ST/ESA/STAT/SER.F/56

STUDIES IN METHODS

Series F No. 56

ENERGY STATISTICS:
A MANUAL FOR DEVELOPING COUNTRIES

UNITED NATIONS

ST/ESA/STAT/SER.F/56

DEPARTMENT OF INTERNATIONAL ECONOMIC AND SOCIAL AFFAIRS
STATISTICAL OFFICE

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PREFACE

The original draft of this Manual was prepared by a consultant, Julian Harris, who from September 1985 until January 1988, had served as Regional Adviser in Energy Statistics for the United Nations Economic and Social Commission for Asia and the Pacific. After his death, the task was completed by a consultant, W. N. T. Roberts. The text as a whole remains essentially the work of Mr. Harris.

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Annexes

EXPLANATORY NOTES

Reference to tons is to metric tons unless otherwise stated.

The following technical abbreviations have been used:

A	angström
BOE	barrels of oil equivalent
Btu	British thermal unit
CNG	compressed natural gas
ECA	energy commodity account
GCV	gross calorific value
GJ	gigajoule
GWh	gigawatt-hour
J	joule
kcal	kilocalorie
kg	kilogram
kj	kilojoule
kl	kilolitre
kWh	kilowatt-hour
LNG	liquified natural gas
LPG	liquified petroleum gas
m^3	cubic metre
MJ	megajoule
MWh	megawatt-hour
NCV	net calorific value
NGL	natural gas liquid
OEB	overall energy balance
SI	International System of Units (Système international d'unités)
Tcal	teracalorie
TCE	tons of coal equivalent
TJ	terajoule
TOE	tons of oil equivalent

Part One

BACKGROUND

I. PURPOSE OF THE MANUAL

1. Considerable advances have been made by developing countries during the last 20 years in the collection and compilation of energy statistics. The pace of development has not been the same in all countries, and while many now produce regular and comprehensive publications, making use of sophisticated compilation and analysis techniques, others still have a long way to go. The present Manual is a guide, which it is hoped will be used in countries whose system of statistics is less advanced to identify the main areas that should be developed and how this might be achieved. It is hoped that it will also be of use in countries where the system is more advanced as a check that it conforms with practices that have been found to be of best service to those engaged in the monitoring and planning of energy policies.

2. The generally accepted aim is for countries to be able to compile statistics annually on the main characteristics shown for each fuel, and for energy in total. These characteristics are mainly concerned with production, supply and consumption, but others relating to the size and capabilities of the different energy industries may also be of considerable importance. The initial task of collecting data from the energy industries (mines, oil producers, refineries and distributors, electrical power stations etc.) may well fall to a number of ministries or other organizations. The success with which these can be collated and compiled into the statistics that policy makers and other users wish to see, will depend to a large extent on the interrelationships among all those involved. Good statistics depend on good working relationships, and for this reason particular attention is given to this topic in chapter IV.

3. The impact of the various oil crises, particularly the major price rises in the 1970s, emphasized the need to consider energy as a subject over and above the individual fuels which, in their different ways, contributed to meeting national energy needs. The question of whether other fuels could be substituted for oil became, and to some extent still is, a major issue. Examination of such matters crossed ministerial boundaries, leading to the creation of ministries (or parts of ministries) with authority for wider energy issues. Though the planning for the future provision of individual fuels has always benefited from good statistics relating to those fuels, their accuracy and comprehensiveness became of greater importance when they had to be viewed in a wider national energy context. It should be remembered that "energy" from a statistical point of view is the sum of the component fuels, and that good energy statistics are therefore dependent on good fuel statistics. For this reason a considerable part of this Manual is devoted to the production of regular, comprehensive and reliable statistics relating to individual fuels.

4. It is perhaps unfortunate that users of energy information are often aware of some of the inadequacies of the statistics on which they are working, and seek to redress this by amending them or adding to them in the way that they think will improve matters. This leads to more than one set of statistics being in use at the same time and dispute as to which should be regarded as authoritative. It is only by vesting authority for statistics collection in one body, by building data up from the bottom, and ensuring that

all sources are covered, that a generally accepted compendium of statistics can be produced.

5. Chapters V to IX of this Manual are concerned with identifying the flows of energy, from production to final consumption, for each individual fuel, and how data on these flows might be expected to be obtained. The very different problems concerned with the collection of data on the flows for biomass fuels (sometimes referred to as "traditional" or "non-commercial" fuels) are covered in chapter X. The data needed to complete the picture of the national scene for each individual fuel, more concerned with describing the size, capabilities and efficiency of the industries related to that fuel, are discussed in chapter XI. Annex I sets out the relationships between the classifications of the various types of fuels.

6. It might be thought that "collection" and "presentation" of energy statistics covered identical ground, that either data are collected in the form in which they will eventually be presented, or that they are presented in replication of the form in which they are collected. To do this would certainly reduce the resources necessary for compiling energy statistics; but relying on such an approach can place a burden on the data-suppliers which they are unwilling to assume (with failure to extract from them the full quality of the information they hold), or it can lead to users not receiving information in the form they would find most useful. Chapter XII covers similar ground to that covered in earlier chapters, but here the treatment concerns presentation of the compiled information in a form convenient to users.

7. The compilation of energy balances from the data obtained for individual fuels is covered in chapter XIII. The theory behind the composition of an energy balance, the different formats in which it can be composed and the treatment of some difficult conceptual issues have been described in an earlier volume, Concepts and Methods in Energy Statistics with Special Reference to Energy Accounts and Balances. 1/ This Manual is more concerned with the mechanics of translating information derived for individual fuels into the appropriate places in an energy balance, using the United Nations recommended format as a model. Finally, chapter XIV discusses the application of microcomputers to the compilation and analysis of energy statistics and reviews briefly some software programs designed especially for energy statistics purposes.

8. The range of energy statistics described in the Manual concerns the analysis of data obtained mainly from energy supply industries. Such data are often referred to as "energy supply statistics". As far as possible they represent information that has already been gathered within the industries for their own management purposes and which can therefore be provided quickly, without significant extra resources being required. The energy industries are of course interested in deliveries of their products to different types of purchaser; in the case of electricity (and gas, where there is a piped distribution system) such delivery statistics also represent consumption statistics. In the case of storable energy however (notably coal, coal products, petroleum products and bottled gas), suppliers normally deliver to wholesale distributors so that the energy supply industries do not always know which sectors actually consume their products or how much is consumed by each

sector. The supply industries may deliver storable energy (particularly coal and petroleum products) directly to major users (such as power stations), but because of stock-changes at the user level, actual consumption will not be known to suppliers. When detailed consumption statistics are needed, a different approach may be required.

9. Statistics compiled from a sample of consumers of energy, often described as "energy demand statistics", are relatively expensive to obtain and tend to suffer from systematic as well as sampling errors. They do, however, have an important place within a country's energy information base, and can add significant knowledge about a country's energy behaviour and needs. In addition, energy demand surveys are likely to provide much of the material recommended to be sought in respect of biomass fuels (see chap. X).

10. It should be mentioned in passing that use of the word "demand" for statistics based on consumer-derived data is often a misnomer. One cannot say that electricity consumption represents true demand in a country where not all potential consumers have access to supply. Similarly, consumption of fuelwood is, at least to some extent, a reflection of the non-availability of alternative fuels and cannot be interpreted as the real demand for such fuel.

11. It is often thought that gaps in energy information may be most easily filled by mounting demand surveys, as these can be tailor-made to provide the fullest range of information. Unless they can be (consistently) repeated they are able to give measurements relating to only one point in time. Bearing this in mind, and also taking into account the length of time such surveys take to design, execute and analyse - and as a result, their high cost also - attention should first be paid to the possibility of obtaining regular and consistent data from supply sources, even if such data are not as comprehensive as one would ideally have liked. It is in pursuit of this general approach that this Manual has been prepared.

II. SOURCES OF ENERGY STATISTICS

A. Categories of source

12. The main sources of energy data may be grouped into three categories: the energy supply industries (including importers), other industries and organizations producing energy, and energy consumers. Although those comprising the first category are described as energy suppliers, their business is likely to be concentrated in one particular fuel, and often in only one part of the overall supply process. Thus a company may be engaged in the mining of coal, but not in the final delivery, or in the production of oil but not in refining. What all such companies have in common, however, is that the main, or only, business which they conduct is directly related to energy. By far the majority of data collected will come from such organizations.

13. Within this first category will come the government-owned and other centrally controlled industries engaged in the production and import of coal, oil and gas, in oil refining and electricity generation, and in the import and distribution of some or all of the products produced from these fuels for final consumption. The extent of central control varies among different countries: in some larger countries control is exercised at a regional level, in others, where there is widespread involvement of the private sector such as with small privately owned coal mines, little effective control may be exercised. The degree to which central Government is directly involved in the industries will have a significant effect on both the ease with which data may be collected, and the range of data that will be considered reasonable to collect. From the point of view of the collector and compiler of data the fewer the number of sources the more quickly he can produce the analyses which users of energy information require.

14. The second source of energy data includes those industries (or other organizations) who choose, or are forced by circumstance, to produce and sometimes supply energy to other consumers, but not as part of their main business. Geographically remote industries may have no access to electricity unless they produce it themselves; iron and steel works requiring coke, and the heat from it, for their own production purposes will often capitalize on this requirement by producing their own coke and their own electricity. Sugar mills nearly always burn the bagasse they produce for generating steam, process heat and electricity. On a smaller scale many industrial establishments and commercial organizations may have generating equipment that they can turn to in the event of failure in the public supply system (and they sometimes sell electricity to other consumers or to the public supply system). It is clearly necessary that these organizations are not omitted from national energy statistics, but it cannot be expected that they will either have the same amount of detail readily to hand, or will feel obliged to provide data to Governments on what to them is not their primary business interest. In most countries these industries account for only a small part of the national energy needs, so lack of finer detail in the data they supply may not give rise to serious omissions or distortions in the statistics eventually prepared. In the few countries where they play a significant role in the national aggregate of energy supply and consumption, means have to be devised to obtain more comprehensive data from them.

15. The third general source of data is the final energy consumer. There is a temptation to assume that the consumer will have all the information considered most important to the energy planner and that therefore this particular source should be given high priority. Unfortunately it is extremely difficult, and expensive, to design and mount the energy surveys required to obtain data in this way. Construction of the sample requires a reliable sampling frame, whether it is of all industries, particular industries or services, or of households. These are not always available. The cooperation of those being surveyed, and the reliability of the data they provide, are almost invariably not of the standard hoped for. Considerable additional effort therefore has to go in to checking the reliability and consistency of data, even when response rates appear to be otherwise satisfactory. Because of the high cost of successful surveys it is unlikely that they can be repeated at frequent intervals. When they are repeated, improved methodology or coverage often lead to a loss of comparability with previous surveys, and, as a result, trend information becomes suspect. As the main reason for repeating the survey is likely to be to obtain measurements of change over time, any failure to obtain good trend information will present a serious drawback. It is not unknown for the results of a survey to be discarded when the results of a later one become available, so great are the differences between them in their design and methodology.

16. This is not to say that surveys of energy consumers cannot on occasion be of direct relevance and importance to the expansion of knowledge about a country's energy consumption patterns. While effort should whenever possible be concentrated initially on energy suppliers to fill the gaps in commercial energy statistics (on grounds of cost, speed of implementation, accuracy, consistency and repeatability), it must be recognized that information on biomass energy will almost certainly depend to some extent on consumer-derived measurements. The approach to gathering regular and consistent information on biomass fuels is convered in detail in chapter X, where emphasis is placed on the need to be able to update survey-derived information without having to resort to the cost of a full-scale survey every time up-to-date information is needed.

B. A programme for data collection

17. The long-term strategy for energy statistics compilation should be designed to reflect the costs and benefits involved in the collection of data from different sources. First, and of greatest importance, there should be a programme for maintaining and developing the data obtained regularly from energy supply industries, with the aim of bringing about any desired improvements in accuracy, coverage, detail, timeliness and frequency. Secondly, there should be a separate programme designed to cover those industrial and other organizations that are engaged in supplying energy as a secondary activity. The number of establishments from which data have to be collected in these first two programmes is relatively small by comparison with the number from which general economic or industrial statistics are sought, though it may also be necessary initially to use some existing general industrial inquiry, such as that from which overall industrial production measures are obtained, to identify those establishments that would be required to participate in the second programme. Third, and last, there should be a realistic programme of less frequent surveys in order (a) to fill any

remaining gaps in the information considered necessary to have on commercial fuels; and (b) to provide baseline information relating to biomass fuels.

C. Intermediate sources

18. Energy data originate from the sources described above. The energy statistics compiler, however, often has no direct contact wiht these original sources but obtains his data instead from secondary sources, usually other ministries with responsibility for the production or distribution of particular fuels. This may have harmful effects on the quality and timing of the energy information that he produces, and may present a constraint on his ability to bring about desired improvements in energy statistics. Chapter IV sets out the type of infrastructure needed to produce timely and reliable information, and also some of the relationships which it would be better to avoid if at all possible. For the purposes of this chapter all that is required is to take note of the different degrees of direct contact which the statistics compiler has with the originators of data.

