-	11	-	-	9 791	4	EXPORTS
+ 33	+ 1 917	+ 711	- 12	+ 16	- 3 179	-	-	+ 67	-	-	-	5	VARIATIONS OF STOCKS
153	-	6 845	481	-	142 933	11 573	13 013	-	34 970	225 541	-	6	TRANSFORMATION INPUT
-	-	-	481	-	-	-	-	-	-	-	-	61	COKING PLANTS
-	-	-	-	-	-	-	-	-	-	-	-	62	BRIQUETTING PLANTS
-	-	-	-	-	-	-	-	-	-	-	-	63	BLAST FURNACES
-	-	-	-	-	-	-	-	-	-	-	-	64	REFINERIES
153	-	42	-	-	-	-	-	-	-	-	-	65	GASWORKS
-	-	6 803	-	-	142 933	11 573	13 013	-	34 970	-	-	66	ELECTRICAL POWER STATIONS
-	-	-	-	-	-	-	-	-	-	225 541	-	67	NUCLEAR REACTORS
1 102	36 047	25 279	799	6 702	-	66 521	42 943	7 964	-	100 464	284 691	7	TRANSFORMATION OUTPUT
-	-	-	-	-	-	66 521	-	-	-	-	-	71	COKING PLANTS
-	-	-	-	-	-	-	-	-	-	-	-	72	BRIQUETTING PLANTS
-	-	-	-	-	-	-	42 943	-	-	-	-	73	BLAST FURNACES
1 102	36 047	25 279	799	6 702	-	-	-	-	-	-	-	74	REFINERIES
-	-	-	-	-	-	-	-	7 964	-	-	-	75	GASWORKS
-	-	-	-	-	-	-	-	-	-	100 464	263 293	76	ELECTRICAL POWER STATIONS
-	-	-	-	-	-	-	-	-	-	-	21 398	77	NUCLEAR REACTORS
-	+ 27	+ 163	-	-	- 2 724	-21 560	-	+24 284	-	-	-	8	EXCHANGES AND TRANSFERS
-	-	-	-	-	2 406	-	-	1 800	-	-	14 772	9	DISTRIBUTION LOSSES
4 698	56 259	21 947	1 321	7 473	234 010	33 388	29 930	3o 504	-	100 464	293 489	1o	AVAILABLE FOR CONSUMPTION
4 688	56 429	22 002	1 319	7 459	234 010	33 386	29 930	30 504	-	100 464	293 489	12	TOTAL CONSUMPTION
-	530	2 283	-	54	-	-	-	-	-	-	-	13	BUNKERS
-	80	3 578	257	-	7 340	25 477	3 719	1 242	-	16 196	31 050	14	ENERGY SECTOR CONSUMPTION
4 688	-	-	1 062	7 405	7 500	329	-	-	-	-	-	15	NON-ENERGY CONSUMPTION
-	55 819	16 141	-	-	219 170	7 552	26 211	29 262	-	84 268	262 439	16	FINAL ENERGY CONSUMPTION
-	5 812	15 137	-	-	136 276	7 582	26 211	16 527	-	28 069	128 112	161	INDUSTRY
-	8 644	58	-	-	-	-	-	-	-	-	8 657	162	TRANSPORTATION
-	41 363	946	-	-	82 894	-	-	12 735	-	56 179	125 470	163	HOUSEHOLDS ETC.
+ 10	- 170	- 55	+ 2	+ 14	-	-	-	-	-	-	-	1o-12	STATISTICAL DIFFERENCES

(1) regenerated lubricants and additives (2) Refuse and waste

	HARD COAL	BROWN COAL BRIQUETTES	COKE	BROWN COAL	BROWN COAL BRIQUETTES	TARS, PITCH, BENZOL	CRUDE OIL	REFINERY GAS	LPG	MOTOR SPIRIT	KEROSINES & JETFUELS	NAPHTAS
1 PRIMARY PRODUCTION	2 832 000	-	-	994 419	-	-	243 074	-	184	176	-	-
2 IMPORTS - PRIMARY	204 397	-	-	27 326	-	-	3 886 929	-	-	-	-	-
3 IMPORTS - DERIVED	-	126	36 879	-	22 040	-	-	-	11 684	194 568	53 062	199 496
4 EXPORTS	423 326	7 065	225 871	73	9 500	-	593	-	12 282	36 652	9 417	35 992
5 VARIATIONS OF STOCKS	- 202 317	- 691	- 184 186	- 3 668	- 600	-	- 134 895	+ 116	+ 506	- 4 092	+ 731	+ 1 452
6 TRANSFORMATION INPUT	2 193 818	691	205 857	998 818	18 607	4 486	3 988 385	15 347	10 120	-	-	6 732
61 COKING PLANTS	1 305 432	-	4 959	-	-	-	-	-	-	-	-	-
62 BRIQUETTING PLANTS	53 505	691	-	111 827	-	4 486	-	-	-	-	-	-
63 BLAST FURNACES	-	-	200 413	-	-	-	-	-	-	-	-	-
64 REFINERIES	-	-	-	-	-	-	3 988 385	-	-	-	-	-
65 GASWORKS	47 993	-	428	-	-	-	-	1 508	10 120	-	-	6 732
66 ELECTRICAL POWERSTATIONS	786 888	-	57	886 991	18 607	-	-	13 839	-	-	-	-
67 NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	-	-	-
7 TRANSFORMATION OUTPUT	-	53 286	1 025 813	-	105 520	64 745	-	235 074	90 988	724 812	56 244	48 488
71 COKING PLANTS	-	-	992 313	-	-	62 081	-	-	-	-	-	-
72 BRIQUETTING PLANTS	-	53 286	-	-	105 520	-	-	-	-	-	-	-
73 BLAST FURNACES	-	-	-	-	-	-	-	-	-	-	-	-
74 REFINERIES	-	-	-	-	-	-	-	235 074	90 988	724 812	56 244	48 488
75 GASWORKS	-	-	33 500	-	-	2 664	-	-	-	-	-	-
76 ELECTRICAL POWERSTATIONS	-	-	-	-	-	-	-	-	-	-	-	-
77 NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	-	-	-
8 EXCHANGES AND TRANSFERS	-	-	-	-	-	- 15 300	-	-	-	+ 8 137	-	-
9 DISTRIBUTION LOSSES	-	-	-	-	-	-	-	-	-	-	-	-
10 AVAILABLE FOR CONSUMPTION	216 936	44 965	446 778	19 186	98 853	44 959	8 130	219 843	80 960	886 949	100 620	206 712
12 TOTAL CONSUMPTION	216 983	44 965	447 863	19 153	97 220	44 959	3 006	219 356	82 156	890 296	99 201	206 272
13 BUNKERS	-	-	-	-	-	-	-	-	-	-	-	-
14 ENERGY SECTOR CONSUMPTION	26 318	31	3 819	-	1 200	-	-	177 828	-	-	-	-
15 NON-ENERGY CONSUMPTION	-	-	18 440	-	-	44 959	3 006	27 840	35 788	-	-	206 272
16 FINAL ENERGY CONSUMPTION												
ENERGY SUPPLIED	190 665	44 934	425 604	19 153	96 020	-	-	13 688	46 368	890 296	99 201	-
USEFUL ENERGY	127 090	26 896	321 492	14 350	63 559	-	-	9 855	27 247	178 059	30 518	-
CONSUMPTION LOSSES	63 575	18 038	104 112	4 803	32 461	-	-	3 833	19 121	712 237	68 683	-
161 INDUSTRY												
ENERGY SUPPLIED	93 492	126	336 234	19 008	10 600	-	-	13 688	15 962	7 480	2 666	-
USEFUL ENERGY	67 011	95	267 783	14 256	7 950	-	-	9 855	11 048	1 496	2 000	-
162 TRANSPORTATION												
ENERGY SUPPLIED	9 291	-	1 454	-	860	-	-	-	368	882 816	96 535	-
USEFUL ENERGY	6 968	-	1 090	-	645	-	-	-	207	176 563	28 518	-
163 HOUSEHOLDS ETC.												
ENERGY SUPPLIED	87 852	44 808	87 916	145	84 560	-	-	-	30 038	-	-	-
USEFUL ENERGY	53 111	26 801	52 619	94	54 964	-	-	-	15 992	-	-	-
10-12 STATISTICAL DIFFERENCES	- 47	-	- 1 085	+ 33	+ 1 633	-	+ 5 124	+ 487	-1 196	- 3 347	+1 419	+ 440