19. Within the energy supply industries information is required at aggregated and disaggregated levels for management purposes. If management of a particular industry is vested in a ministry or other government-controlled body, then a considerable quantity of data may be required centrally in order that control and management may be undertaken effectively. This may represent far more data than are required for the production of statistics for general monitoring and planning purposes, but may well provide the database from which all statistics may be compiled. Such a situation may well lead to the ministry or other government organization controlling the industry - in effect the industry itself - producing all the statistics relating to a fuel or group of fuels. Whoever is responsible for the compilation of energy statistics may obtain from this other central organization all the information on this fuel (or group of fuels) and have no contact with the originators of the data. At first sight this makes the burden less, by reducing the number of sources to one, but there may still be a need to raise queries direct with different components of the industry.

20. Where there is a central ministry responsible for the public supply of electricity, and that ministry is the focal point for the collection of all data relating to public electricity supply, agreement has to be reached on the location of responsibility for the collection of data on self-generated electricity. It is unlikely, but not impossible, that the electricity ministry will be devoting significant resources to obtaining information about electricity for which it is not responsible.

21. The actual sources of oil and gas data may similarly be other government bodies, which may themselves be already compiling and making available statistics relating to those fuels. In the same way that data collection for public supply and self-generated electricity has to be carefully differentiated, attention also must be given to the problem in some countries where the production of oil or gas is divided between the Government and the private sector. The private sector may be extremely unwilling to divulge data which they consider might be used to their disadvantage, and thus be unwilling to provide any ministry, but particularly one they see as their competitor, with anything like a full range of the data being sought. Under such

circumstances every effort should be made to make sure that their returns of data are made to a neutral party, for example to a national statistics office or to the statistics department of a ministry with energy responsibilities, on the clear understanding that the data will be used for statistical purposes only.

22. In some larger countries, statistics are collected at a subnational level before onward transmission to a central authority for aggregation and analysis. This places the national energy statistics compiler a further step away from the originators of data. Under such circumstances the regional collection points will themselves need to ensure accuracy and comprehensiveness within the area of their coverage, and to be able to answer any central queries that may arise. Conversely, when "final" statistics are compiled regionally, and national figures are aggregates of regional figures, there is need for considerable expertise at the centre, not only to be able to answer queries without having to refer the matter to regions, but also to ensure that in adjusting regional data to a national basis there are no omissions or double-counting in the results, especially in regard to international trade.

23. Regional collection of data may be instituted as a convenient way of channelling large volumes of data to a central point: alternatively it may be because great importance is placed on having detailed regional analyses of data. It can be argued that energy is essentially a national topic, that the actual locations of energy production arise from accidents of nature or from deliberate planning, and that attempts to show a complete range of subnational statistics, including production, consumption and interregional trade, are unnecessary and misleading, as well as being costly in resource terms. Alternatively the view may be taken that it is essential in planning the future energy infrastructure to take into account the different locations of production and consumption, and to have a clear idea of the distances over which energy products are distributed. While it is necessary to strike a balance between these two opposing views when assessing what approach is correct for a particular country, one should also note that the problems of compiling regional statistics to consistent formats and definitions may result in some loss of accuracy when these are aggregated to national level. As a general rule one would expect that the greatest concern for accuracy should be at the national level, with international trade taken fully into account, even though this may lead to some unavoidable anomalies in regional analyses.

D. Activities covered by the sources of data

24. Every country should be able to list the energy activities taking place within its boundaries and identify the companies involved in those activities, each of which will have a contribution to make to the statistics eventually produced. Whether all these companies supply data to one central point or to a number of different points, it is necessary to ensure that all of any significance are included in the statistics being compiled. The following list indicates the broad range of activities to be covered, where they exist in a country.

(a) Solid fuels

Mining (deep mines and surface mines)

International trade

Briquetting

Manufacture of gas

Manufacture of coke

Distribution of coal to power stations

Distribution of coal to final consumers

Distribution of briquettes

Distribution and/or consumption of gas

Distribution and/or consumption of coke

Distribution for non-energy use

(b) Oil and petroleum products

Crude oil (and condensate) production

Separation of gases and liquified petroleum gas (LPG)

International trade in crude oil

International trade in petroleum products

Refinery activities

Bottling of LPG

Distribution of petroleum products to power stations

Distribution of petroleum products to the petrochemical industry

Backflows to refineries from the petrochemical industry

Distribution of petroleum products to intermediate (e.g. filling stations) and final consumers

Distribution for non-energy use

(c) Natural gas

Production

Separation of liquids and LPG

Liquefaction

International trade (gaseous and compressed)

Distribution to power stations

Distribution to final (energy) consumers

Distribution for non-energy use

(d) Derived gases

Distribution to final consumers

(e) Electricity

Public supply generation

Self-generation

International trade in electricity

Consumption of electricity by self-producers

Distribution of electricity to final consumers

(f) Biomass

Consumption of fuelwood, charcoal and other biomass fuels by final consumers

III. PROBLEMS OF COVERAGE, DEFINITIONS AND FREQUENCY

A. Coverage of energy statistics

25. The formal definition of "energy" is the power to do work which a body possesses. Producing heat is a common manifestation of "doing work", as are producing light and motive force.

26. For the purposes of this Manual, and in reflection of governmental interests, energy may be regarded as the work derived from the provision of certain combustible fuels and of electricity. By convention, those sources of energy which occur naturally, such as coal, crude oil, natural gas, and fuelwood are termed "primary fuels", and those that are derived from these primary fuels, such as coal-gas, coke, petroleum products, and charcoal as "secondary fuels". The energy in both primary and secondary fuels can be converted into electricity which, strictly speaking, is a form of energy rather than a fuel but when generated in this way is often treated as a secondary fuel.

27. Mechanical energy and electricity may also be derived from the kinetic energy of a mass of water moving from a higher to a lower level, as happens in hydroelectricity generation at dams, run of the river, tidal or wave plants, or of a mass of air moving from a higher to a lower area of pressure, as happens at wind plants. Heat may be produced from harnessing the sun's rays, from subterranean hot rocks (usually by the passage of water over them), or from certain chemical processes other than combustion which give off heat. Energy derived in these ways is treated as primary energy, as it is emanating from a natural source: it is also classified as "renewable" because unlike coal, oil or natural gas, the resources from which it is obtained are in no way depleted. Electricity generated from the heat obtained by the fission of radioactive material (harnessed to produce steam to drive turbines) has traditionally, for convenience, been classified as primary electricity, though some would argue that this is conceptually incorrect.

28. Over the last century conventions have evolved for the statistical measurement of the separate production and consumption processes that apply for most primary and secondary fuels. For the major commercial fuels (coal, oil and petroleum products, gases and electricity), which have world-wide usage, these conventions have been put not only to the test of time but also to the test of general acceptability, nationally and internationally, to Governments, energy industries and other users of the information assembled. Conventions regarding the treatment of fuelwood and other biomass forms of energy, perhaps because they no longer make significant contributions in many more developed countries, have been slower to evolve. In addition, biomass takes many different forms and it is not immediately apparent that conventions acceptable for fuelwood can apply equally well to charcoal, vegetal residues and animal wastes.

29. The statistical treatment of some of the more recent developments in renewable energy is still open to debate, though this is not the case with electricity derived from new primary sources (e.g. from wind), where the conventions developed for hydroelectricity apply equally for other renewable techniques. Perhaps the largest area where agreement on the best recording

methods is still awaited is in the treatment of "heat" as a fuel in its own right. Heat derived from industrial processes, including the generation of electricity, that has previously been wasted is now being put to use heating space or water, and is substituting for other fuels that have previously been consumed for these specific purposes. Geothermal heat has been harnessed for similar uses. The quantities of heat available, the quantities being harnessed, and the quantities being utilized are not always all directly measurable.

30. These are problems on which firm general guidelines must await until specific technologies become more widely, and consistently, applied. This is not to say that one can ignore those instances where heat is now being harnessed, and omit them from statistical coverage; rather that where it occurs it is better to treat it on a case-by-case basis with the aim of producing information which is both relevant and generally consistent with other energy information being obtained.

B. Problems of definition

31. It is hoped that the most common problems of definition that countries are likely to encounter are covered in Part Two of this Manual, which is concerned with the collection of data relating to individual fuels. Some of these problems are briefly described below. For a fuller exposition of matters relating to definitions the reader is referred to Energy Statistics: Definitions, Units of Measure and Conversion Factors. 2/

32. One circumstance that often presents statistical problems is when the product being produced is not identical with the product in subsequent processes, even though it is referred to by the same name. What is produced from a coal mine, may well contain substantial quantities of waste material and be different in chemical composition, and energy content, from the coal finally consumed. Crude oil from an oil well may contain dissolved energy and non-energy gases and liquids, which are removed from the crude oil before or when it is processed at refineries. Natural gas, whether produced in association with crude oil or independently, may contain non-energy gases and dissolved energy liquids that have to be separated out before natural gas of defined chemical content can be marketed. It is important to know what each product actually consists of at different stages of the production-conversion-consumption process, in order to be able to ascribe appropriate energy conversion factors. Some of the apparent losses of energy that appear in national energy accounts (and apparent gains) may well be due to a failure to take into account the changes in energy content of a particular product. Such problems are addressed in detail in chapters V to VIII.

33. Within energy balances (chap. XIII) provision has to be made for transfers between different fuels. For example some or all of the gas derived from coal may end up being mixed with natural gas, with measures of final consumption being in terms of "gas". For simplicity the final consumption may be described as being of natural gas, but it is clearly necessary to distinguish the separate origins of the different components.

34. By convention crude oil is taken to be an energy product. Some of the products derived from it at refineries, however, have no energy uses and are described as non-energy products. It is important to record how much of an apparent supply of energy (crude oil) is in fact ending up not contributing to energy supply. Additionally, some energy products (e.g. natural gas, liquified petroleum gas (LPG), naphtha and even diesel) may be used as feedstock at fertilizer or petrochemical plant: the extent to which this is happening is likely to be of great relevance to energy planners, but such consumption will need to be carefully distinguished as being for non-energy use. Some naphtha (and maybe other light petroleum products) may flow back from the petrochemical industry to refineries, and such flows form part of the input to the petroleum industry.

35. Coal may be supplied to the iron and steel industry for conversion to coke, or alternatively coke may be supplied directly, which is then consumed partly to provide heat and partly to contribute to a desired chemical process. By convention all such consumption is categorized as being for energy use, although strictly speaking part of it is for non-energy purposes.

36. The separation of public supply and self-generated electricity is to some extent artificial. An industry generating electricity for its own consumption may also be the local provider of electricity for public consumption. The distinction which collectors of data apply to these two sources is more a reflection of likely differences in the availability of the data they seek. Where it is assumed that considerably more detail will be readily available from the public supply industry, this is partly because, as a specialist concern, it is likely to require more detail for the successful running of its operations, and partly because it is likely to be either under direct government control or to be otherwise centrally managed, and therefore more willing to make such data available to another part of Government. Data on fuel inputs to self-generation are likely to be poorly documented or simply not available.

C. Frequency of statistics collection

37. For the successful management of a particular energy industry, such as an oil refinery or an electricity generation station, data is likely to be collected with great frequency. This will not apply across all energy industries, and smaller organizations, such as those likely to be found in the private mining sector, may find it hard to compile even annual data. At the collection end there may be more resources available to monitor the progress and development of a particular industry in which there is direct government involvement, than there are to compile regular and comprehensive fuel and energy statistics.

38. The frequency with which fuel statistics are all compiled and energy tables produced must therefore represent a balance between the availability of data and the availability of central resources. Comprehensive annual data should be the first target, but it may be unrealistic to expect that complete comprehensiveness could be achieved more frequently than annually. The compilation and publication of annual information will itself take some months and this will result in annual information being regarded at certain times of the year as being considerably out of date. To fill this gap more frequent

measurements are needed of the most important components of energy information. With restricted resources it may be found possible to publish only those series that are already being collected and utilized in ministries exercising some degree of direct control over energy industries. For example data may be readily to hand on oil, gas and electricity production but there may be nothing automatically available to the Government on the output of refineries or on coal production. This would enable more frequent monitoring of the availability of some energy products but would give few indications of the changes in total energy availability and little if anything on final consumption.

39. Once reasonably comprehensive annual information is being prepared, attention should be divided between further improvements and additions to the annual series and the preparation of more frequent tables. Chapter XII sets out the series which might, with the necessary resources to achieve them, form the basis for more frequent presentation. The development of more frequent data collection and presentation will of necessity be a step-by-step process, with concentration initially on those series which are more readily available and those which are required to fill the most obvious gaps in a portrayal of the total energy scene.

40. Just how frequent "more frequent" should be will again depend on data and resource availability. Because it is likely that some of the information is not going to be available without some specific new collection procedure, causing additional work to those completing returns as well as to those receiving them, it is probably better to start by planning for quarterly rather than monthly data assembly. If some of the data is already collected at monthly intervals this would not rule out the inclusion of three separate months' information within a quarterly compilation of statistics. Quarterly information assembly has one distinct advantage over monthly, in that it can be composed of either 13 weeks' or three calendar months' data. Any adjustment to account for the small differences between data relating to these two periods only needs to take place every four or five years. A mixture of data coverage, some fuels being for 13 weeks, some being for three months, is likely to be acceptable so long as it is made clear in accompanying notes exactly what time periods are being covered. The introduction of a 13-week and/or three-monthly reporting system also has the advantage that it can be used as a testbed to determine whether a later move to monthly presentation would be warranted and the type of problems that such a move would cause.

41. As well as providing faster indications of changes that are taking place, quarterly information can provide insight into the main seasonal patterns which annual information is unable to show. The importance of monitoring seasonal differences and trends will depend to a large extent on national geographical and geophysical characteristics.

42. A move to monthly collection and compilation of statistics may well cause problems in having to make allowances for the different time periods to which different blocks of data refer. It is unlikely that all available data will in fact relate to calendar months: some will be in the form of aggregations of either four or five weeks' data. Methodology has to be agreed for adjustments to data so that the statistics produced represent as closely as possible a common time period.

43. Once a decision has been reached that quarterly (or monthly) information is required, two specific dangers have to be guarded against. The first is that production of quarterly statistics for the main energy aggregates can easily give rise to delay in production of the more detailed and comprehensive annual information. The second, often interlinked with the first, is that the sum of four quarters' data may be found to disagree or be otherwise inconsistent with the annual data. Provision therefore has to be built in for retrospective revisions to quarterly series.

44. Chapter XII looks more closely at the types of information that might be prepared with annual frequency, and those that might be prepared more frequently.

D. Conversion factors

45. The compilation of energy tables, as opposed to tables relating to one fuel only, requires conversion of the different units in which the fuels are expressed to a common unit of measurement. In addition it may also be necessary to apply some form of conversion for certain individual fuels (e.g. to express different grades of coal in terms of coal of a standard calorific content). Conversion factors are often only considered in the context of the preparation of energy balances, but they have wider application in the preparation of any tables designed to show energy in aggregated form or in the preparation of inter-fuel comparative information.

46. Reference is made in many parts of this manual to the heat content of different fuels and products. Annex II gives conversion factors for the fuels most likely to be encountered, based on those published elsewhere by the United Nations. While there is a strong case for consistency in the factors used in different countries for seemingly identical products, it should be noted that variations do exist because of variations in chemical formulation. For example "premium" gasoline in one country may be to a slightly different chemical formulation (and therefore have a different energy content) from that in another country; natural gas may contain variations in the proportions of ethane and methane; what is described as LPG may in fact be solely propane or solely butane or any combination of the two. Not only do differences exist between countries, but they also occur over time within one country. Only those products which are single energy compounds, such as "pure" methane, or "pure" ethane, and electricity (which as already mentioned is an energy form rather than a product) have precise and unalterable energy contents. In presenting suggested conversion factors acknowledgment therefore has to be given to the fact that slightly different factors may be more appropriate in many countries. Even within any one country, the energy content of a given fuel (e.g. coal, natural gas, crude petroleum) may change through time because of a change in the quality of the fuel (due to a change in the source of that fuel). When this happens, the question arises of whether the conversion factors should always be changed in step or whether constant factors should be used. This problem is similar to the problem of whether to use current or constant prices in economic statistics, and the answer to the question depends as always on the purpose for which the information in common energy units is required.

47. One fundamental principle, however, should always apply: that net (rather than gross) calorific values (NCVs rather than GCVs) should be applied - i.e. that the heat required to evaporate moisture, which is present in all fuels (except electricity) and is also produced in the combustion process, should not be treated as part of a fuel's energy providing capability. It has recently been suggested that in the light of developments in gas-fired condensing boilers, which do in fact utilize part of the GCV of the gas employed, a partial move from NCVs to GCVs might at some stage in the future be desirable. Such a move, however, may for the time being be discounted.

IV. INFRASTRUCTURE FOR ENERGY STATISTICS COLLECTION

A. Responsibilities for energy administration

48. Perhaps the most serious problem to be faced in the development of sound energy statistics is defining and agreeing on the roles that should be played by the energy industries, ministries with individual fuel responsibilities, planning commission, national statistical office and any coordinating energy ministry. In an ideal situation there would be one ministry responsible for the administration, development and planning and monitoring of all energy matters, with separate divisions responsible for individual fuels and another for energy in total. This rarely happens.

49. A more usual arrangement is for there to be a separation of responsibilities for different fuels among a number of ministries. These ministries, as well as being responsible for monitoring and planning, may also directly control some or all of the production and distribution of the fuel concerned. For example the production of public supply electricity may be undertaken by the same central government organization that is responsible for the policy and planning for electricity: where this happens it may be unclear who should be monitoring the incidence of, and changes in, the generation and supply of electricity from private establishments. Another ministry, completely without interest in electricity, may be handling the development of oil or gas production, some or all of which may be under direct governmental control. Coal matters may fall to another ministry. In addition such topics as the activities of refineries, or the prices charged for energy products, may come under other ministries with general, rather than fuel-specific, interests.

50. Ministerial interest, if there is any, in biomass fuels is likely to be subsumed within a much wider interest in all aspects of forestry or agriculture. The development of new energy technologies, including those which are linked to renewable forms of energy, may only be one component of a far wider brief for ministries responsible for technological or industrial development.

51. Many countries have acknowledged the fact that energy policies, not always mutually consistent, are being developed independently at a number of central points, by creating bodies with overall energy monitoring and policy-development functions. These general energy responsibilities may be vested in an existing central economic planning body, in a new central energy planning body (which may be within an existing ministry, or be completely independent), or they may be grafted on to the responsibilities of one of the existing energy ministries. Such central energy organizations may well have a high proportion of analysts, economists and advisers who rely heavily on the energy industries and on other ministries for the supply of technical and statistical information, but who have little influence on the range of information available. Sometimes, however, such relatively new (and "high prestige") bodies make their own ad hoc data demands on the energy industries, and such demands are likely to receive priority over routine data reporting by the energy industries to other parts of Government. This outcome is not necessarily in the interest of Government as a whole.

B. Disadvantages in multi-ministry energy responsibilities

52. The division of responsibilities for different fuels and for energy as a whole will have arisen partly for historical reasons (not all fuel ministries will have been created at the same time), and partly as a reaction to the perceived need for a broader approach to energy issues. In the short term this may have enabled countries to adapt their policies quickly in the light of radical changes in the supply, costs and relative attractiveness of different fuels; in the longer term it may well aggravate some of the underlying problems, not least the availability of good energy statistics on which future planning will rely.

53. The basic data for individual fuels from which all energy statistics will be derived will emanate from a variety of energy industries and other sources. A not unusual channel for the supply of such data is in the first instance from the industries to the ministries which exercise policy responsibility for those fuels. In addition data may be collected at another central point, perhaps at the central statistical office, on those subjects which the industries cannot themselves cover (e.g. biomass fuel data, purposes for which fuels are consumed, etc.). In such circumstances the ministry or other central body in charge of overall energy planning has to meet its information needs by receiving, probably in diluted form, data collected and compiled by other ministries. Thus, one might be looking for a structure where the greatest amount of data is collected and used within the energy industries themselves for their own administrative purposes; sub-sets of these data are made available to the ministries which oversee their functions; and smaller sub-sets are then passed on to whoever is incorporating them into an overall energy context. It is difficult with such an organization for the central energy planner to derive the benefits he would obtain from more direct contact with the energy industries involved.

54. In other circumstances central energy ministries, or central statistical offices, may be the recipients of data directly from the energy sector. They in turn provide other ministries with the information that each requires. From a statistical and general organizational point of view such an arrangement has considerable attractions, not least because statistical responsibilities are focused at one point. In practice such a structure is often found to work less well than it should, perhaps because of lack of specialist energy knowledge among the statistical staff involved.

55. In building an infrastructure where the most appropriate data flow regularly from data-supplier to the final user a number of problems have to be addressed. First one has to accept that cooperation and dialogue between ministries and energy industries, and between different ministries, are not always as forthcoming as one might hope. There may well be a feeling that data collected can sensibly and realistically be handled only by the original collector, that only he fully understands what the data are about, and that only he and those immediately around him should have access to "his" data. Secondly, the expertise and understanding of energy statistics may be higher among some collectors than others, and among some users than collectors. This can lead to figures being "improved" without reference to those from whom they originate. Thirdly, where information is found not to be comprehensive, or the quality or accuracy are thought to be suspect, the final user may well

decide to bypass the usual statistics collection procedures and obtain the data himself direct from the originator. Fourthly, as a result of statistics being collected by abnormal procedures, there may be duplication of collection, different figures purporting to be the same measures, inconsistencies in data when the collection system changes, and gaps in information when data fail to be collected.

56. Anybody charged with the collection and assembly of energy statistics requires to have a sound understanding of the industries from which most data are obtained, and of the processes by which fuels are produced, converted and consumed. He also needs to be knowledgeable about the concept and application of conversion factors which enable different fuels to be compared or aggregated. Appropriate training is required before anybody can fulfil these tasks satisfactorily. Without trained staff to handle the assembly of good quality energy statistics it is only to be expected that others will attempt to improve upon or provide substitute information for what is being made available.

57. Failure to acknowledge the skills required by those engaged in the collection and compilation of energy statistics is sometimes compounded by a failure also to appreciate the level of resources needed for the assembly of good statistics. This problem is not confined to energy statistics, but it is perhaps more important in this field because of the wide selection of agencies that may seek to make good the apparent gaps and inadequacies that may be occurring, and by so doing making the situation more muddled in the longer term.

C. Suggested infrastructure for routine energy statistics

58. The organization of energy statistics collection has to reflect the division of responsibilities for fuel and energy policies prevailing in a country. Whatever structure exists, it is preferable that one, and only one, central body should be compiling statistics under the heading "Energy". Ideally the term "energy" should embrace all individual fuel data, and not be confined to those statistics which compare or aggregate different fuels in common terms. This should ensure there is the greatest consistency possible in the coverage and definitions used (e.g. in the categorization of customers to whom fuels are supplied) and the time periods to which data relate: it will ensure that the treatment of "borderline" fuels (e.g. LPG derived from oil or natural gas) is correctly handled with no omissions or double-counting. For electricity it should enable privately generated electricity to be incorporated with public supply generation, or the two to be considered separately, as user needs determine. It should ensure that the presentation of statistics on different fuels is done consistently, and reflect the prominence which each fuel should have.

59. There are various places where a central statistics collection body might be situated. In some countries the central statistical office handles the collection of individual fuel data (sometimes receiving it second-hand from other ministries) and the compilation of energy tables. This has the advantage that information can be supplied by industries without their being worried that it will be used in some way to their competitive disadvantage. It has the disadvantage that initially there is likely to be little direct

knowledge of energy matters, and the technical procedures called for in the preparation of energy information, leading to a requirement for appropriate training in such areas.

60. It is not unknown for the statistical office in one of the fuel ministries (e.g. that looking after electricity development and policy) to be given a coordinating role in the preparation of energy statistics. While those involved in such work will have expert knowledge in one fuel, they will need to acquire equivalent expertise in other fuels in order to achieve the correct balance in what they prepare and present. Their energy responsibilities may well not take precedence over those for the individual fuel, and as a result ministry, rather than government, priorities may apply.

61. The third option is to incorporate responsibility for the assembly of energy statistics in the ministry that has overall control over energy planning and monitoring, provided that sufficient resources can be devoted (with appropriate training) to ensuring that a thorough job is done. A variation of this, which may be applicable in some countries, is for all statistics to be prepared within a national energy institute outside government, whose role is to provide ministries with advice on energy and individual fuel policies.

62. Whichever option is found to be best for a particular country the general aims should be the same. These are that all fuel and energy statistics used throughout government should be based on one data collection system; that sufficient resources should be made available to satisfy the needs of all users; and that the people responsible for the system should, after appropriate training and with the benefit of experience, be acknowledged as experts in the field of national energy statistics.

D. Infrastructure for survey data collection

63. Although energy surveys are not considered specifically in this manual it should be pointed out that deciding where responsibility should rest for the design and execution of such surveys will require separate consideration. In addition to expertise on energy matters there will be a call for expertise on such aspects as sample design, interviewing techniques and analysis procedures. These additional needs are more likely to be met within a national statistical office, or within an academic energy institute or other academic body. They are less likely to be found in a fuel or energy ministry, whose contribution to the survey will be centred around technical energy problems.