GAS DIESEL OIL	RESIDUAL FUEL OIL	PETROLEUM COKE	OTHER PETROLEUM PRODUCTS	NATURAL GAS	COKEOVEN GAS	BLAST FURNACE GAS	GASWORKS GAS	OTHER FUELS	HEAT	ELECTRICAL ENERGY	TOTAL	
-	-	-	8 545	603 039	-	-	-	34 970	-	56 632	4 773 039	1 PRIMARY PRODUCTION
-	-	-	-	851 177	-	-	-	-	225 541	-	5 197 370	2 IMPORTS - PRIMARY
823 666	171 320	41 518	55 543	-	-	-	-	-	-	63 468	1 673 370	3 IMPORTS - DERIVED
50 929	65 760	11 779	40 660	2 817	-	-	42	-	-	35 248	968 006	4 EXPORTS
+ 81 089	+ 28 440	- 352	+ 160	-11 976	-	-	+ 251	-	-	-	-430 032	5 VARIATIONS OF STOCKS
-	273 800	14 093	-	538 487	43 600	54 472	-	34 970	225 541	-	8 627 824	6 TRANSFORMATION INPUT
-	-	14 093	-	-	-	-	-	-	-	-	1 324 464	61 COKING PLANTS
-	-	-	-	-	-	-	-	-	-	-	170 509	62 BRIQUETTING PLANTS
-	-	-	-	-	-	-	-	-	-	-	200 413	63 BLAST FURNACES
-	-	-	-	-	-	-	-	-	-	-	3 983 385	64 REFINERIES
-	1 680	-	-	-	-	-	-	-	-	-	68 461	65 GASWORKS
-	272 120	-	-	538 487	43 600	54 472	-	34 970	-	-	2 650 031	66 ELECTRICAL POWERSTATIONS
-	-	-	-	-	-	-	-	-	225 541	-	225 541	67 NUCLEAR REACTORS
1 524 788	1 011 160	23 411	249 740	-	250 612	179 759	30 005	-	100 464	1 024 888	5 799 797	7 TRANSFORMATION OUTPUT
-	-	-	-	-	250 612	-	-	-	-	-	1 305 006	71 COKING PLANTS
-	-	-	-	-	-	-	-	-	-	-	158 806	72 BRIQUETTING PLANTS
-	-	-	-	-	-	179 759	-	-	-	-	179 759	73 BLAST FURNACES
1 524 788	1 011 160	23 411	249 740	-	-	-	-	-	-	-	3 964 705	74 REFINERIES
-	-	-	-	-	-	-	30 005	-	-	-	66 169	75 GASWORKS
-	-	-	-	-	-	-	-	-	100 464	947 655	1 048 319	76 ELECTRICAL POWERSTATIONS
-	-	-	-	-	-	-	-	-	-	77 033	77 033	77 NUCLEAR REACTORS
+ 1 018	+ 6 145	-	-	-10 264	-81 225	-	+91 489	-	-	-	0	8 EXCHANGES AND TRANSFERS
-	-	-	-	9 063	-	-	6 [illegible]	-	-	53 179	69 023	9 DISTRIBUTION LOSSES
2 379 632	877 505	38 705	273 328	881 609	125 787	125 287	111 922	-	100 464	1 056 561	8 348 691	10 AVAILABLE FOR CONSUMPTION
2 386 947	880 080	38 647	272 987	881 609	125 785	125 287	114 922	-	100 464	1 056 560	8 354 718	12 TOTAL CONSUMPTION
22 419	91 320	-	2 284	-	-	-	-	-	-	-	116 023	13 BUNKERS
3 384	143 120	7 530	-	27 653	95 981	15 566	4 680	-	16 196	111 780	635 088	14 ENERGY SECTOR CONSUMPTION
-	-	31 117	270 703	28 255	1 239	-	-	-	-	-	667 619	15 NON-ENERGY CONSUMPTION
												16 FINAL ENERGY CONSUMPTION
2 361 144	645 640	-	-	825 701	28 565	109 719	110 242	-	84 268	944 780	6 935 988	ENERGY SUPPLIED
1 594 146	449 956	-	-	608 620	22 852	87 775	79 989	-	80 055	718 251	4 440 710	USEFUL ENERGY
766 998	195 684	-	-	217 081	5 713	21 944	30 253	-	4 213	226 529	2 495 278	CONSUMPTION LOSSES
												161 INDUSTRY
245 848	605 480	-	-	513 405	28 565	109 719	62 262	-	28 089	461 203	2 553 827	ENERGY SUPPLIED
177 787	419 836	-	-	387 105	22 852	87 775	49 809	-	26 685	383 433	1 936 776	USEFUL ENERGY
												162 TRANSPORTATION
365 641	2 320	-	-	-	-	-	-	-	-	31 885	1 391 170	ENERGY SUPPLIED
129 693	1 740	-	-	-	-	-	-	-	-	28 560	373 984	USEFUL ENERGY
												163 HOUSEHOLDS ETC.
1 749 655	37 840	-	-	312 297	-	-	47 980	-	56 179	451 692	2 990 992	ENERGY SUPPLIED
1 286 666	28 380	-	-	221 515	-	-	30 180	-	53 370	306 258	2 129 950	USEFUL ENERGY
- 7 315	- 2 575	+ 58	+ 341	-	+ 2	-	-	-	-	+ /	- 6 027	10-12 STATISTICAL DIFFERENCES

A = ENERGY SUPPLIED

		HARD COAL	COAL BRIQUETTES & PATENT FUEL	COKE	BROWN COAL	COAL BRIQUETTES & PATENT FUEL	REFINERY GAS	LPG	MOTOR SPIRIT	KEROSINES & JETFUELS	NAPHTHAS
INDUSTRY	A	93 492	126	336 234	19 008	10 600	13 688	15 962	7 480	2 666	-
	B	67 011	95	267 783	14 256	7 950	9 855	11 048	1 496	2 000	-
PISTON ENGINES	A	-	-	-	-	-	-	1 058	7 480	-	-
	B	-	-	-	-	-	-	317	1 496	-	-
CEMENT KILNS	A	8 400	-	-	-	-	-	-	-	-	-
	B	3 192	-	-	-	-	-	-	-	-	-
RADIATION FURNACES	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
BLAST FURNACES	A	-	-	312 160	-	-	-	-	-	-	-
	B	-	-	249 728	-	-	-	-	-	-	-
FURNACES AND BOILERS	A	85 092	126	24 074	19 008	10 600	13 688	14 904	-	2 666	-
	B	63 819	95	18 055	14 256	7 950	9 855	10 731	-	2 000	-
ELECTRIC MOTORS AND FURNACES	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
ELECTROLYSIS	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
LIGHTING	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
TRANSPORTATION	A	9 291	-	1 454	-	860	-	368	882 816	96 535	-
	B	6 968	-	1 090	-	645	-	207	176 563	28 518	-
PISTON ENGINES	A	-	-	-	-	-	-	138	682 816	-	-
	B	-	-	-	-	-	-	41	176 563	-	-
TURBO-PROP	A	-	-	-	-	-	-	-	-	9 632	-
	B	-	-	-	-	-	-	-	-	2 408	-
AIRCRAFT JET	A	-	-	-	-	-	-	-	-	86 817	-
	B	-	-	-	-	-	-	-	-	26 045	-
ELECTRIC RAIL HAULAGE	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
SPACE HEATING	A	9 291	-	1 454	-	860	-	230	-	86	-
	B	6 968	-	1 090	-	645	-	166	-	65	-
LIGHTING	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
HOUSEHOLDS ETC.	A	87 882	44 808	87 916	145	84 560	-	30 038	-	-	-
	B	53 111	26 801	52 619	94	54 964	-	15 992	-	-	-
COOKERS	A	11 412	5 809	11 424	-	-	-	16 100	-	-	-
	B	2 853	1 452	2 856	-	-	-	5 957	-	-	-
WATER HEATERS	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
SPACE HEATING	A	70 942	38 999	76 064	145	84 560	-	13 938	-	-	-
	B	46 112	25 349	49 442	94	54 964	-	10 035	-	-	-
DISTRICT HEATING	A	5 528	-	428	-	-	-	-	-	-	-
	B	4 146	-	321	-	-	-	-	-	-	-
ELECTRIC MOTORS AND APPLIANCES	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
PISTON ENGINES (1)	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
FURNACES AND BOILERS (2)	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
LIGHTING	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-