64. More likely than not, surveys will need to reflect the information requirements of more than one ministry. This calls for concerted dialogue among the ministries involved. It is not unknown, however, for different ministries to undertake separate overlapping surveys on the invalid grounds that surveys are best handled (in terms of quality and timing) directly by those who possess the most knowledge of the subject being covered. This has on occasion led to misuse of some of the collected material, and little or no use is made of other material. It has also led to different ministries using conflicting findings as the basis for their separate policies and to the imposition of avoidable burdens on respondents.

65. Great emphasis has to be placed on the importance of cooperation and coordination among ministries, which should lead to general acknowledgement that a variety of centres of energy and statistical expertise need to be involved in the overall design and execution of surveys if maximum benefit is to be obtained from them.

Part Two

COLLECTION OF ENERGY STATISTICS AND LIKELY SOURCES OF DATA

V. COAL AND COAL PRODUCTS

A. Production

66. The accuracy and comprehensiveness of data collected on coal production will depend to a great extent on the structure of the coal producing industry. If there is central control or ownership of all mines, data will be more readily collectable than if, as happens in many countries, there is a widespread group of small independent producers. The structure of the mining industry will also have a great bearing on the frequency with which it is practicable to collect data.

67. A decision therefore has to be taken on how much of the coal producing industry should be regularly covered in detail. This will be determined by their ability to provide on-time data covering the weight of coal mined (i.e. excluding the weight of other rock and waste material obtained in the mining process) in the period specified (week, month, quarter etc.), together with some regular or intermittent assessment of the coal's quality.

68. The need for information on the quality of coal mined arises from the fact that the energy content of different coals (usually measured in terms of their net calorific value) may vary from about 2,000 to more than 7,000 kilocalories per kilogram (kcal/kg). 3/ Each mine may also produce coal of varying energy content which will need monitoring from time to time.

69. When all coal produced in a country is of broadly similar energy content the unit for collection, metric tons, may be sufficient for reporting purposes (in this Manual, all reference to tons is to metric tons). Otherwise some adjustment to the data for individual mines, or groups of mines, will be necessary to ensure that different measurements are consistent in energy terms. It is not unusual therefore to express coal information in terms of metric tons of coal of a standard energy content.

70. For example a country might produce one million tons (10^9 kg) of lignite and two million tons (2.10^9 kg) of hard coal with energy contents of 3,000 kcal/kg and 6,500 kcal/kg respectively. The total energy content of the coal produced is $(10^9.3000)+(2.10^9.6500) = 16.10^{12}$ kcal. If for the purposes of standardization "coal" is adjudged to have an energy content of 7,000 kcal/kg the total production would be expressed as $16.10^{12}/7000.10^3$ = 2,286,000 tons of "standardized coal" or of "coal equivalent".

71. While it is reasonable to expect the managers of larger or centrally controlled mines to record regular data for their own purposes on the quantity and quality of the coal produced, there may also be widespread mining operations where little, if anything, is consistently recorded. In aggregate these smaller concerns may account for a significant proportion of national coal production. Where these circumstances prevail it is necessary first to obtain knowledge of the extent of such operations from the licences issued, or from other government-held record of their existence, and secondly to obtain from the mine operators the best estimate of their production in quantity and quality terms. For some well organized larger concerns it may be possible to obtain data of similar reliability to those obtained for centrally-controlled mines: at the other extreme it may be necessary to assess from visiting them

(or a sample of them) how many "loads" (trucks, barrows etc.) of approximately what weight and quality are produced in a given time period. This might be collected in terms of "loads per day", which could be grossed up to produce monthly, quarterly or annual estimates. It is unlikely that good estimates will be obtained if the mining operations are not being conducted in accordance with government regulations.

B. Exports and imports of coal

72. The usual source of information on the quantities of exports and imports is the Customs (or Customs and Excise) Department. Data should be available from this source on the tonnage and value of international transactions recorded during a given period. The period of time actually covered is unlikely to relate to the period in which consignments actually entered or left the country, but rather to the period during which records were entered. There may be time-lags between the movement of individual consignments and their being noted in Customs records. For these reasons, where comparable data are also available from other sources, such as a centralized coal importing (or exporting) organization, they are often found to be different from those recorded by Customs and utilized in the production of statistics on international trade. Bearing in mind that the main statistical purpose of Customs records is to compile trade and balance-of-payments figures, they should not be regarded as the best source of data for energy or coal industry purposes. If the export and import of coal are handled by a small number of specialist organizations they will usually be, collectively, a more satisfactory source of data for compiling energy statistics.

73. Information on the quality of coal exported or imported is also required. Most large contracts will specify the minimum energy content of the coal being traded. Such information is likely to be available from specialist trading organizations, but it is unrealistic to expect it to be recorded by Customs offices, as it would serve them no direct purpose. However, in the absence of specific data on energy content, estimates may sometimes be made based on the cost per ton figures which can be derived from Customs data. Different qualities of coal are traded at different prices, the higher the price the greater the energy content, but there will also be variations in prices according to the quantities consigned and (for c.i.f. prices) transportation distances.

74. In some countries the import of coal is restricted to a small number of industrial organizations who are responsible for arranging the importation and for their own final consumption of the product. Where this occurs it should be possible to obtain comprehensive data directly from them concerning the quantity and quality of the coal involved (also data concerning their stocks and final consumption, which are covered in later sections).

C. Stocks

75. Large quantities of coal, accounting for a significant proportion of the amount annually mined, are likely to be held as stock in a variety of places. These may be at pitheads or at other points in close proximity to mines, at ports, at power stations or at other industrial establishments.

76. Stocks of coal are not easily measured. Where no weights are recorded of additions to, and extractions from, stocks, one usually has to resort to estimates of the volume of coal held (using geometric calculations appropriate to the shapes of the stockpiles being measured), converted to weight according to the coal's estimated density. Where the amount of stock is regularly recorded local factors are often derivable, e.g. tons per metre of a coal-pile's length (this assumes constant height and width). Such figures will provide at best good approximations. Furthermore they will not take into account such factors as unevenness in the surface on which the coal is stored, or make any allowance for pulverized coal-dust or other waste accumulating at the bottom of the pile which, on exposure, might be found to be unusable.

77. The purpose of measuring stock is primarily to avoid the often misleading assumption that coal production (plus imports minus exports) may be taken to equate with coal consumption. The refinement needed to this equation is the introduction of stock change, rather than stock levels themselves; changes may either be recorded as net additions to/extractions from stock or as the difference between the stock held at two points in time. The resulting formula then becomes:

Production + Imports - Exports +/- Stock change = Consumption

It is apparent therefore that any constant underlying error in stock measurement will not be serious so long as the changes in stock levels are being accurately recorded.

78. While it may be noted that some countries record "production" as the amount of coal leaving mine sites, this is conceptually incorrect and may give a misleading impression of mining activity. Coal extracted from mines, after on-site removal of impurities, is unlikely all to be put immediately on trains, lorries or other means of onward distribution. The amount retained at the mines as stock, more readily available for distribution and consumption than coal still under the ground, forms a significant element in the supply and distribution chain and should not be statistically ignored.

79. In the same way, stocks held at the points of import or export can, if not regularly measured, give rise to misleading interpretations. An increase of stock held at ports, if not accounted for separately, is likely to be wrongly classified as an addition to domestic consumption, or will find its way into a "statistical difference" measure (see chap. XIII, sect. E, below). An unrecorded decrease in stock would result in more coal being exported than the statistics showed to be available. Either of these happenings could lead to a general reduction in the credibility of the coal statistics produced.

80. If stocks of coal at power stations are not recorded (in those countries where electricity is generated from coal) it may be possible, after investigation of the recording procedures involved, to deduce that the difference between coal industry figures for "deliveries to power stations" and electricity industry figures for "consumption at power stations" may in fact be attributable to changes in stock levels of coal held at power stations. If the coal industry figures of "deliveries to power stations" were taken as equal to the coal consumed in every time period for the generation of electricity, then a misleading impression would be obtained of the efficiency (and changes in efficiency) of coal-burning power stations.

81. Provision should therefore be made for the collection of data on the levels of major stock holdings from the organizations that are responsible for holding them. Failing this, measures of changes in stock holdings should be sought from them. "Stocks at mines" data should be sought from major producers; "Stocks at ports" data from traders or whoever else owns this coal; "Stocks at power stations" from the appropriate part of the electricity generating industry. Where coal is directly imported by a small number of industries then they too should be asked to provide stocks data (see para. 74 above).

D. Coal industry's own use of coal

82. There will be instances where coal is consumed by the coal industry to aid in the process of producing coal (e.g. to provide electricity to power elevators or other machinery at mines). The coal so utilized should be recorded by those providing data on mining output (as well as any electricity generated from such consumption), and returned alongside the production data. As will be seen later in chapter XIII below, such "own use" constitutes one component of intermediate disposals of production.

E. Coal deliveries to power stations

83. Coal is used extensively for the generation of electricity. In some countries this may be the only significant use to which coal is put. The quantities of coal delivered to power stations must be obtained from the organization(s) responsible for those deliveries (the national coal company, mine owners, coal distribution companies etc.), depending how distribution is organized nationally. Stocks of coal at power stations should also be recorded (see paras. 80 and 81 above).

84. Data on the consumption of coal for electricity generation is covered under "Electricity" in chapter IX. Some of the electricity generated from coal may not be for public supply but only for use within the organization generating it. The treatment of this "self-generated" electricity is also covered in chapter IX. It may not always be possible to distinguish coal delivered to industry for the self-generation of electricity from that delivered for other purposes. Estimates of the amount of coal consumed may be derived for measured amounts of electricity generation, but further specific enquiries may be necessary to provide reliable approximations of coal being utilized in this way (see also sect. I, below).

F. Coal use in other conversion industries

85. Coal may be converted into a variety of different energy forms. Conversion to electricity is the most widespead of these, but other processes play a significant role in many countries. These other processes include the production of coke from coal, the conversion of raw coal to briquettes or other refined coal products, usually of higher energy content, and the conversion of coal to coal gases.

86. In each case the end-product has properties (e.g. purity, cleanliness, weight) that raw coal does not possess to the same extent, and which make it a more attractive product (economically or environmentally) with a different range of potential uses. In the process of converting coal to a coal-product some of the energy content is lost in the form of waste heat.

87. In order to obtain a comprehensive picture of the coal component of a country's energy needs, and to provide elements for the national energy balance (see chapter XIII), the operators of coal conversion industries need to supply data on (a) their consumption of raw coal, and (b) their output of refined coal, in the form of coke, briquettes etc. Even in cases where the conversion involves little more than repackaging, e.g. compressing dust into marketable briquettes, with negligible loss of energy content, measures of "Input" and "Output" should still be obtained wherever possible. The dust to briquette example may involve a recycling process that warrants monitoring in its own right: in other cases the difference between output and input (i.e. energy lost) may provide a strong indicator of the viability of the process and of its potential for further development.

88. Whereas coke and briquettes are forms of converted coal not altogether dissimilar from the original product, the same cannot be said for gases derived from either coal or from coke. However, it should still be possible to measure the quantities of gas generated for subsequent energy use either through the measurement of the volumes marketed to consumers, or through calculations of the quantities consumed for the different chemical or energetic processes to which it is put within the industry responsible for its generation.

89. For simplicity, gases derived from coal may be grouped under three headings: gas-works gas, coke oven gas and blast furnace gas. The first of these involves the input of a primary fuel, coal, and the output of the secondary fuel, coal-gas. The second also involves the input of a primary fuel, coal, but the output is essentially a secondary by-product from the manufacture of another secondary fuel, coke. The third involves the input of a secondary fuel, coke, and the output of another secondary (or it might be called tertiary) fuel, blast furnace gas, as the by-product of an energy consuming chemical process. These fuels are considered also in chapter VIII, which is concerned with the statistical measurement of derived gases.

90. Data on coal and coke inputs, and coke and gas outputs have to be obtained from the operators of the plants involved. Account has to be taken of the fact that some of the outputs of coke and gas are unlikely to be generally marketed. They may find specialist use within the plant or they may be utilized in some further chemical process. Quantities used in such reprocessing should be shown separately if possible, as it may be considered inappropriate to include them as part of energy supply.

G. Deliveries of coal to final consumers

91. The most appropriate sources of data relating to final deliveries of coal will depend on the structure of the coal distribution industry and the purposes for which coal is finally consumed. In those countries where there are only a few industrial consumers and there is no general market for coal,

the consuming industries may be the best source of data; they can at the same time provide additional data relating to their stockholdings (and by so doing enable accurate figures for their final consumption to be derived) and on the purposes for which different quantities of coal are being consumed. Coal consumption in the iron and steel industry should wherever possible fall into this category, with the industry supplying the required data direct to the central collecting agency.