(1) Agriculture and Fishing (2) Commerce, Handicraft, Small industry

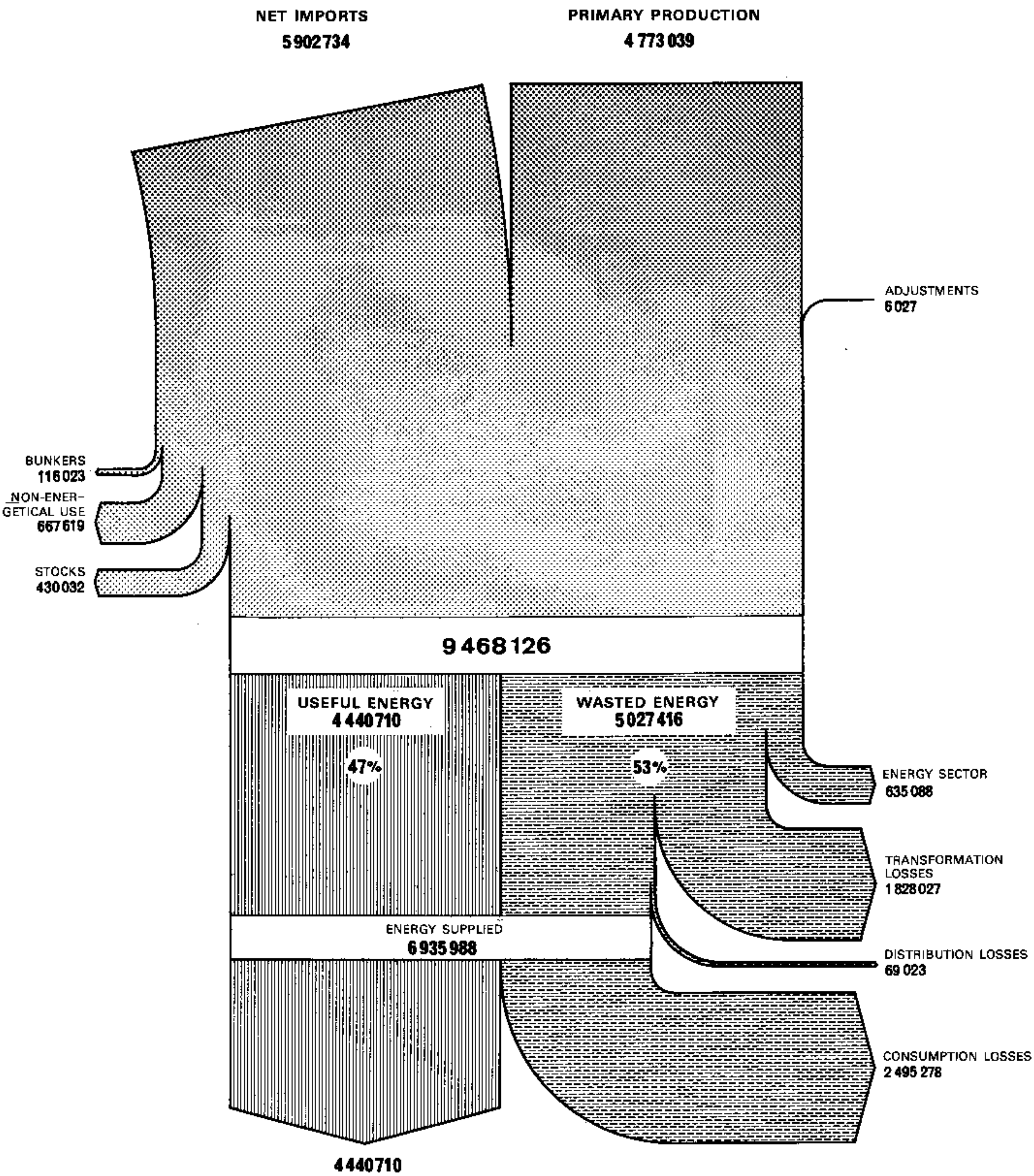
FINAL ENERGY CONSUMPTION

B = USEFUL ENERGY

GAS DIESEL OIL	RESIDUAL FUEL OIL	NATURAL GAS	COKEOVEN GAS	BLAST FURNACE GAS	GASWORKS GAS	HEAT	ELECTRICAL ENERGY	TOTAL		
245 848	605 480	513 405	28 565	109 719	62 262	26 089	461 203	2 553 827	A	INDUSTRY
177 787	419 836	387 105	22 852	87 775	49 809	26 685	363 433	1 936 776	B	
16 497	-	-	-	-	-	-	-	25 035	A	PISTON ENGINES
5 774	-	-	-	-	-	-	-	7 587	B	
-	79 080	39 085	-	-	-	-	-	126 565	A	CEMENT KILNS
-	30 050	14 852	-	-	-	-	-	48 094	B	
-	25 040	18 008	-	-	-	-	-	43 048	A	RADIATION FURNACES
-	10 016	7 203	-	-	-	-	-	17 219	B	
-	75 000	-	-	61 367	-	-	-	448 527	A	BLAST FURNACES
-	60 000	-	-	49 093	-	-	-	358 821	B	
229 351	426 360	456 312	28 565	48 352	62 262	28 089	-	1 449 449	A	FURNACES AND BOILERS
172 013	319 770	365 050	22 852	38 682	49 809	26 685	-	1 121 622	B	
-	-	-	-	-	-	-	382 568	382 568	A	ELECTRIC MOTORS AND FURNACES
-	-	-	-	-	-	-	363 440	363 440	B	
-	-	-	-	-	-	-	64 800	64 800	A	ELECTROLYSIS
-	-	-	-	-	-	-	19 440	19 440	B	
-	-	-	-	-	-	-	13 835	13 835	A	LIGHTING
-	-	-	-	-	-	-	553	553	B	
365 641	2 320	-	-	-	-	-	31 885	1 391 170	A	TRANSPORTATION
129 693	1 740	-	-	-	-	-	28 560	373 984	B	
360 269	-	-	-	-	-	-	-	1 243 223	A	PISTON ENGINES
126 094	-	-	-	-	-	-	-	302 698	B	
-	-	-	-	-	-	-	-	9 632	A	TURBO-PROP
-	-	-	-	-	-	-	-	2 408	B	
-	-	-	-	-	-	-	-	86 817	A	AIRCRAFT JET
-	-	-	-	-	-	-	-	26 045	B	
-	-	-	-	-	-	-	31 727	31 727	A	ELECTRIC RAIL HAULAGE
-	-	-	-	-	-	-	28 554	28 554	B	
5 372	2 320	-	-	-	-	-	-	19 613	A	SPACE HEATING
3 599	1 740	-	-	-	-	-	-	14 273	B	
-	-	-	-	-	-	-	158	158	A	LIGHTING
-	-	-	-	-	-	-	6	6		
1 749 655	37 840	312 297	-	-	47 980	56 179	451 692	2 990 992	A	HOUSEHOLDS ETC.
1 256 666	28 380	221 515	-	-	30 160	53 370	306 258	2 129 950	B	
-	-	12 056	-	-	11 051	-	28 080	95 932	A	COOKERS
-	-	4 461	-	-	4 089	-	21 060	42 728	B	
-	-	8 707	-	-	7 589	-	56 826	73 122	A	WATER HEATERS
-	-	5 396	-	-	4 705	-	51 144	61 247	B	
1 684 640	-	269 645	-	-	26 067	56 179	47 444	2 368 623	A	SPACE HEATING
1 263 910	-	194 145	-	-	18 768	53 370	45 072	1 761 261	B	
-	37 840	-	-	-	-	-	-	43 796	A	DISTRICT HEATING
-	28 380	-	-	-	-	-	-	32 847	B	
-	-	-	-	-	-	-	193 634	193 634	A	ELECTRIC MOTORS AND APPLIANCES
-	-	-	-	-	-	-	183 953	183 953	B	
65 015	-	-	-	-	-	-	-	65 015	A	PISTON ENGINES (1)
22 756	-	-	-	-	-	-	-	22 756	B	
-	-	21 889	-	-	3 273	-	-	25 162	A	FURNACES AND BOILERS (2)
-	-	17 511	-	-	2 618	-	-	20 129	B	
-	-	-	-	-	-	-	125 708	125 708	A	LIGHTING
-	-	-	-	-	-	-	5 029	5 029	B	

OVERALL ENERGY FLOW-SHEET

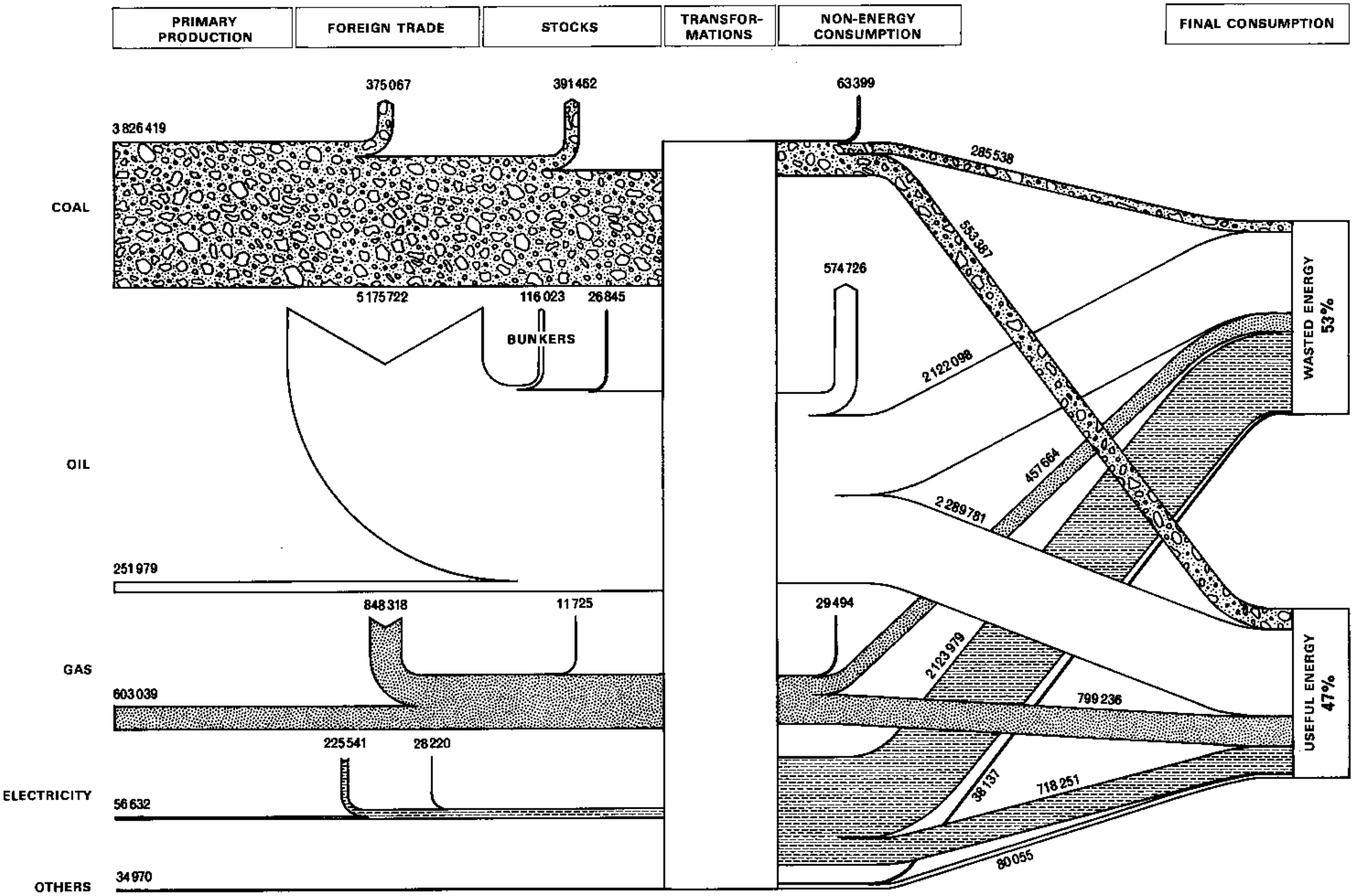
TJOULES



F.R. GERMANY 1975

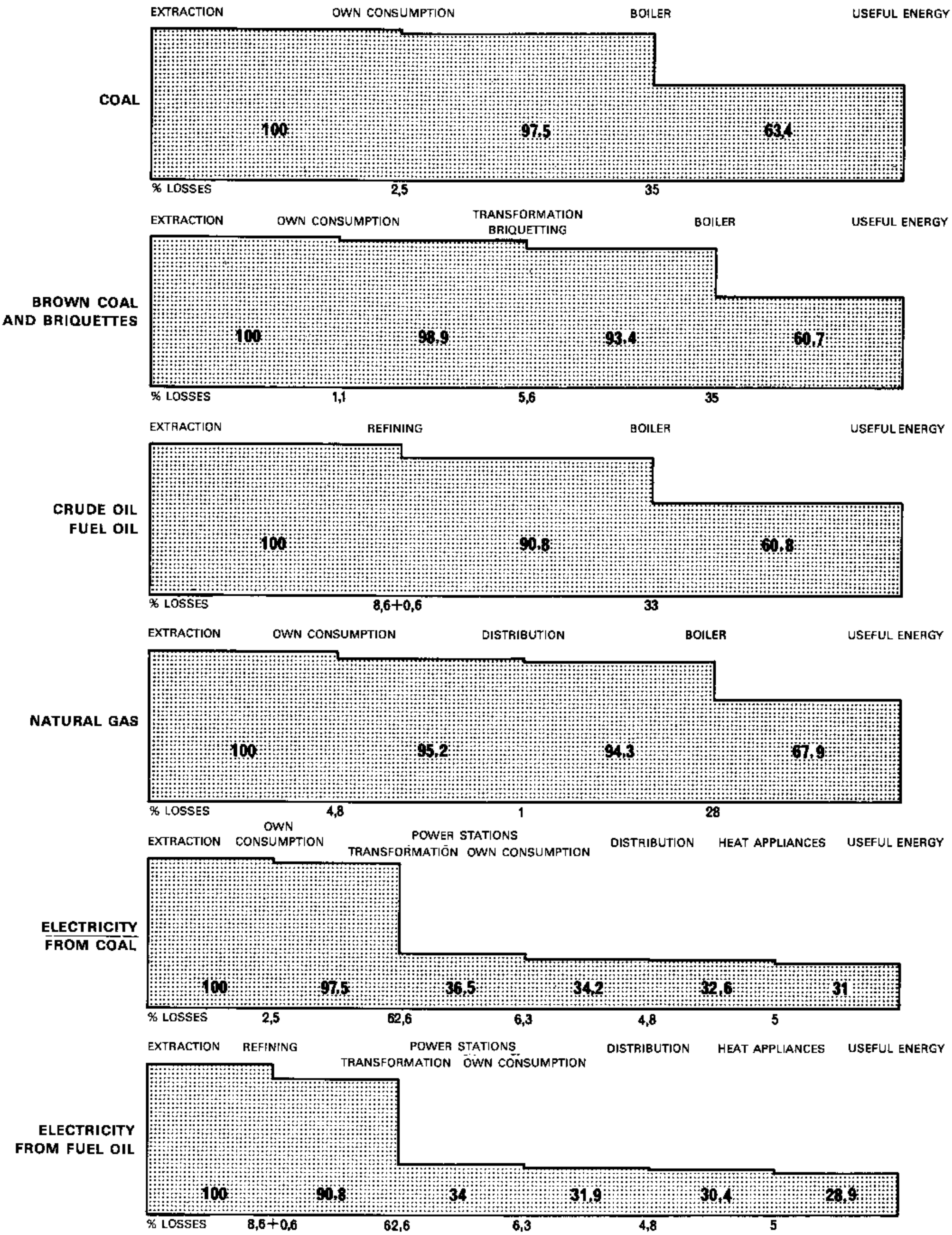
TJOULES

ENERGY FLOW-SHEET



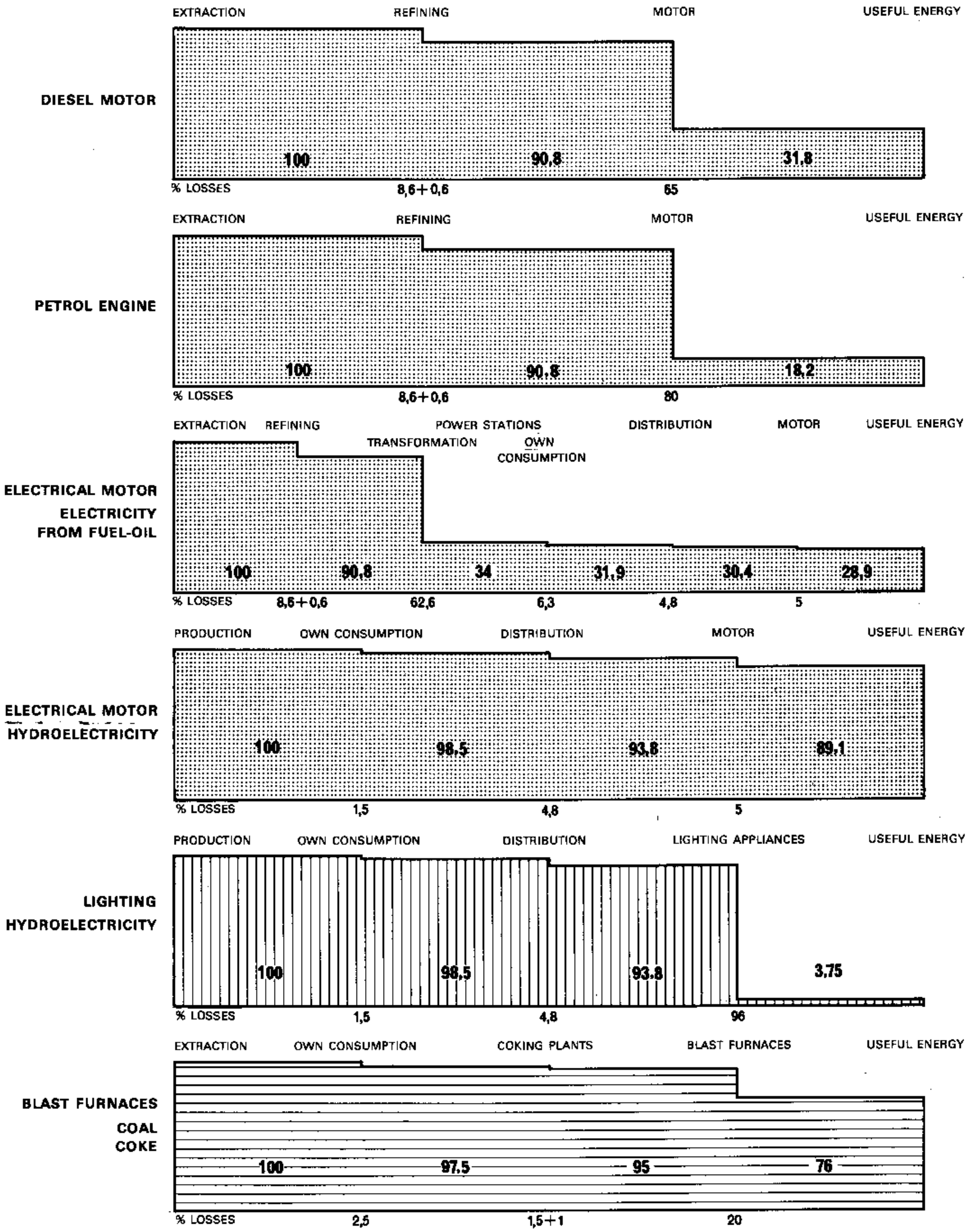
ENERGY SUB-FLOWS

FOR SPACE HEATING (HOUSEHOLDS AND SIMILAR)



ENERGY SUB-FLOWS

FOR MOTIVE POWER (INDUSTRY AND TRANSPORT)



TABLES AND GRAPHS – FRANCE 1975

TABLE OF CONVERSION FACTORS

(net calorific value)
1 kcal = 4 186 kJ

ENERGY SOURCE	kcal/kg	kJ/kg
Hardcoal (output)	variable	variable
Coking coal	7 000	29 300
Coal for power stations (1)	5 306	22 179
Coal for briquetting	7 500	31 400
Low grade coal for cement works	6 000	25 120
Industrial coals	6 800	28 500
Anthracites	7 500	31 400
Household coals	7 000	29 300
Hard coke	6 800	28 500
Pitch and tars	9 000	37 700
Benzol	9 450	39 500
Coal briquettes	7 500	31 400
Brown coal	1 575	6 580
Black lignite	4 400	18 400
Brown coal briquettes	4 800	20 000
Crude oil	variable	variable
Motor spirit, white spirit, industrial spirits, naphthas	10 500	44 000
Kerosines and jet fuels	10 300	43 000
Gas-diesel oil and lubricants	10 100	42 300
Residual fuel oil	9 600	40 000
Petroleum coke	7 000	29 300
Bitumens	9 000	37 700
Paraffins, waxes, etc.	7 200	30 000
LPG	11 000	46 000
Refinery gas	14 000	58 000
	Tcal GCV	TJoules NCV
Natural gas	1	3.838
Coke-oven gas	1	3.838
Blast-furnace gas	1	4.18600
Gasworks gas	1	3.831
	GWh	TJoules
Electricity	1	3.6

(1) recorded during transformation in thermal power stations

TABLE OF THE EFFICIENCIES OF APPLIANCES AT THE FINAL CONSUMPTION STAGE

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Appliance	Average efficiency
Coal-fired stove	50 %
Coal-fired cooker	25 %
Coal-fired domestic heating boiler	65 %
Coal-fired industrial furnaces and boilers	75 %
Coal-fired district heating boilers	75 %
Cement kilns (medium dry path, humid, 1/2 humid)	40 %
Blast furnaces	80 %
Gas engine	30 %
Petrol engine	20 %
Diesel engine	35 %
Turbo prop	25 %
Aircraft jet	30 %
LPG cooker	37 %
Oil-fired cooker	37 %
Petrol-fired stove	55 %
Oil-fired domestic heating boiler	67 %
Glassworks radiation furnace (fuel oil or gas)	40 %
Oil-fired industrial furnaces and boilers	75 %
Space heating with LPG	72 %
District heating boilers-fired with heavy fuel oil	75 %
Paraffin and naphtha burners	75 %
Gas cookers	37 %
Gas-fired water heater	62 %
Gas-fired domestic heating boiler	72 %
Gas-fired industrial furnaces and boilers	80 %
Electric cooker	75 %
Electric water heater	90 %
Electric lighting	4 %
Electrolysis	30 %
Electric motors	95 %
Electric rail locomotion	90 %
Electric heating	95 %
Electric furnaces	95 %

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COMPARISON OF BALANCE-SHEETS

(Primary input
(Energy supplied
(Useful energy

Final energy consumption		Industry	Transports	Households, etc.	TOTAL
Primary input	TJ	2 265 865	1 100 905	2 388 963	5 755 733
balance-sheet	%	39	19	42	100
Energy supplied	TJ	1 768 865	1 104 860	1 996 727	4 870 452
balance-sheet	%	36	23	41	100
Useful energy	TJ	1 298 121	293 284	1 248 461	2 839 866
balance-sheet	%	46	10	44	100

Final energy consumption		Solid fuels	Petroleum	Gas	Electricity	TOTAL
Primary input	TJ	506 661	3 208 071	565 499	1 475 473	5 755 704
balance-sheet	%	9	56	10	25	100
Energy supplied	TJ	491 869	3 223 550	572 031	582 876	4 870 452 (1)
balance-sheet	%	10	66	12	12	100
Useful energy	TJ	332 655	1 683 576	404 505	419 004	2 839 866 (1)
balance-sheet	%	12	59	14	15	100

(1) of which heat = 126 (geothermal)

BREAKDOWN OF WASTED ENERGY

24

TJ

100 %	TOTAL	3 190 341	consumption	2 030 586
			transformation	862 249
			energy sector	383 110
			distribution	77 656
5,8 %	Solid fuels	194 514	consumption	159 214
			energy sector	8 734
			coal briquetting *	8 056
			coke ovens *	18 510
56,4 %	Oil	1 892 700	consumption	1 539 974
			energy sector	273 492
			refining *	79 234
7,8 %	Gas	262 429	consumption	167 526
			energy sector	50 488
			distribution	33 040
			blast furnaces *	9 144
			gasworks *	2 231
30,0 %	Electricity	1 003 953	consumption	163 872
			energy sector	50 396
			distribution	44 611
			power stations *	745 074
0,0 %	Heat	5	distribution	5