92. Where there is more widespread consumption of coal, and in particular where there is a strong domestic market involving wholesalers or other middlemen in the distribution chain, it is unrealistic (and uneconomic) to attempt to derive routine consumption figures from consumers' data. Instead one has to make do with figures showing consumption, or more accurately "Deliveries for consumption", obtained from the suppliers of the coal. Who these final suppliers of coal are can only be determined on a country-by-country basis.

93. In some cases there may be no intermediate transactions between the sale by production companies and the purchase by the final consumer; where this happens the coal producer should be able to supply the data sought on deliveries for final consumption. In other cases an elaborate distribution system may operate, with more organizations involved in the distribution chain than can be covered economically in routine data collection. In these circumstances a decision has to be reached, striking a balance between the detail and accuracy required and the cost of data collection, on the point in the distribution chain where final delivery data should be sought. This might be at the point at which a State marketing organization (or other national coal distribution enterprise), or a small number of large public or private organizations, disposed of their coal.

94. As a general rule one would not expect the same degree of accuracy or timeliness in data received from a general trading organization, as one would from a specialist organization whose business is concentrated in coal or a range of energy products.

H. Deliveries of other solid fuels to final consumers

95. Data on the deliveries of coal briquettes to final consumers are likely to be collected in similar fashion to that described above for coal. The sources of data will depend very much on the extent of usage of briquettes as a recognized fuel. In some countries they are the most widely used domestic fuel for cooking and space-heating; in others (where they exist at all) they may be restricted to a few specialized uses.

96. The major final use of coke will almost certainly be found in the iron and steel industry. Whatever difficulties may be faced in obtaining consumption data from industry in general (see sect. I, below), priority should be given in those countriess that have significant iron and steel production to obtaining data on the quantity of coke consumed in blast furnaces and iron foundries. The importance of this measure arises from the high energy intensity in the manufacture of iron and steel, and the large quantities of coal and coke likely to be consumed in the various production and finishing processes.

97. Coke may also be used by other industries or as a domestic fuel. Account has again to be taken of the distribution structure and how widespread such usage is. This will point to whether coke producers, from whom other data are already being obtained, should be the source of data for these components of final consumption, or whether other distributors should be approached for data.

I. Breakdown of final consumption by end-use

98. The most straightforward and least expensive means of obtaining a breakdown of final consumption by type of consumer is for the final distributor of the fuel to categorize his deliveries by economic sector and, within sector, by type of industry. If possible this should be based on the categories of industry identified in the International Standard Industrial Classification (ISIC), or national adaptations of this standard. This will provide strong indications of where the fuel is being consumed, and, by implication, the major uses to which it is being put. It will not, however, provide authoritative information on the exact purposes for which consumption is taking place; this is only likely to become available from in-depth surveys (at considerable cost) of the industries concerned.

99. Coal, coke, and other solid fuels may be used for generating electricity, for providing process heat (heat needed by an industry in the manufacture of end products), or for space-heating. It is important to identify the quantities of all fuels, including solid fuels, being used for the generation of electricity, not least for the successful preparation of energy balances (chap. XIII). Deliveries to public supply power stations have already been covered in section E above. Such deliveries are deliveries for consumption by the fuel conversion industry, whereby another fuel is created; they are not part of final energy consumption.

100. Fuel used by industry for producing its own electricity (and which may to some extent, or from time to time, be sold to public supply electricity companies for consumption elsewhere) may only be identifiable, and even then with some difficulty, by surveys designed to identify the purposes for which consumption is taking place. In the absence of comprehensive survey material it may still be possible to obtain rough indications from the major industrial electricity producers of the proportions of coal consumed for electricity generation and for other purposes. Even rough apportionments based on information provided by the companies involved (say 60 per cent for electricity generation, 40 per cent for other purposes), may enable important gaps in energy accounts to be filled. If such apportionments are incorporated it should be made clear in any final presentation of statistics where such methodology has been adopted.

101. It may be possible to identify those electricity self-producers who consume coal for no other purpose than the generation of electricity, and to obtain estimates of their coal consumption (without allowance for stock changes which may be taking place) from data obtained from the company or organization supplying the coal. This will provide less accurate and informative data than one would hope to obtain for any major electricity producer. Before such a procedure is applied attempts should be made to obtain more comprehensive data directly from those self-producers that are considered to be of major energy significance.

102. It should be emphasized again that fuel used for the generation of electricity does not form part of final consumption (but consumption of the electricity generated does). Fuel used by industry for other purposes (process- and space-heat etc.) makes up what is described as industrial final energy consumption. Where coal is used to supply both process heat and heat for other purposes, companies may find extreme difficulty in separating these in any regular statistical return. Many users will, however, have one predominant use for coal (or other solid fuel), and any ad hoc surveys designed to throw light on the purposes for which fuel is consumed should concentrate on these main uses.

103. As indicated at the start of this section, coal consumption may conceptually be broken down in two ways. The first is concerned with the classification of the industry (iron and steel, cement, brickmaking etc.) and of other sectors (transport, public administration, households etc.). Coal suppliers may be prevailed upon to break down data on their deliveries under such sectoral and subsectoral headings. The second seeks to obtain information on the actual uses for which coal is being consumed: such information will not form part of regular routine statistical collection, but may only be obtained by ad hoc or periodic surveys of sectoral (or subsectoral) energy usage. Exactly the same principles apply for obtaining breakdowns of the final consumption of other fuels.

J. A common unit for coal statistics

104. As already indicated "coal" is a generic term used to describe different products of widely varying energy content. Where, as is sometimes the case, the varieties of coal used in a country do not vary greatly (say plus or minus 10 per cent in the mean calorific value) it is realistic to aggregate data without correction for the differences in calorific values.

105. In those countries which consume markedly different ranges of coal (e.g. imported steam coal for electricity generation, and home-produced lignite for household consumption), it would be misleading to aggregate and express consumption data in the original units of "tons of coal". In the preparation of energy balances (chap. XIII) allowance has to be made for any significant differences in the calorific values of coals consumed. It is also realistic to consider converting all production, international trade, conversion and consumption data to be used in the preparation of statistics relating to coal into a common energy-based coal unit. Such a unit, as previously described in section A, will be based on a hypothetical coal of a standard energy content. The suggested standard of 7,000 kcal/kg (net calorific value) represents something approaching the best quality anthracite. It is not put forward as a typical quality, but as one that has been used extensively within different countries, and on which many international comparisons have been compiled.

K. Preparatory work for the collection of coal statistics

106. To obtain regular, reliable and consistent information relating to coal and products derived from coal it is suggested that the following procedures be applied:

(a) Produce a flow chart showing the procedures and processes which coal and other solid fuels go through in the country, from production and import to their final consumption by different sectors. An example of such a chart is shown in annex III;

(b) Establish the most appropriate sources of data to represent each identified flow;

(c) Establish from these sources the extent to which it is practicable to collect regular and accurate data from them, preferably derived from information they already hold for their own management purposes;

(d) Where data are not readily available devise appropriate means for obtaining estimates for such flows, possibly by use of ad hoc survey;

(e) Establish the quality (or qualities) of coal being utilized in different flows to determine the extent to which conversion to a common coal unit is necessary.

VI. CRUDE OIL AND PETROLEUM PRODUCTS

A. Crude oil

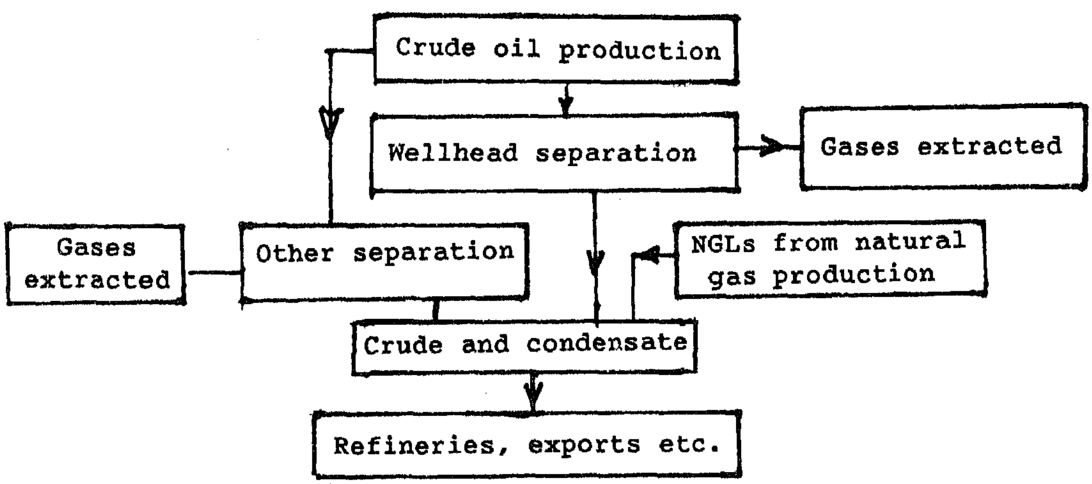
1. Production

107. In order to obtain a completely accurate record of oil production, a distinction has to be made between the quantity extracted from wells (gross production) and the quantity eventually available for refining or export. Any gas extracted from oil wells in association with crude oil ("associated gas") may be flared, reinjected or form part of natural gas production: this is covered in chapter VII on natural gas. The flow of oil from wells, from which gross production is measured, may be at abnormal temperature and pressure, and may also contain some dissolved gases. These are separated from the oil, in the case of offshore wells often at a considerable distance from the wellhead to yield methane (C1), ethane (C2), propane (C3), butane (C4) and other condensates (C5+).

108. Methane and ethane form the constituents of natural gas, the latter in small quantities compared with the former. Butane and propane are the constituents of liquefied petroleum gas (LPG). Condensates of a higher order cannot readily be marketed as individual products in their own right but can be processed at refineries in the production of other petroleum products.

109. Net production of crude oil is therefore the amount available after separation of gases and condensates, as measured at standard temperature and pressure. Condensate production, which comes both from crude oil, as described above, and from natural gas (often referred to as natural gas liquids - NGLs), is measured separately.

110. It is important to be able to define the flows of oil and natural gas from the various points or types of production into the processing and distribution chain. This requires separate measurement of the quantities before and after going through separation plants. The following diagram illustrates the likely pattern of flows:



111. The importance of oil production (where it occurs) to the national economy, and in particular to the tax regime, is reflected in the fine detail of producers' contractual agreements. The importance to all parties of being able to monitor these agreements closely leads to comprehensive and accurate data being recorded by oil companies wherever oil is produced. It is not always the case, however, that government ministries are fully aware of all the data collected and used by oil producers for their own management purposes. The resources available to oil producers for the collection and analysis of data often exceed those available to their counterparts within government. In some cases there is reluctance on the part of oil companies to supply what they regard as their own management data to government; in others there is some ambiguity as to the precise meaning of the data supplied to government. Nevertheless the source of all production data, and related information, will be the oil-producing companies. The closer the working relationships with these companies, the better the availability and understanding of production-related data.

112. Energy statistics compilers will sometimes have to rely on obtaining oil production data secondhand, that is from a central oil ministry or other central organization exercising some form of central control over production activities. In such circumstances it is necessary for there to be (a) good understanding by the compilers of the different activities, terms and definitions applied; (b) proper understanding by the central organization of the need for reliable production data to be made available for incorporation with other energy data; and (c) close working relationships between the two different central organizations.

2. Exports and imports of crude oil and petroleum products

113. Although this section falls under the heading of "Crude oil", the problems of measuring the exports and imports of petroleum products are almost identical. The two are therefore considered together in the following paragraphs.

114. All countries will to a greater or lesser extent be engaged in the international trade either of crude oil, or of petroleum products, or of both. It is not unusual for this "oil" to form the largest single component of international trade, and of the national balance of payments. It is essential therefore, not only for energy statistics purposes, that prompt and reliable information should be available relating to such trade.

115. Basic data on oil trade may be obtained from Customs sources. These are likely to show the type of oil or petroleum product being traded, the weight in tons (or the volume, usually in barrels), the value, and the declared country of origin or destination. Because of delays in making and processing returns there may be some vagueness on the exact time period to which figures relate. It is quite likely that these data will prove insufficient for the level of accuracy and detail required for energy statistical analysis. Data collected in terms of volume may well not show the specific gravity of the oil involved, which, if variable, is required in order that weight figures may be derived. The values of consignments may be thoroughly checked and validated for the purposes of trade statistics assembly and balance-of-payments calculations, but errors in the quantities involved and in the classification

of products may pass unnoticed. There may also be differences in the need for data on origins and destinations leading, for example, to the countries of immediate origin or destination being wrongly taken to be the same as those of final origin or destination.