(*) transformation losses

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BREAKDOWN OF CONSUMPTION BY TYPE OF APPLIANCES

%

INDUSTRY	energy supplied	useful energy
Internal combustion engines	1,6	0,7
Cement kilns	7,2	3,9
Radiation furnaces (glassworks)	2,4	1,3
Blast furnaces	12,3	13,4
Steamcrackers	2,6	3,2
Other furnaces and boilers (1)	57,2	59,6
Electric motors and furnaces	12,7	16,5
Electrolysis	3,3	1,4
Lighting	0,6	0,0
	100	100
TRANSPORTS		
Internal combustion engines	89,9	83,2
Turboprops and aircraft jets	7,3	8,1
Electric rail-haulage	2,0	6,8
Heating	0,8	1,9
Lighting	0,0	0,0
	100	100
HOUSEHOLDS, ETC.		
Cooking	6,0	3,7
Water-heaters	3,5	4,3
Space heating	73,4	78,7
Electric motors and appliances	5,3	8,0
Internal combustion engines (2)	6,0	3,3
Technical furnaces and boilers (3)	1,3	1,7
Lighting	4,5	0,3
	100	100

(1) including space heating
(2) agriculture and fishing
(3) handicraft, agriculture, small-scale industry

TRANSFORMATION BALANCE-SHEET

COAL BRIQUETTING PLANTS

INPUT			OUTPUT		
	1 000 t	TJ		1 000 t	TJ
Hard coal	2 755	86 507	Coal briquettes	2 795	87 763
Pitch	247	9 312			
	3 002	95 819		2 795	87 763
LOSSES (8.4 % of input)					8 056

Calorific values NCV

	kcal/kg	kJ/kg
Hard coal	7 500	31 400
Coal briquettes	7 500	31 400
Pitch	9 000	37 700

Consumption for transformation

Coal briquettes 2 000 t = 63 TJ

27 TRANSFORMATION BALANCE-SHEET

COKING PLANTS

INPUT	1 000 t	TJ	OUTPUT	1 000 t	TJ
Coking coal	14 835	434 665	hard coke	11 445 t	326 183
Coke (1)	307	8 750	tars, pitch (2)	455	17 154
Petroleum coke	104	3 047	benzol	94	3 713
	15 246	446 462		Tcal	
			coke oven gas	21 077 GCV	
				19 327 NCV	80 902
					427 952
LOSSES (4.14 % of input)					18 510
			of which flared		2 207

Calorific values NCV

	kcal/kg	kJ/kg
coking coal	7 000	29 300
hard coke	6 800	28 500
petroleum coke	7 000	29 300
tars and pitch	9 000	37 700
benzol	9 450	39 500

Consumption for transformation

coke oven gas	8 777 Tcal NCV	7 987 Tcal NCV	=	33 434 TJ NCV
coke		15 000 t	=	428 TJ
electricity		467 GWh	=	1 681 TJ
blast furnace gas		916 Tcal NCV	=	3 834 TJ NCV
natural gas (methane)		1 219 Tcal GCV	=	4 642 TJ NVC
				44 019 TJ

(1) recycled

(2) of which 247 000 t (9 312 TJ) used in the coal briquetting plants.

TRANSFORMATION BALANCE-SHEET

BLAST FURNACES

INPUT	1 000 t	TJ	OUTPUT	Tcal NCV	TJ
hard coke	4 722	134 577	blast furnace gas	29 965	125 433
hard coke	5 958	169 803	gross consumption of energy for the reduction of iron ore		216 923
	10 680	304 380			
heavy fuel oil	1 178	47 120			
		351 500			342 356
LOSSES = (flares) 6,8 % of input				2 229	9 144

Calorific values NCV

	kcal/kg	kJ/kg
hard coke	6 800	28 500
heavy fuel oil	9 600	40 000

Note

For blast furnace gas GCV x 0.99 = NCV

Blast furnaces are considered as an "unavoidable" transformer of energy. The transformation input only includes hard coke which matches the gross production of blast furnace gas (125 433 + 9 144 = 134 577 TJ). The only loss attached to transformation is the gas which is flared (9 144 TJ).
All other operations are considered as being destined for the production of pig iron (reduction of iron ore).

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TRANSFORMATION BALANCE-SHEET

REFINERIES

INPUT			OUTPUT		
	1 000 t	TJ		1 000 t	TJ
Crude oil	109 253	4 599 770	Refined products(1)	107 371	4 520 536
LOSSES (1.7 % of input)				1 882	79 234

Calorific values NCV

Crude oil = weighted average of the petroleum products obtained
= 10 058 kcal/kg = 42 102 kJ/kg

Consumption for transformation

	1 000 t	TJ NCV
refinery gas	2 042	118 430
LPG	104	4 784
residual fuel oil	3 627 B	145 080
	5 773 (2)	268 294
electricity	3 722 GWh	13 399
		281 693 TJ

(1) Gross production, leaving aside the double accounting of petrochemical feedstocks. Excluding 94 000 t of reprocessed lubricants.

(2) Moreover 64 000 t of refinery gas and 168 000 t of residual fuel oil burnt in refinery power stations.

TRANSFORMATION BALANCE-SHEET

GASWORKS

INPUT	1 000 t	tcal GCV	tcal NCV	TJ NCV	OUTPUT	tcal GCV	tcal NCV	TJ NCV
natural gas (cracked)		4 326	3 969	16 614	gasworks gas	5 153	4 732	19 808
LPG	292	-	3 212	13 426	propane-air mixture	3 080	2 803	11 733
						8 233	7 535	31 541
naphtha	109	-	1 145	4 796	LPG for enriching (1)	353	322	1 348
gasoil	1	-	10	42				
residual fuel oil	6	-	58	242				
			8 394	35 120		8 586	7 857	32 889
LOSSES (6.35 % of input)							537	2 231
Mixing :								
coke oven gas	865	791	3 311		mixed coke oven gas	865	791	3 311
					LPG for enriching (1)	-353	-322	-1 348

NOTE: The net production (after transformation losses) of derived gas (gasworks gas and propane-air-mixture) is 7 535 tcal NCV, 31 541 TJ.

Gasworks consumption

	tcal GCV	tcal NCV	TJ NCV	
gasworks gas	58	53	222	327
propane-air-mixture	27	25	105	
LPG (113 000 t)	1 361	1 240	5 198	
electricity	163	GWh =	587 TJ	
			6 112 TJ	

(1) This LPG is added to enrich natural gas and therefore must be transferred to the natural gas balance-sheet.

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TRANSFORMATION BALANCE-SHEET

THERMAL POWER STATIONS

INPUT	1 000 t	TJ	OUTPUT	GWh	TJ
coal	12 508	277 415			
brown coal	1 641	10 798			
black lignite	956	17 590			
gas oil	52	2 200			
residual fuel oil	12 091	483 640			
refinery gas	64	3 745			
	tcal NCV				
natural gas	25 480	106 659			
coke oven gas	4 172	17 464			
blast furnace gas	10 427	43 647			
garbages, refuse	903	3 775	electricity	106 886	384 790
Total for electricity production	=	966 933			384 790
LOSSES = 60,3 % of input					582 143

Consumption for transformation

Own consumption in thermal power stations = 5 715 GWh = 20 574 TJ

TRANSFORMATION BALANCE-SHEET 32

NUCLEAR REACTORS

INPUT			OUTPUT		
	GWh	TJ		GWh	TJ
Heat from nuclear fission	63 577	228 876	Electricity	18 318	65 945
LOSSES = 71,2 % of input					162 931

Consumption for transformation

Electricity 867 GWh = 3 121 TJ

FRANCE 1975 TERAJOULES

CONSUMPTION OF ENERGY SECTOR

	Hard Coal	Coal briquettes	Coke	Lignite	Petroleum products	Natural gas	Coke oven gas	Blast furnace gas	Gas-works gas	Electricity	TOTAL
Coal mines and briquetting	8 225	63								7 092	15 380
Lignite mines and briquetting				18						158	176
Coking plants			428			4 642	33 434	3 834		1 681	44 019
Refineries					268 294					13 399	281 693
Production of natural gas						8 251				177	8 428
Gas works					5 198				327	587	6 112
Power stations										26 978 (1)	26 978
Pumped storage Power stations										324	324
	8 225	63	428	18	273 492	12 893	33 434	3 834	327	50 396	383 110

(1) breakdown (conventional thermal power stations 20 574
(nuclear reactors 3 121
(hydroelectric power stations 3 283

		Hard Coal	Coal Briquettes & Patent Fuel	Coke	Brown Coal	Black Lignite	Brown Coal Briquettes	Tars, Pitch, Benzol	Crude Oil	Refinery Gas	LPG	Motor Spirit	Kerosines & Jetfuels
		1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t	1000 t
1	PRIMARY PRODUCTION	23 644	–	–	1 641	1 545	–	–	1 080	–	294	415	–
2	IMPORTS – PRIMARY	17 410	–	–	–	10	–	–	106 081	–	–	–	–
3	IMPORTS – DERIVED	–	39	2 772	–	–	182	–	–	–	244	618	57
4	EXPORTS	502	43	729	–	15	–	–	–	–	658	1 728	866
5	VARIATIONS OF STOCKS	– 3 690	– 20	– 944	–	– 286	– 2	–	+ 1 770	–	+ 50	+ 205	– 39
6	TRANSFORMATION INPUT	30 098	–	5 029	1 641	956	–	247	109 253	64	292	–	–
61	COKING PLANTS	14 835	–	307	–	–	–	–	–	–	–	–	–
62	BRIQUETTING PLANTS	2 755	–	–	–	–	–	247	–	–	–	–	–
63	BLAST FURNACES	–	–	4 727	–	–	–	–	–	–	–	–	–
64	REFINERIES	–	–	–	–	–	–	–	109 253	–	–	–	–
65	GASWORKS	–	–	–	–	–	–	–	–	–	292	–	–
66	ELECTRICAL POWER STATIONS	12 508	–	–	1 641	956	–	–	–	64	–	–	–
67	NUCLEAR REACTORS	–	–	–	–	–	–	–	–	–	–	–	–
7	TRANSFORMATION OUTPUT	–	2 795	11 445	–	–	–	549	–	2 302	2 763	16 315	3 553
71	COKING PLANTS	–	–	11 445	–	–	–	549	–	–	–	–	–
72	BRIQUETTING PLANTS	–	2 795	–	–	–	–	–	–	–	–	–	–
73	BLAST FURNACES	–	–	–	–	–	–	–	–	–	–	–	–
74	REFINERIES	–	–	–	–	–	–	–	–	2 302	2 763	16 315	3 553
75	GASWORKS	–	–	–	–	–	–	–	–	–	–	–	–
76	ELECTRICAL POWER STATIONS	–	–	–	–	–	–	–	–	–	–	–	–
77	NUCLEAR REACTORS	–	–	–	–	–	–	–	–	–	–	–	–
8	EXCHANGES AND TRANSFERS	+ 8	–	–	–	– 8	–	–	–	–	–	–	–
9	DISTRIBUTION LOSSES	–	–	–	–	–	–	–	–	–	–	–	–
10	AVAILABLE FOR CONSUMPTION	6 772	2 771	7 515	–	290	180	302	–	2 238	2 401	15 825	2 705
12	TOTAL CONSUMPTION	6 812	2 769	7 512	–	289	180	302	–	2 238	2 401	15 959	1 910
13	BUNKERS	–	–	–	–	–	–	–	–	–	–	–	–
14	ENERGY SECTOR CONSUMPTION	393	2	15	–	1	–	–	–	2 042	217	–	–
15	NON-ENERGY CONSUMPTION	52	–	154	–	–	–	302	–	51	–	–	–
16	FINAL ENERGY CONSUMPTION	6 367	2 767	7 343	–	288	180	–	–	145	2 184	15 959	1 910
161	INDUSTRY	2 895	3	7 000	–	221	–	–	–	145	350	99	15
162	TRANSPORTATION	32	24	13	–	–	3	–	–	–	–	15 718	1 876
163	HOUSEHOLDS ETC.	3 440	2 740	330	–	67	177	–	–	–	1 834	142	19
10–12	STATISTICAL DIFFERENCES	– 40	+ 2	+ 3	–	+ 1	–	–	– 322	–	–	– 134	+ 795

NAPHTAS 1000 t	GAS DIESEL OIL 1000 t	RESIDUAL FUEL OIL 1000 t	PETROLEUM COKE 1000 t	OTHER PETROLEUM PRODUCTS 1000 t	NATURAL GAS TcalPCS	COKEOVEN GAS TcalPCS	BLAST FURNACE GAS TcalPCS	GASWORKS GAS (3) TcalPCS	OTHER FUELS Tj	HEAT Tj	ELECTRICAL ENERGY Gwh		
-	-	-	-	94 (2)	68 573	-	-	-	3 775	114 569 (4)	60 592	1	PRIMARY PRODUCTION
-	-	-	-	-	104 379	-	-	-	-	114 438	-	2	IMPORTS - PRIMARY
1 162	1 989	3 083	550	214	-	-	-	1	-	-	8 781	3	IMPORTS - DERIVED
144	3 604	3 198	-	1 172	-	-	-	-	-	-	6 276	4	EXPORTS
+ 115	+ 3 847	+ 79	-	+ 41	+ 1 759	-	-	+ 84	-	-	-	5	VARIATIONS OF STOCKS
109	53	12 097	104	-	32 636	4 635	10 427	-	3 775	228 876	-	6	TRANSFORMATION INPUT
-	-	-	104	-	-	-	-	-	-	-	-	61	COKING PLANTS
-	-	-	-	-	-	-	-	-	-	-	-	62	BRIQUETTING PLANTS
-	-	-	-	-	-	-	-	-	-	-	-	63	BLAST FURNACES
-	-	-	-	-	-	-	-	-	-	-	-	64	REFINERIES
109	1	6	-	-	4 326	-	-	-	-	-	-	65	GASWORKS
-	52	12 091	-	-	28 310	4 635	10 427	-	3 775	-	-	66	ELECTRICAL POWER STATIONS
-	-	-	-	-	-	-	-	-	-	228 876	-	67	NUCLEAR REACTORS
3 450	36 958	36 952	-	5 078	-	21 077	29 965	8 586	-	-	125 204	7	TRANSFORMATION OUTPUT
-	-	-	-	-	-	21 077	-	-	-	-	-	71	COKING PLANTS
-	-	-	-	-	-	-	-	-	-	-	-	72	BRIQUETTING PLANTS
-	-	-	-	-	-	-	29 965	-	-	-	-	73	BLAST FURNACES
3 450	36 958	36 952	-	5 078	-	-	-	-	-	-	-	74	REFINERIES
-	-	-	-	-	-	-	-	8 586	-	-	-	75	GASWORKS
-	-	-	-	-	-	-	-	-	-	-	106 886	76	ELECTRICAL POWER STATIONS
-	-	-	-	-	-	-	-	-	-	-	18 318	77	NUCLEAR REACTORS
-	-	-	-	-	+ 353	- 865	-	+ 512	-	-	-	8	EXCHANGES AND TRANSFERS
-	-	-	-	-	8 342	-	-	265	-	5	12 392	9	DISTRIBUTION LOSSES
4 474	39 137	24 819	446	4 255	134 086	15 577	19 538	8 918	-	126	175 909	10	AVAILABLE FOR CONSUMPTION
4 540	38 859	24 454	449	4 292	134 086	15 577	19 538	8 918	-	126	175 909	12	TOTAL CONSUMPTION
-	642	4 063	-	41	-	-	-	-	-	-	-	13	BUNKERS
-	-	3 627	-	-	3 361	8 777	916	85	-	-	13 999	14	ENERGY SECTOR CONSUMPTION
3 142	432	-	449	4 251	16 000	1 773	-	-	-	-	-	15	NON-ENERGY CONSUMPTION
1 398	37 785	16 764	-	-	114 725	5 027	18 622	8 833	-	126	161 910	16	FINAL ENERGY CONSUMPTION
1 398	5 154	14 392	-	-	52 422	5 027	18 622	1 105	-	-	82 024	161	INDUSTRY
-	7 267	14	-	-	84	-	-	-	-	-	6 167	162	TRANSPORTATION
-	25 364	2 358	-	-	62 219	-	-	7 728	-	126	73 719	163	HOUSEHOLDS ETC.
- 66	+ 278 (1)	+ 365 (1)	- 3	- 37	-	-	-	-	-	-	-	10-12	STATISTICAL DIFFERENCES

(1) incl. military consumption (2) regenerated lubricants (3) Refuse and waste (4) among which 131 Tj geothermal

	HARD COAL	COAL BRIQUETTES & PATENT FUEL	COKE	BROWN COAL	BROWN COAL BRIQUETTES	TARS, PITCH, BENZOL	CRUDE OIL	REFINERY GAS	LPG	MOTOR SPIRIT	KEROSINES & JETFUELS	NAPHTAS
1 PRIMARY PRODUCTION	592 164	-	-	39 226	-	-	45 470	-	13 524	18 260	-	-
2 IMPORTS - PRIMARY	510 113	-	-	184	-	-	4 466 222	-	-	-	-	-
3 IMPORTS - DERIVED	-	1 225	79 002	-	3 640	-	-	-	11 224	27 192	2 451	51 128
4 EXPORTS	14 709	1 350	20 777	276	-	-	-	-	30 268	76 032	37 236	6 336
5 VARIATIONS OF STOCKS	- 92 285	- 628	- 26 904	-5 262	- 40	-	+ 74 521	-	+ 2 300	+ 9 020	-1 677	+ 5 060
6 TRANSFORMATION INPUT	798 587	-	143 327	28 388	-	9 312	4 599 770	3 745	13 426	-	-	4 796
61 COKING PLANTS	434 665	-	8 750	-	-	-	-	-	-	-	-	-
62 BRIQUETTING PLANTS	86 507	-	-	-	-	9 312	-	-	-	-	-	-
63 BLAST FURNACES	-	-	134 577	-	-	-	-	-	-	-	-	-
64 REFINERIES	-	-	-	-	-	-	4 599 770	-	-	-	-	-
65 GASWORKS	-	-	-	-	-	-	-	-	13 426	-	-	4 796
66 ELECTRICAL POWERSTATIONS	277 415	-	-	28 388	-	-	-	3 745	-	-	-	-
67 NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	-	-	-
7 TRANSFORMATION OUTPUT	-	87 763	326 183	-	-	20 867	-	133 516	127 098	717 860	152 779	151 800
71 COKING PLANTS	-	-	326 183	-	-	20 867	-	-	-	-	-	-
72 BRIQUETTING PLANTS	-	87 763	-	-	-	-	-	-	-	-	-	-
73 BLAST FURNACES	-	-	-	-	-	-	-	-	-	-	-	-
74 REFINERIES	-	-	-	-	-	-	-	133 516	127 098	717 860	152 779	151 800
75 GASWORKS	-	-	-	-	-	-	-	-	-	-	-	-
76 ELECTRICAL POWERSTATIONS	-	-	-	-	-	-	-	-	-	-	-	-
77 NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	-	-	-
8 EXCHANGES AND TRANSFERS	+ 147	-	-	- 147	-	-	-	-	-	-	-	-
9 DISTRIBUTION LOSSES	-	-	-	-	-	-	-	-	-	-	-	-
10 AVAILABLE FOR CONSUMPTION	196 643	87 010	214 177	5 337	3 600	11 555	- 13 557	129 771	110 452	696 300	116 315	196 856
12 TOTAL CONSUMPTION	196 517	86 947	214 093	5 317	3 600	11 555	-	129 771	110 446	702 196	82 130	199 760
13 BUNKERS	-	-	-	-	-	-	-	-	-	-	-	-
14 ENERGY SECTOR CONSUMPTION	6 225	63	428	18	-	-	-	118 430	9 982	-	-	-
15 NON-ENERGY CONSUMPTION	1 482	-	4 389	-	-	11 555	-	2 958	-	-	-	138 248
16 FINAL ENERGY CONSUMPTION												
ENERGY SUPPLIED	186 810	86 884	209 276	5 299	3 600	-	-	8 383	100 464	702 196	82 130	61 512
USEFUL ENERGY	119 526	42 470	164 469	3 851	2 339	-	-	6 706	52 086	140 439	24 652	53 130
CONSUMPTION LOSSES	67 284	44 414	44 807	1 448	1 261	-	-	1 677	47 578	561 757	57 478	8 382
161 INDUSTRY												
ENERGY SUPPLIED	81 930	94	199 500	4 066	-	-	-	8 383	16 100	4 356	645	61 512
USEFUL ENERGY	59 943	61	158 115	3 050	-	-	-	6 706	12 880	871	484	53 130
162 TRANSPORTATION												
ENERGY SUPPLIED	938	754	371	-	60	-	-	-	-	691 592	80 668	-
USEFUL ENERGY	610	490	241	-	39	-	-	-	-	138 318	23 779	-
163 HOUSEHOLDS ETC.												
ENERGY SUPPLIED	103 942	86 036	9 405	1 233	3 540	-	-	-	84 364	6 248	817	-
USEFUL ENERGY	58 973	41 919	6 113	801	2 300	-	-	-	40 006	1 250	389	-
10-12 STATISTICAL DIFFERENCES	+ 326	+ 63	+ 84	+ 20	-	-	- 13 557	-	+ 6	- 5 896	+34 185	- 2 904