116. It will be seen from this that further data will probably be required which may only be obtained from further inquiry of the oil producers, or others responsible for international trade transactions, in order that the complete needs of energy statisticians may be satisfied. Wherever possible, to minimize the burden on those making the returns, and to facilitate comparisons between information compiled from different sources, the additional data should be based on (or at least consistent with) other returns being made to government. In order to avoid confusion with other international trade statistics being issued by other parts of government, it may well be considered advisable to use different terms when presenting energy statistics: "shipments" and "arrivals" are sometimes used to distinguish them from "export" and "import" figures issued elsewhere. Terminology of this kind can be particularly helpful in tables used for compiling commodity accounts (showing the supplies and uses of energy sources expressed in original units).

117. The data required from exporters and importers (who may be oil producers, other oil companies, government trading organizations or private trading concerns, depending how trading is structured within the country) will therefore comprise:

(a) Crude oil: Arrivals (imports) by original source and, where relevant, by type of crude. Shipments (exports) by final destination and, where relevant, by type of crude. These data to be collected in tons (or, if this is not available, in volume terms with the specific gravities of the oil involved, in order that tonnage can be calculated);

(b) Petroleum products: Arrivals (imports) for defined list of products by country of original source (where refined or where originally shipped from). Shipments (exports) of defined list of products, by final destination;

(c) Foreign trade: May also occur in semi-finished products used for blending in order to alter the final characteristics of a finished product. Such trade should be included where it is significant.

118. Where condensates are traded separately from crude oil, they should be identified separately in the data collected, though they will also be aggregated in overall "crude oil and condensate" totals.

119. Some producing countries which do not have the required refinery capacity send some or all their crude oil production for refining abroad. Where this happens it is appropriate for the crude oil sent for refining abroad to be categorized as an export, and for the products returned to the country to be counted as imports. It is recognized that the contractual arrangements for such transactions sometimes make this information hard to obtain readily.

3. Crude oil stocks

120. Stocks of crude oil may be held near wellheads, at ports awaiting transportation, at refineries awaiting processing, or at other strategic sites. It is necessary to obtain data from all such major stockholding points to avoid reaching what might prove misleading conclusions on changes in disposal patterns. This is of particular importance when new stockholding facilities are installed, e.g. when a new refinery is opened, which may absorb a significant amount from production or arrivals of crude oil, and which is not immediately matched by any increase in the quantity of products available for delivery to consumers.

121. Data should be collected (in tons) from the oil companies or other organizations owning the stocks. The same procedures should be followed for condensates. As already noted in the chapter covering coal the primary measure sought for energy accounting purposes is the change in stock levels rather than the absolute quantities involved. However the absolute levels are likely to represent something more than of passing interest: they may be of considerable strategic importance, particularly at times of potential oil crisis.

4. Deliveries of crude oil to refineries

122. The amounts of crude oil (and condensates) delivered to refineries may be obtained either from the oil companies effecting the deliveries or from the refineries themselves. In practice these may be different parts of the same organization. Because crude oil is likely to be handled in large quantities, and by only a small number of companies who supply the refineries, no elaborate procedures are called for in collecting the required data. An additional advantage is that the data supplied by the few major oil companies are likely to cover a sufficient range of flows and activities to ensure that some level of internal checking can be made on the different processes that are applied to crude oil from production to disposal. It can be confirmed that all those supplying data follow the rule that production, plus imports, minus exports, plus or minus stock change, and plus or minus other transactions that will need to be specified (e.g. transfers between oil companies), are equal to their deliveries to refineries.

123. The need for such internal checks becomes apparent when one considers the possible effects which might arise from failing to identify the above-mentioned other transactions, of which inter-company transfers are probably the most important. It is not unusual for oil companies to trade crude oil among themselves, and it is necessary to provide for these in any returns they make (plus any other disposals of crude oil not covered under specified headings).

124. As well as representing the end of the distribution chain for crude oil, it must also be borne in mind that the quantities of crude oil arriving at refineries are an essential starting point for the measurement of subsequent petroleum product outputs, and for the measurement of refinery efficiency. Obtaining data from the suppliers of crude oil, measured perhaps in terms of deliveries to all refineries, does not do away with the need to collect similar data in respect of each refinery. The best sources of individual

refinery data are likely to be the refineries themselves. Where, as often happens, the supplier of crude oil is also the owner and operator of the refinery (or refineries) the likelihood of inconsistencies between these two sources of refinery input data may not apply.

5. Deliveries of crude oil and condensates for final consumption

125. In some comparatively rare circumstances the quality of crude oil produced is sufficiently high for it to be used directly as a fuel in its own right or as a blending component with certain refined products. The same applies for many condensates. If this happens then it is necessary to make allowance for this form of specific usage (as an "other specified oil company transaction") in the returns from oil companies (see sect. A.4, above).

B. Petroleum products

1. Refinery inputs of crude oil

126. As indicated above, data should be collected from each refinery on the quantities of crude oil (and condensates) processed. This will take two forms: first, the quantities of crude oil (tons) received at the refinery, which should equate with the quantities delivered and as reported by oil delivery companies; secondly, the quantities input into the refining process. Differences between the two measures should largely be accounted for by changes in the levels of stock of crude oil held at the refineries; they may also arise on account of transfers of crude oil between refineries. Provision should be made therefore in returns from refineries for (a) receipts of crude oil, (b) stocks of crude oil, (c) transfers or other transactions of crude oil, and (d) inputs to the refining process. Receipts, stocks, transfers and inputs of condensates should be similarly reported.

127. Whereas the unit that oil companies usually apply in respect of crude oil is "barrels", which require to be converted, either by the companies or by those receiving data, into tons, the unit usually applied in all stages of the refinery process is "tons". In some cases the unit in which data are sought from refineries is "kilolitres": this is unfortunate in that it places a considerable additional burden on the recipients of data, who will need to convert these volumes into tons according to the wide range of specific gravities that will apply for the individual products produced. It is also unfortunate in that it encourages refineries to hold data in volume terms, contrary to the normal practice of the refining industry.

2. Other refinery inputs

128. A small proportion of the output from refineries is in the form of products that have no direct marketable use, but which can be re-input into the refinery process as blending components. These are one form of "backflow"; the quantities involved should appear under headings of both input and output. If they were recorded only as outputs then the apparent efficiency (quantity of output expressed as a percentage of quantity of input) of the refinery would be overstated. To avoid this, account has to be taken

of them as additional refinery inputs, even though the actual measurement of them may only be at the output stage. Another backflow occurs when a country has a petrochemical industry. This flow consists of the return to refineries of energy materials (such as naphtha) that are either surplus to that industry's requirements or are by-products of that industry's activities and not needed by it for further use.

129. In the same way refinery gases generated during the refining process, which are consumed in supplying heat to the refining process, should be treated as both outputs and inputs. Because there is usually no tangible end-product requiring to be re-input, there is a temptation to disregard the generation and consumption of these gases in the interests of simplicity. Omitting them as a component of input leads to a slight under-assessment of the overall energy needs in the production of a given level and mix of petroleum products. Consumption of refinery gas and of some fuel oil by a refinery as fuel constitutes part of "own use" (see sect. B.5, below).

130. A distinction must be drawn between those products which are consumed in the (chemical) refining process and those which are consumed for other purposes elsewhere in the refinery. The latter are categorized under "industry own-use", described in section B.5, below.

3. Refinery output of products

131. The marketable end-products of the refinery process range from gases, through "light" products such as gasoline, and "heavy" products such as fuel oil, to solid or near-solid products such as bitumen, waxes and cokes, which serve few if any energy purposes. Although the mixture of end-products can to some extent be adjusted by the refinery operator, the overall pattern of end-products is determined largely by the chemical content of the crude oil processed, and the facilities for further processing (cracking and reforming) with which the refinery is equipped. Each refinery should as a result have a fairly constant pattern of production.

132. The terms used to describe the end-products, and under which they are marketed to consumers, varies from country to country. An identical product may be marketed under completely different names, or the same name may be used in different places for products which are in fact quite different. It is therefore up to each country to determine the linkage between the conventional terms for different products and those which apply in the country concerned. Definitions of groups of products such as those published by the United Nations 2/ provide a guide as to how a nation's products should be categorized, as well as indicating some of the terms more often used internationally. The names used here to describe products, together with mention of some of the commoner alternative terms, will therefore not have general applicability in all countries.

133. Refinery output statistics, whether in aggregate or in respect of each refinery, need to embrace all end-products whether used for energy purposes or not. Grouping these under headings based on those recommended by the United Nations, one would seek the following breakdowns of output:

Light petroleum products

Aviation gasoline (Avgas, aviation spirit etc.)

Motor gasoline (motor spirit, regular/premium gasoline etc.)

Jet fuel (aviation turbine fuel (ATF), Avtur, jet A-1 etc.) a/

Kerosene (burning oil) a/

Naphtha (including middle distillate feedstock (MDF)), white spirit/ industrial spirit

Heavy petroleum products

Gas-diesel oil (gas-oil, diesel, high-speed/low-speed diesel, marine diesel, distillate fuel oil etc.)

Residual fuel oil (heavy fuel oil, fuel oil, bunker oil etc.)

Petroleum gases b/

Propane

Butane

Refinery gas (still gas)

Other petroleum products

Lubricating oil

Bitumen

Petroleum wax

Petroleum coke

Blending components

Other

---

a/ Jet fuel and kerosene are sometimes identical products.

b/ Liquefied petroleum gas (LPG) consists of propane, butane, or a combination of these two.

134. It is desirable that the units in which the outputs of all products are measured are by weight (tons). As already indicated, outputs may on occasion be sought in terms of kilolitres (or other volume measures). Because the specific gravities of many products are found to vary within defined limits,

either with the passage of time, or between different refineries, it is preferable for output tonnages to be recorded and returned by the refineries to avoid the application of notional volume-to-weight conversions by the recipients of data.

4. Refinery losses

135. Providing that all inputs to the refining process, and all outputs, are accurately recorded in weight terms, the loss of energy at each refinery, and at all refineries in aggregate, may be obtained by deduction. In addition, by expressing the outputs as percentages of their respective inputs, measures of refinery efficiency may be obtained.

5. Refinery consumption: own use

136. It is important to measure the quantity of fuels consumed at refineries in non-processing operations (e.g for generating electricity, transport within the refinery etc.), which is not available to the general market. Though this does not form part of the chemical accounting process that will be the main interest to refinery management, and as a result may not be carefully monitored, the omission of such energy consumption would give rise to false conclusions on the supply of different forms of energy for final consumption. "Own use" consists both of refinery fuel used in the actual refining process and fuels used for the mentioned ancillary purposes.

6. Exports, imports, inter-company and inter-product transfers of petroleum products

137. The approach to be adopted for the collection of data on international trade in petroleum products has been covered under the heading of "Crude oil" in section A.3 above, and mention has also been made of the need to make allowance in the design of returns for the coverage of inter-company transfers.

138. In order to obtain figures for the availability and final consumption of individual petroleum products (or groups of products) it is necessary that international trade data and inter-company transfers are recorded separately for each product. "Availability" here may be defined as refinery output plus imports minus exports, and "final consumption" as the deliveries to final consumers after allowing for consumption within the energy industries. Failure to record inter-company transfers at the individual product level consistently (i.e. for one company's "transfer out" to be balanced by another company's "transfer in") will result in discrepancies in the information finally presented. Where blending of semi-finished products occurs, inter-product transfers may also have to be shown separately.

7. Stocks of petroleum products

139. The need for data on the stocks of different petroleum products arises for two different reasons. First, it may be unwise on grounds of accuracy to produce an estimate of consumption based only on figures of refinery output

and international trade (after adjustment for identified transfers), without allowing for the possible build-up or run-down in stocks of a particular product. Secondly, there are certain petroleum products of strategic importance; if their availability were threatened and government intervention were necessary, reliable information on the quantities and locations of stock might assume considerable importance.

140. One can argue on statistical grounds that stock measures are necessary for accurate consumption statistics to be derived, or for separately collected availability and consumption statistics to be reconciled. However, acknowledgement has to be given to the fact that collecting such data comprehensively is an expensive and time-consuming process: it will also give rise to queries on data that would not otherwise occur and which themselves will take further effort to resolve. Nevertheless it may be possible at limited cost to obtain data on stocks of "key" products held at a relatively small number of important points (e.g. at refineries and at power stations). This restricted regular coverage of stocks has had to be accepted in most countries by energy statisticians, and by the users of energy statistics.

141. On occasion the importance of obtaining more comprehensive data on the size and location of stocks of products may warrant further ad hoc investigation. When such information is collected by other organizations it is to be hoped that it will be made available to energy statisticians in order that more accurate energy statistics may be prepared.

8. Deliveries of petroleum products to secondary energy industries

142. Before looking at the quantities of petroleum products being delivered to final consumers one needs to identify how much is being delivered to, and consumed by, secondary energy industries, the most important of which is likely to be the electrical power generation industry. A great deal of information is likely to be available from electricity producers on their consumption of heavy fuel oil, diesel, and lubricating oils (see chap. X, which covers returns from electricity producers).