	GAS DIESEL OIL	RESIDUAL FUEL OIL	PETROLEUM COKE	OTHER PETROLEUM PRODUCTS	NATURAL GAS	COKEOVEN GAS	BLAST FURNACE GAS	GASWORKS GAS	OTHER FUELS (3)	HEAT	ELECTRICAL ENERGY	TOTAL
1 PRIMARY PRODUCTION	-	-	-	3 976 (2)	263 220	-	-	-	3 775	114 569 (4)	218 131	1 312 315
2 IMPORTS - PRIMARY	-	-	-	-	400 676	-	-	-	-	114 438	-	5 491 633
3 IMPORTS - DERIVED	84 135	123 320	16 115	7 819	-	-	-	4	-	-	31 612	438 867
4 EXPORTS	152 449	127 920	-	45 536	-	-	-	-	-	-	22 594	535 485
5 VARIATIONS OF STOCKS	+ 162 729	+ 3 160	-	+1 292	+ 6 739	-	-	+ 322	-	-	-	+ 138 347
6 TRANSFORMATION INPUT	2 242	483 882	3 047	-	123 273	17 464	43 647	-	3 775	228 876	-	6 507 557
61 COKING PLANTS	-	-	3 047	-	-	-	-	-	-	-	-	446 462
62 BRIQUETTING PLANTS	-	-	-	-	-	-	-	-	-	-	-	95 819
63 BLAST FURNACES	-	-	-	-	-	-	-	-	-	-	-	134 577
64 REFINERIES	-	-	-	-	-	-	-	-	-	-	-	4 599 770
65 GASWORKS	42	242	-	-	16 614	-	-	-	-	-	-	35 120
66 ELECTRICAL POWERSTATIONS	2 200	483 640	-	-	106 659	17 464	43 647	-	3 775	-	-	966 933
67 NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	228 876	-	228 876
7 TRANSFORMATION OUTPUT	1 563 323	1 478 080	-	196 080	-	80 902	125 433	32 889	-	-	450 735	5 645 308
71 COKING PLANTS	-	-	-	-	-	80 902	-	-	-	-	-	427 952
72 BRIQUETTING PLANTS	-	-	-	-	-	-	-	-	-	-	-	87 763
73 BLAST FURNACES	-	-	-	-	-	-	125 433	-	-	-	-	125 433
74 REFINERIES	1 563 323	1 478 080	-	196 080	-	-	-	-	-	-	-	4 520 536
75 GASWORKS	-	-	-	-	-	-	-	32 889	-	-	-	32 889
76 ELECTRICAL POWERSTATIONS	-	-	-	-	-	-	-	-	-	-	384 790	384 790
77 NUCLEAR REACTORS	-	-	-	-	-	-	-	-	-	-	65 945	65 945
8 EXCHANGES AND TRANSFERS	-	-	-	-	+ 1 348	- 3 311	-	+ 1 963	-	-	-	0
9 DISTRIBUTION LOSSES	-	-	-	-	32 027	-	-	1 013	-	5	44 611	77 656
10 AVAILABLE FOR CONSUMPTION	1 655 496	992 758	13 068	163 631	516 683	60 127	81 786	34 165	-	126	633 273	5 905 772
12 TOTAL CONSUMPTION	1 643 736	978 160	13 156	166 449	514 663	60 127	81 786	34 158	-	126	633 272	5 867 965
13 BUNKERS	27 157	162 520	-	1 734	-	-	-	-	-	-	-	191 411
14 ENERGY SECTOR CONSUMPTION	-	145 080	-	-	12 893	33 434	3 834	327	-	-	50 396	383 110
15 NON-ENERGY CONSUMPTION	18 274	-	13 156	164 715	61 417	6 798	-	-	-	-	-	422 992
16 FINAL ENERGY CONSUMPTION												
ENERGY SUPPLIED	1 598 305	670 560	-	-	440 353	19 895	77 952	33 831	-	126	582 876	4 870 452
USEFUL ENERGY	945 655	460 108	-	-	306 127	15 916	62 362	20 100	-	126	419 004	2 839 866
CONSUMPTION LOSSES	652 650	210 452	-	-	134 226	3 979	15 590	13 731	-	-	163 672	2 030 586
161 INDUSTRY												
ENERGY SUPPLIED	218 014	575 680	-	-	201 220	19 895	77 952	4 232	-	-	295 286	1 768 865
USEFUL ENERGY	153 866	389 316	-	-	145 890	15 916	62 362	3 386	-	-	232 145	1 298 121
162 TRANSPORTATION												
ENERGY SUPPLIED	307 394	560	-	-	322	-	-	-	-	-	22 201	1 104 860
USEFUL ENERGY	109 402	420	-	-	97	-	-	-	-	-	19 888	293 284
163 HOUSEHOLDS ETC.												
ENERGY SUPPLIED	1 072 897	94 320	-	-	238 811	-	-	29 599	-	126	265 389	1 996 727
USEFUL ENERGY	682 387	70 372	-	-	160 140	-	-	16 714	-	126	166 971	1 248 461
10-12 STATISTICAL DIFFERENCES	+ 11 760 (1)	+ 14 598 (1)	- 88	- 2 818	+ 2 020	-	-	+ 7	-	-	+ /	+ 37 807

(1) incl. military consumption (2) regenerated lubricants (3) Refuse and waste (4) among which 131 Tj geothermal

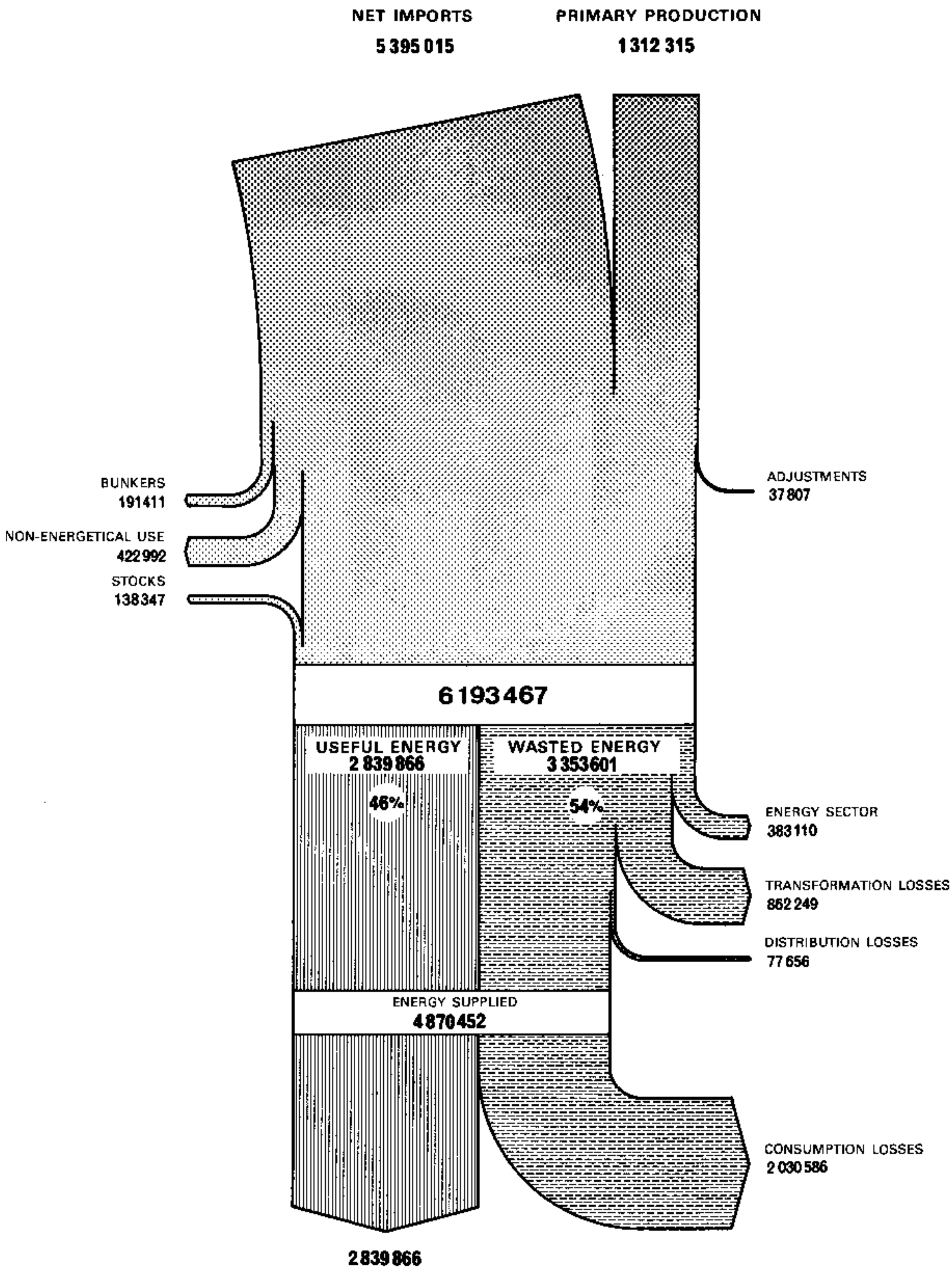
		HARD COAL	COAL BRIQUETTES & PATENT FUEL	COKE	BROWN COAL	BROWN COAL BRIQUETTES	REFINERY GAS	LPG	MOTOR SPIRIT	KEROSINES & JETFUELS	NAPHTAS
INDUSTRY	A	81 930	94	199 500	4 066	-	8 383	16 100	4 356	61 512	645
	B	59 943	61	158 115	3 050	-	6 706	12 880	871	53 130	484
PISTON ENGINES	A	-	-	-	-	-	-	-	4 356	-	-
	B	-	-	-	-	-	-	-	871	-	-
CEMENT KILNS	A	4 296	-	-	-	-	-	-	-	-	-
	B	1 718	-	-	-	-	-	-	-	-	-
RADIATION FURNACES	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
BLAST FURNACES	A	-	-	169 803	-	-	-	-	-	-	-
	B	-	-	135 842	-	-	-	-	-	-	-
FURNACES AND BOILERS, STEAMCRACKERS	A	77 634	94	29 697	4 066	-	8 383	16 100	-	61 512	645
	B	58 225	61	22 273	3 050	-	6 706	12 880	-	53 130	484
ELECTRICAL MOTORS AND FURNACES	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
ELECTROLYSIS	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
LIGHTING	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
TRANSPORTATION	A	938	754	371	-	60	-	-	691 592	-	80 668
	B	610	490	241	-	39	-	-	138 318	-	23 779
PISTON ENGINES	A	-	-	-	-	-	-	-	691 592	-	-
	B	-	-	-	-	-	-	-	138 318	-	-
TURBOPROP, AIRCRAFT JET	A	-	-	-	-	-	-	-	-	-	80 668
	B	-	-	-	-	-	-	-	-	-	23 779
ELECTRIC RAIL HAULAGE	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
SPACE HEATING	A	938	754	371	-	60	-	-	-	-	-
	B	610	490	241	-	39	-	-	-	-	-
LIGHTING	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
HOUSEHOLDS ETC.	A	103 942	86 036	9 405	1 233	3 540	-	84 364	6 248	-	817
	B	58 973	41 919	6 113	801	2 300	-	40 006	1 250	-	389
COOKERS	A	4 102	4 396	-	-	-	-	59 248	-	-	-
	B	1 025	1 099	-	-	-	-	21 922	-	-	-
WATER HEATERS	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
HEATING	A	99 840	81 640	9 405	1 233	3 540	-	25 116	-	-	645
	B	57 948	40 820	6 113	801	2 300	-	18 084	-	-	355
ELECTRICAL MOTORS AND APPLIANCES	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
PISTON ENGINES	A	-	-	-	-	-	-	-	6 248	-	172
	B	-	-	-	-	-	-	-	1 250	-	34
FURNACES AND BOILERS	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-
LIGHTING	A	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-