143. Because of possible changes in stock levels at power stations and the diversion of some supplies to non-generating uses, it is important if possible to obtain separate measures from petroleum product distributors of the quantities of each relevant product being supplied to the electricity industry. A problem is likely to arise in that while distributors are likely to have good records of the quantities of products distributed to the public supply electricity industry, they may well not have similar quality data in respect of their deliveries to other industrial or private generators of their own electricity.

144. As indicated in chapter IX, there are likely to be difficulties in obtaining all the electricity data required from private and own-use generation. Under such circumstances a fall-back position would be to examine the quantity of fuel consumed (heavy fuel oil or diesel) to estimate the amounts of electricity being generated. It may be important, therefore, having identified the organizations concerned, to prevail upon petroleum product distributors to provide data on the deliveries of particular products

to these organizations. In passing one may note that it is sometimes difficult to identify where private generation of electricity is occurring from records held by government: in some cases this may be eased by the petroleum product distributor being able to help in their identification from knowledge of his customers' activities.

145. The problems of electricity generation by those outside the public supply industry will be unimportant in some countries, where the latter plays a dominant role. There are, however, some countries in which significant quantities of electricity generated come from companies whose main business is outside the electricity generation area, and some such companies deliver electricity to the public supply. Where this is the case it is of particular importance to ensure that the organizations involved are covered, as nearly as possible, in the same degree of detail as one would expect to cover the public supply industry.

9. Deliveries of petroleum products for final consumption

146. In order to obtain as much information as possible on the sectors in which final consumption is occurring the aim must be to obtain the maximum amount of detail from the suppliers of petroleum products (oil distributors, importers etc.). Though measures of sectoral consumption may theoretically be more comprehensively obtained from surveys of final consumers, these will be expensive to mount, difficult to repeat consistently, and will divert resources from making other improvements to energy statistics. The extent to which oil companies can provide relevant breakdowns of their deliveries of each petroleum product (or groups of products) will depend partly on the infrastructure of the distribution industry, and the extent to which they deliver to final consumers as opposed to wholesalers or other middlemen. It will also be influenced by the specifications of many of the products they are marketing, for example whether the diesel they sell for motor vehicle use is distributed in indistinguishable form from that for marine use. Above all it will depend on the extent to which the distributors have for their own purposes classified their customers under different sectoral headings.

Industrial consumption

147. Apart from the electricity industry there are likely to be other substantial industrial consumers of petroleum products. In some smaller countries it may be possible to identify without difficulty who the main industrial consumers are, and to obtain from distributors their deliveries of products to these organizations. In other countries one may have to rely on the distributors' own classification of customers to provide any sort of breakdown of their deliveries. It is in the distributors' own interests to be able to analyse their customers under standard classification headings, such as those provided in the International Standard Industrial Classification of All Economic Activities (ISIC). Negotiations with them may well identify possible improvements in their customer classification which they would welcome for their own purposes. Unfortunately it is unlikely that they would welcome a classification system imposed on them purely for governmental use, and any figures obtained under such a system would have to be regarded with some suspicion.

148. Further observations on the breakdown of industrial consumption by main type of industry (iron and steel, cement, brickmaking etc.) and by purpose of use may be obtained from chapter V (sects. G to I), which deals with the same problem in the context of solid fuels. Consumption by industry for the purposes of transport (including transport within an industrial site) is covered in the following paragraphs.

Transport consumption

149. For certain petroleum products - gasoline, jet fuel, much of diesel, and some heavy fuel oil - the transport sector is as important as any other. Road, rail, air and water transport assume widely ranging degrees of importance in different countries, but taken together they are likely to be an area of considerable growth and one where policy decisions assume some urgency. These decisions rely heavily on the availability of good statistics describing and monitoring the national scene.

150. The distribution chains for the fuels used for transport will be of varying lengths and complexity. Two methods of approach are possible for collecting data; these may be used in combination, depending on national circumstances. The first requires oil companies and product distributors to make returns of their deliveries to consumers in the transportation sector: this includes deliveries to filling stations as well as those direct to businesses engaged in road, rail, air or water transport. However, this may present inadequate coverage of the transport sector, as it excludes those deliveries to industry in general, which may consume large quantities of fuel for transport of goods or people, and which may make little if any use of the national filling-station network. It may also fail to differentiate for those fuels such as "motor" diesel (and to a lesser extent gasoline) between deliveries for road transport and those for marine use.

151. The second approach is to identify as closely as possible the type of transport for which particular fuels are designed, and to assume that actual usage is in accordance with designed usage. Motor gasoline is unlikely to be consumed in significant quantities outside the road transport subsector (though in some countries it is also used extensively for water transport). Many countries have different grades of diesel (or differently packaged diesels) aimed at the separate road and marine transport markets. Under such circumstances it may be possible to ascribe all, or almost all, deliveries of a particular road transport fuel to road, rail, water or air subsectors, though to do so may require collection of a finer breakdown of fuel products than other sections of this manual might imply.

152. Where, as is sometimes the case, a particular fuel is consumed in significant proportions in more than one sector, some method of sectoral apportionment of deliveries should be sought. The most obvious case of this is diesel, which is consumed for both transport and non-transport use; a less obvious example is kerosene, used both as jet fuel for air transport and as domestic kerosene for cooking and lighting. The basis for apportionment may have to be rough and ready (e.g. to assume that deliveries are divided equally between two different usages), or it may be based on information derived from end-use survey material. In the case of kerosene, however, it is likely that deliveries for aviation use will be sufficiently well documented for statistical purposes.

153. It should be noted that though fuel consumed for the transport of industrial goods or personnel should correcly be attributed to the transport sector, it is often, for convenience of collection and analysis, attributed to industry. Where this is a procedure which has been established for some time it is unlikely that it can be changed without some disruption to the time series and trends which have been incorporated in secondary analyses, models and other established monitoring procedures. It is important to indicate in footnotes to tables, or in accompanying notes, where such non-conventional definitions apply, and, where possible, to indicate approximate quantities for the wrongly categorized consumption.

Bunkers

154. In the above paragraphs on transport consumption no mention has been made of the distinction between fuel consumed within the country and that consumed outside. Fuels used by transport operators whose activities take place partly or wholly outside the territory of a given country are classified as "bunkers". The obvious example is ships engaged in the carriage of passengers or freight, and by extension the concept also covers air, road and rail transport that crosses national frontiers. In the case of ships, the concept also includes fuel used by fishing vessels, but fishing and water transport in territorial waters and on inland waterways (lakes, rivers and canals) are in principle excluded from bunkers and form instead part of domestic consumption.

155. This extraterritoriality aspect of bunkers can cause problems. National energy statistics normally relate to supplies and uses of energy within the national territory (including territorial waters and air space) and it follows that bunkers supplied for use outside this territory are analogous to exports so far as the country of origin is concerned. (This analogy is only partial, because true exports cross two frontiers - that of the country of origin and that of the country of destination.) In practice, however, international bunkers are shown separately from exports in national energy statistics because, in the context of energy planning, the factors influencing the demand for bunkers are different from those affecting the demand for exports.

156. In principle, bunkers taken on board abroad by nationally registered carriers should be treated as imports - which would correspond to the treatment accorded to this flow in balance-of-payments statistics. To correspond with this treatment, only bunkers supplied by the country (whose energy statistics we are considering) to foreign-registered ships, aircraft and land transport undertakings should be treated as "export-like" bunkers, and domestically-provided bunkers delivered to nationally-registered transport undertakings that engage in international transport should be treated as part of the transport sector. In practice, energy statistics are based on territoriality rather than nationality, and all international bunkers are classified as "bunkers" while all bunkers acquired abroad are ignored.

157. Though there may be country-specific ways of identifying international from intranational transportation, or of obtaining good approximations of what the breakdown should be in some countries (e.g. by recording deliveries billed in United States dollars separately from those billed in local currency), in others this may prove conceptually as well as practicably impossible. For example a vessel (aircraft or ship) may follow a route which involves many calls at ports or airports in one country and a short journey to a foreign

country for one call. The frequency and location of refuelling might be used to ascribe consumption to a "domestic" or an "international" heading, but this is unlikely to provide the best form of information which the country in fact needs. When an unusual situation such as this exists the country itself should decide the most appropriate form of categorization, if necessary overruling international convention.

158. In a similar way it may not be sensible to follow international convention rigidly when seeking data in respect of fuel consumed for fishing in international or other countries' waters. If such fishing is a major contributor to a country's economy then the energy consumed is likely to warrant separate indentification. However on this occasion, though national distributors may or may not be able to provide data on their supplies to the fishing fleet, they will definitely not be a source of information concerning the quantities of fuel purchased abroad. Such information could only be derived from surveys of the boats involved or of the companies owning them.

Other sectors

159. If distributors of petroleum products are able to classify deliveries under different industrial and transportation subsectoral headings they may well be able to extend their breakdown of deliveries to other subsectors. The "Other" sector consists of agriculture, public administration, commerce, household (or domestic) and other consumers. It is not unusual for the "Other" sector, or the other subsector within it, to include a variety of industrial and transport consumption which has failed to be picked up under the correct heading, owing to deficiencies, often unavoidable, in the methodology of classification adopted. Countries usually have a good idea where this is occurring, and if it cannot be corrected there should be appropriate footnotes or accompanying explanations to the tabular information compiled.

160. A component of "Other" consumption may well be that of the armed forces. While it is desirable from the point of view of the energy statistician or energy planner to have this information shown separately, this may not in fact be permitted. In some countries the data will not be available to the collector of statistics. It is important however that where armed forces consumption cannot be shown separately, it is "lost" under another heading such as "central Government and public administration". If it is deliberately omitted from the statistics eventually produced, estimates of the quantities involved may well be more possible by deduction (based on the difference between product availability and product deliveries) than if it is included under some catch-all heading.

161. Where apportionments have been applied to obtain estimates of key sectoral consumption (e.g. to derive the proportion of diesel deliveries to be attributed to the transport sector) it is important to avoid ending up with a residual which is wrongly categorized to the "Other" sector. Such use of apportionments should distribute all of the deliveries of a product to defined sectors or subsectors, not merely some of the deliveries.

10. Deliveries of petroleum products for non-energy use

162. In compiling statistics designed primarily to show energy requirements and consumption patterns it is important to differentiate any use of petroleum products for non-energy purposes. Some products have no significant energy use: these include white and industrial spirits, lubricating oils, bitumen and petroleum waxes. All deliveries of such products may confidently be attributed to non-energy use.

163. Some other products present greater difficulty as they potentially have both energy and non-energy uses. These include naphtha, which may be used as a petrochemical feedstock (non-energy) or as a blending component in gasoline (energy) or as a source of derived gas (an input to conversion). Methane, ethane, propane and butane, which may be products of oil refining as well as products derived from "raw" natural gas, may also be used as petrochemical feedstock.

164. The main non-energy industries consuming energy products in large quantities are in those that manufacture petrochemicals and fertilizers (see also chap. VII, sect. J, which covers the non-energy use of natural gas). Where such industries do not exist in a country it is reasonable to equate "non-energy use" with the deliveries of non-energy products. Where they do exist they are are likely to be large-scale consumers: however there should be little difficulty for distributors or refinery operators in providing separate data on their deliveries to them.

165. Where there are large industries who use part of their supply for non-energy and part for energy purposes some means of apportioning the deliveries to them under these two headings may have to be derived by inquiry of the industries concerned. This is likely to be more of a problem for natural gas than for petroleum products.

11. Preparatory work for the collection of crude oil and petroleum products statistics

166. To obtain regular, reliable and consistent information relating to crude oil and petroleum products it is suggested that the following procedures be followed:

(a) Produce a flow chart showing the processes and procedures which apply for crude oil and petroleum products, from the production or import stages to the distribution of products to final consumers. An example of such a chart is shown at annex IV;

(b) Establish the most appropriate sources of data to represent each identified flow;

(c) Establish from these sources the extent to which it is practicable to collect regular data from them, preferably derived from information they already collect and hold for their own management purposes;

(d) Where data are not readily available, devise means for obtaining estimates for such flows from industrial inquiries or ad hoc sample surveys.

These are likely to be concerned with the final distribution and end-use of particular products;

(e) Prepare a programme of data collection from oil and petroleum product industry sources, supplemented by additional inquiries and survey material, which can be accommodated within the resources available.

C. Liquefied petroleum gas (LPG)

1. Production

167. LPG is a generic term for gases which may conveniently be stored and distributed by keeping them under pressure in liquid form. The term applies in practice to propane (C3), butane (C4), or mixtures of the two. The net calorific values of propane and butane are markedly different when expressed in volume terms (85.8 and 111.8 MJ/M_3 respectively); less different when expressed in terms of weight (168.2 and 192.8 MJ per ton). Butane, being the heavier of the two gases, requires less pressure to keep it in liquid form.