B = USEFUL ENERGY

GAS DIESEL OIL	RESIDUAL FUEL OIL	NATURAL GAS	COKEOVEN GAS	BLAST FURNACE GAS	GASWORKS GAS	HEAT	ELECTRICAL ENERGY	TOTAL		
218 014	575 680	201 220	19 895	77 952	4 232	-	295 286	1 768 865	A	INDUSTRY
153 866	389 316	145 890	15 916	62 362	3 386	-	232 145	1 298 121	B	
24 111	-	-	-	-	-	-	-	28 467	A	PISTON ENGINES
8 439	-	-	-	-	-	-	-	9 310	B	
-	100 400	22 156	-	-	-	-	-	126 852	A	CEMENT KILNS
-	40 160	8 862	-	-	-	-	-	50 740	B	
-	27 600	15 559	-	-	-	-	-	43 159	A	RADIATION FURNACES
-	11 040	6 224	-	-	-	-	-	17 264	B	
-	47 120	-	-	-	-	-	-	216 923	A	BLAST FURNACES
-	37 696	-	-	-	-	-	-	173 538	B	
193 903	400 560	163 505	19 895	77 952	4 232	-	-	1 058 178	A	FURNACES AND BOILERS, STEAMCRACKERS
145 427	300 420	130 804	15 916	62 362	3 386	-	-	815 124	B	
-	-	-	-	-	-	-	225 324	225 324	A	ELECTRICAL MOTORS AND FURNACES
-	-	-	-	-	-	-	214 058	214 058	B	
-	-	-	-	-	-	-	58 802	58 802	A	ELECTROLYSIS
-	-	-	-	-	-	-	17 641	17 641	B	
-	-	-	-	-	-	-	11 160	11 160	A	LIGHTING
-	-	-	-	-	-	-	446	446	B	
307 394	560	322	-	-	-	-	22 201	1 104 860	A	TRANSPORTATION
109 402	420	97	-	-	-	-	19 888	293 284	B	
301 726	-	322	-	-	-	-	-	993 640	A	PISTON ENGINES
105 604	-	97	-	-	-	-	-	244 019	B	
-	-	-	-	-	-	-	-	80 668	A	TURBOPROP, AIRCRAFT JET
-	-	-	-	-	-	-	-	23 779	B	
-	-	-	-	-	-	-	22 093	22 093	A	ELECTRIC RAIL HAULAGE
-	-	-	-	-	-	-	19 684	19 884	B	
5 668	560	-	-	-	-	-	-	8 351	A	SPACE HEATING
3 798	420	-	-	-	-	-	-	5 598	B	
-	-	-	-	-	-	-	108	108	A	LIGHTING
-	-	-	-	-	-	-	4	4	B	
1 072 897	94 320	238 811	-	-	29 599	126	265 389	1 996 727	A	HOUSEHOLDS ETC.
682 387	70 372	160 140	-	-	16 714	126	166 971	1 248 461	B	
140	-	30 642	-	-	12 566	-	8 352	119 446	A	COOKERS
52	-	11 337	-	-	4 650	-	6 264	46 349	B	
-	-	25 672	-	-	8 020	-	36 180	69 872	A	WATER HEATERS
-	-	15 917	-	-	4 972	-	32 562	53 451	B	
958 970	93 400	163 890	-	-	1 478	126	26 280	1 465 563	A	HEATING
642 510	70 050	118 000	-	-	1 064	126	24 966	983 137	B	
-	-	-	-	-	-	-	104 832	104 832	A	ELECTRICAL MOTORS AND APPLIANCES
-	-	-	-	-	-	-	99 590	99 590	B	
113 787	920	-	-	-	-	-	-	121 127	A	PISTON ENGINES
39 825	322	-	-	-	-	-	-	41 431	B	
-	-	18 607	-	-	7 535	-	-	26 142	A	FURNACES AND BOILERS
-	-	14 886	-	-	6 028	-	-	20 914	B	
-	-	-	-	-	-	-	89 745	89 745	A	LIGHTING
-	-	-	-	-	-	-	3 589	3 589	B	

OVERALL ENERGY FLOW-SHEET

TJOULES



FRANCE 1975

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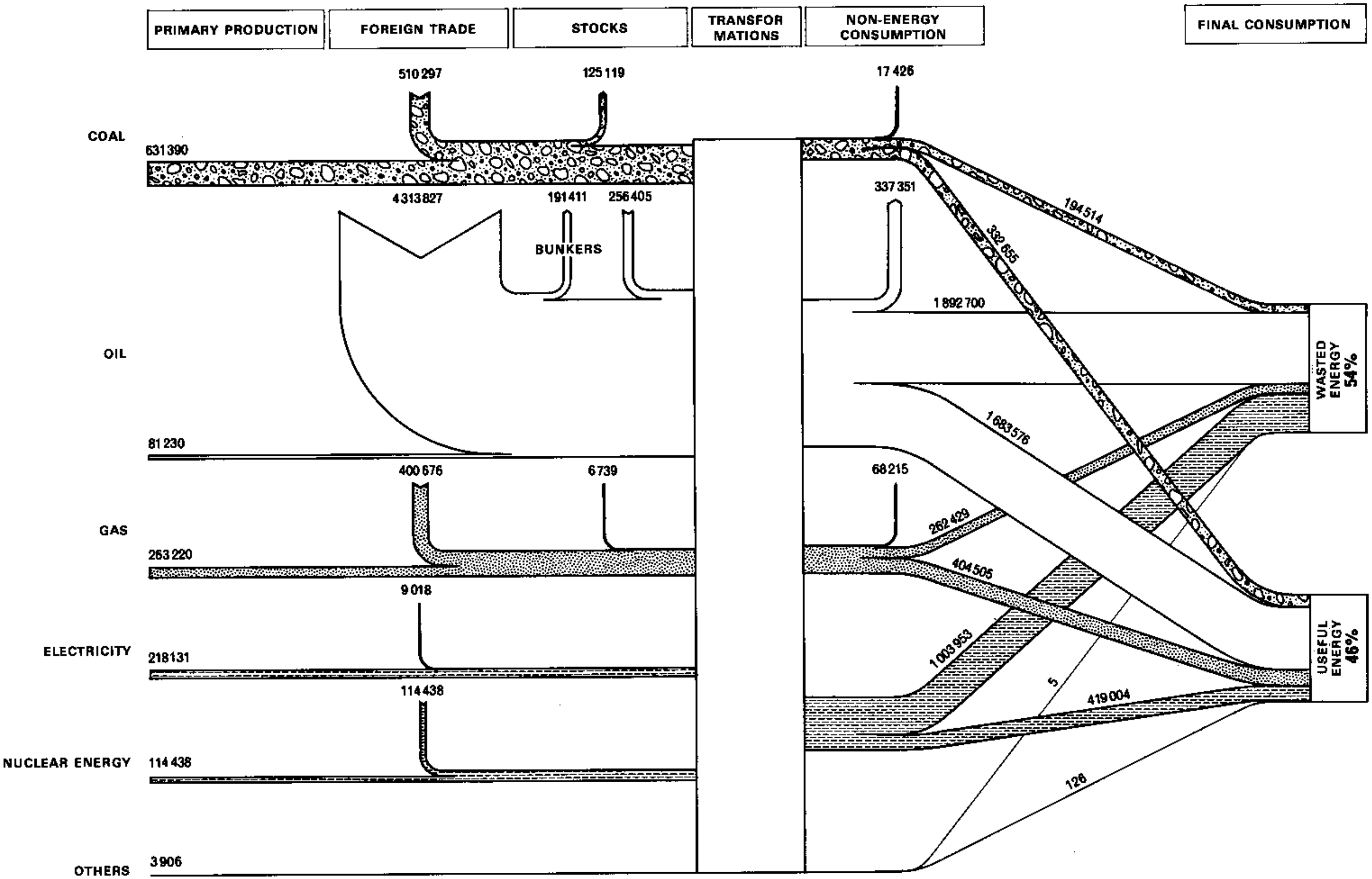
ENERGY FLOW-SHEET



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To enable it to improve its service to the Commission on the question of the rational use of energy, the Statistical Office has attempted to compile overall energy balance-sheets in terms of the amount of energy actually used by the final consumer.

These balance-sheets are based on the various stages of supply and demand from the primary input stage to the 'useful energy' recovered by the consumer in final output and are expressed in terms of real energy content (and not in terms of their substitute energy equivalence between different sources of energy). They bring out the real loss in energy at the various stages of conversion and consumption and provide a more accurate picture of the effective consumption of energy.

This study is first and foremost a model designed to point the way to later refinements. For the moment, it applies only to France and the Federal Republic of Germany, and relates to 1975.

This document also sets out the methods used, the assumptions made for the practical application and the conclusions which may be drawn from this initial trial.

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