168. As described in earlier chapters, the supply of propane and butane may be as a by-product of crude oil or natural gas production, or they may have been obtained as products of the processes to which crude oil and raw natural gas have to be subjected. For many countries without indigenous oil or gas resources LPG is an imported product, either in bulk, possibly for later transfer to pressurized containers ("bottles"), or already in such containers. Bottles come in a variety of sizes designed for both industrial and domestic use; their contents are sometimes described in weight, and sometimes in volume terms.

169. Although data on the quantities of propane and butane produced by oil and gas companies are likely to be obtainable from them without great difficulty, and similarly on the quantities they bottle (as LPG) or make available to bottling companies, there may be difficulty in obtaining good figures relating to internationally traded LPG.

2. Exports and imports of LPG

170. The extent to which companies, or individuals, are permitted to export or import LPG varies considerably. In most countries the trade is restricted by law on safety grounds to oil or gas companies or licensed specialist LPG traders. Where such restrictions exist it is possible to obtain from them the information required on the chemical (and hence energy) content of the product traded, the quantities involved (in tons), the countries of origin or destination, and the proportions traded in bulk and bottled form.

171. Other countries, however, exercise less control over the trading of LPG, and relatively small quantities may be handled by a large and undefined number of companies outside the energy industry. It is quite likely too that Customs records will not readily make good deficiencies in any returns available from trading companies. LPG may be traded under a variety of proprietary names, and the returns to Customs may be in volume or weight terms or even on occasion in terms of "bottles" of undefined size. Differences in prices,

depending on the quantity and form of transaction, may make it difficult to translate Customs figures recorded in value terms into estimates of the weights involved.

172. Energy statisticians may therefore have to spend a disproportionate amount of time disentangling the figures for LPG imports and overall supply and attempting to procure a satisfactory reporting system that can be agreed by all the parties concerned.

3. Stocks of LPG

173. Where it is possible to obtain satisfactory supply figures from oil, gas or other companies on their production and international trade, it is likely to be possible to obtain figures in respect of their stocks of LPG as well. Where only poor figures are being obtained, with difficulty, on quantities produced and traded, there is little point in attempting to obtain data on stocks until the situation improves.

4. Deliveries of LPG to final consumers

174. The amount of bottled LPG available to consumers will be the output of bottling plants, plus imports (less any exports) in bottles, plus or minus the stock change of bottles at bottling or international trading depots. If LPG is also imported (or exported) and traded in bulk one may expect this to be handled only by specialist companies who are capable of making regular and reliable returns of data.

175. Where most or all of the final distribution of LPG is in the hands of a few companies (who may include oil and gas companies involved in supplying other data) it is reasonable to expect that they will be able to supply a breakdown of their deliveries by sector (industry, transport, household etc.). On other occasions it may be possible for them to identify the quantities earmarked only for certain specific usage (e.g. for transport).

176. If the distribution system involves a large number of organizations, including middlemen to whom large distributors might also be making deliveries, some form of estimation of sectoral consumption would have to be utilized. No specific guidelines can be put forward that would have potential application in all countries because of the widely differing distribution and accounting procedures which currently prevail. One might wish to consider, however, whether it would be appropriate to categorize (a) all bulk deliveries as being for industrial use, and (b) all deliveries to middlemen for household use (or for estimated proportions of household and other use). Alternatively one might say that deliveries of all bottles of a certain size and above are for industrial use, and below that size for household use. Apportioning deliveries between sectors is likely to be further complicated in many countries by the high incidence of LPG use by restaurants and other eating establishments, who may well be utilizing bottles of similar size to those used in households.

177. Where demand for LPG is growing substantially, as is happening in many countries, the suppliers are likely to be as interested in identifying the demand for the product in at least as much detail as that sought by energy statisticians. Close cooperation, including the mutual sharing of available information, may point ways towards obtaining more comprehensive information in the future.

5. Preparatory work for the collection of LPG statistics

178. Statistics relating to LPG may need to be assembled from a variety of sources, some of which may be of questionable reliability. To obtain the best possible data under the circumstances that apply, it is suggested that the following procedures be adopted:

(a) Produce a flow chart showing the different sources of bulk and bottled LPG, the processes through which it goes and the distribution chain for the product. An example of such a chart is shown in annex V;

(b) Establish the most appropriate sources of information to provide quantification of these flows;

(c) Establish from these sources the extent to which it is practicable to collect the desired regular data from them, preferably to be derived from data they already collect and hold for their own management purposes. Where it is clear that a source will not be able to provide data of an acceptable quality, ascertain whether any alternative source exists;

(d) Devise means of estimating the flows for which no satisfactory data is likely to be forthcoming from (c). This may include identifying a requirement for material that may only be obtained from surveys, the cost of which may be high if the current incidence of LPG usage is still comparatively low.

VII. NATURAL GAS

A. Production

179. Natural gas may be obtained from gas wells, from oil wells in conjunction with the production of crude oil (associated gas), or in small quantities as a by-product from the processing of crude oil. The main chemical constituent of natural gas is methane (C1), though quantities of ethane (C2) of up to 20 per cent by volume may also be retained in gas finally consumed.

180. The gas emerging from wells may also contain significant proportions of non-energy gases (e.g. hydrogen sulphide, carbon monoxide, nitrogen etc.) which need to be removed because of their polluting characteristics and to ensure that natural gas, as distributed to consumers through the gas network, is of a consistent quality. In addition some of the gas produced may consist of products that are liquid at normal temperature and pressure, or that are more conveniently handled in liquid form by storing them under pressure. These liquids consist mainly of propane (C3) and butane (C4) (constituents of LPG), and condensates or natural gas liquids (NGLs or C5+). These energy products will be extracted from the raw natural gas for separate use as LPG, or will be added to the crude oil flow for processing at refineries.

181. The energy content of "raw" natural gas produced from different wells can vary widely. If there is a high proportion of non-energy gases the net calorific value (NCV) may be as low as 750 Btu/ft^3 (27.95 MJ/m^3); if there is a large proportion of ethane, LPG gases or condensates it may be higher than 1,100 Btu/ft^3 (41 MJ/m^3). Gas exists under the ground of even lower calorific value than 750 Btu/ft^3, but at about this level extraction is unlikely to prove economic. (As pointed out in an earlier chapter, the United Nations recommends the use of measurement units based on the joule and its multiples. However, the Btu/ft^3 is used in the present example in order to keep the numbers simple.)

182. Removal of impurities will have the effect of reducing the volume of gas and increasing its calorific value. Removal of LPG gases and condensates will lower both the volume and the calorific content of the remaining gas, but the volume removed (and transferred to LPG or to oil) will have a higher calorific value than the gas remaining. For example 1,000 ft^3 of gas of calorific value 750 Btu/ft^3 will break down to 750 ft^3 of gas of calorific value 1,000 Btu/ft^3 and 250 ft^3 of non-energy (waste) gas. 1,000 ft^3 of gas of calorific value 1,100 Btu/ft^3 might break down into 925 ft^3 gas of calorific value 1,000 Btu/ft^3 and 75 ft^3 of LPG and condensates with an average calorific value of 2,333 Btu/ft^3. These illustrations assume no energy is lost in the separation process.

183. Natural gas from a number of wells is likely to be mixed together before being distributed to consumers. It is necessary therefore that gases from all sources be of similar chemical (and energy) content before they are mixed. Small variations in content are likely to be allowed within defined limits, which will lead to small variations in the calorific value of the gas actually supplied at different periods of time (and in some countries in different areas of the country). These small changes, largely brought about by differences in the methane and ethane proportions have to be ignored in the

preparation of natural gas statistics, as it is unrealistic to monitor them continuously.

184. An exception to the general rule occurs when gas containing inert impurities (mainly nitrogen) is piped direct from a well to specific consumers. Such gas may be burned in its raw state without damage to equipment or to the environment. Where this happens the data showing the amount of gas produced and consumed will have to take into account the significantly sub-standard energy content of the gas. Taking the first of the above two examples, 1,000 ft^3 of gas of calorific value 750 Btu/ft^3 would need to be recorded as 750 ft^3 of "natural gas" with standard energy content (1,000 Btu/ft^3), and the remaining 250 ft^3 ignored. Alternatively, the 1,000 ft^3 could be recorded but with a calorific value of only 750 Btu/ft^3.

185. The gross production from wells, as initially measured at wells, may therefore be somewhat different from the net production of natural gas, where "net" production is defined as the amount of gas of specified chemical content which is intermixed for subsequent distribution and consumption. In obtaining data from well operators, or from gas companies owning or controlling the wells, it is necessary for there to be complete understanding on whether (and when) figures relate to mixtures of gases and what the calorific calues of those mixtures are, or whether (and when) they relate to "natural gas" in some standardized form. Countries sometimes publish data on natural gas expressed in energy units (using an appropriate multiple of the British thermal unit, calorie or joule) in order to ensure comparability of the data through time and space.

B. Flaring and reinjection

186. The gas produced at some wells, particularly at oil wells (associated gas) may not be capable, for physical or economic reasons, of being collected and fed into the gas supply system. Such gas will either be flared (wasted) or reinjected into the reservoir for later re-extraction, or to boost the recovery of oil. Some gas from gas-only wells is sometimes injected into oil wells in order to boost the oil yield. However the volumes of gas vented are likely to be of importance and interest in their own right, either to show "what might have been" (had the gas been collected and not flared) or "what will be" (when at some future time the gas is collectable). Data on the venting and flaring of gas are of growing importance because of the potential environmental effects of such practices.

C. Consumption of gas at wells

187. Natural gas being produced at a well, particularly if off-shore, is often found to be the most, or only, convenient fuel to provide heat and power for the operation of the well. It is desirable to know the quantity being consumed in this way as it may form a significant part of the needs for the "energy industry own-use" consumption category. However the statistic may not be readily available from wellhead operators (depending on the siting of meters), and it is not always featured in figures relating to gross production.

188. The gas statistics eventually produced should indicate, in footnotes or accompanying text, whether such consumption is included or excluded.

D. Gas cleaning and separation (shrinkage)

189. The processes needed to convert raw wellhead gas to gas suitable for final consumption have been outlined in section A above.

190. Having identified the processes that apply within the country, the aim should be to obtain from the gas companies, or other operators of the plants concerned, the quantities of raw inputs of defined characteristics, the quantities of natural gas outputs, the quantities of other energy by-products produced (LPG etc.), and, by deduction, the energy lost in the cleaning and separation processes.

191. Some gas may undergo more than one separation. It may be "cleaned" at or near the wellhead, and cleaned again perhaps after mixing with gas from other sources. This may be as part of a gas collection process, or it may apply immediately before consumption, say, at electricity power generating stations. It is important to detect all points at which the constituent parts of the natural gas flow may change as a result of such processes. It is equally important to ensure that all producers of energy by-products, such as LPG, are identified in order that their contributions to the overall energy supply may be obtained.

E. Gas liquefaction

192. For transportation over long distances, usually as part of international trade, natural gas may be converted to liquid form by subjecting it to pressure. The process of converting natural gas to liquefied natural gas (LNG) is itself an energy consuming process.

193. The data to be sought from gas companies or other operators of liquefaction plants are the quantitites of natural gas input to the plant, and the quantities of LNG produced, measured conventionally in terms of the cubic feet or cubic metres which the gas would have at normal temperature and pressure. Some of the difference between these two measures may be accounted for by gas consumed at liquefaction plants ("energy industry own use"), but most is likely to represent losses in energy, including the amounts flared.

F. Exports and imports of natural gas

194. Gas may be traded internationally either in the form of LNG (over longer distances), or through pipelines to or through neighbouring countries.

195. The quantities of LNG exported may be obtainable from the operators of liquefaction plants (assuming their output is all destined for export) after adjustments have been made for stock changes, or from the owners of the gas concerned, or from Customs records. If there are any imports of LNG these should be recorded in returns made by the importers, who may well be gas companies, or from Customs records. Returns based on Customs records are likely to be subject to the same deficiencies as those described for coal, oil, and petroleum products in the previous chapters.

196. Internationally traded piped gas presents perhaps greater problems of accurate measurement. The flow of gas destined for export, the flow crossing the frontier, and the flow arriving at its destination in the foreign country will be slightly different because of losses during the transmission process. There may also be differences in meter calibrations by which the flows are measured (this is a general problem with the measurement of any flow of gas), or in the temperatures and pressures of the gas at different points. For national energy accounting purposes the measures to be sought are the amount destined for export and/or (if the country imports gas) the amount of imports actually received. These should be available from the company or companies effecting the transactions, though they may not agree precisely with the figures recorded for the measurement of international trade.

G. Stocks of natural gas

197. In a gas-producing country the most effective and cheapest way to store gas is by leaving it in the well. Because of the relatively high investment cost of other storage facilities it will be stored at relatively few intermediate sites. These may be associated with production, international trade or collection prior to final distribution. Where significant capacity exists, i.e. where there is the potential for significant changes in stock, figures should be obtained from the gas producers, traders or distributors, as appropriate. This will enable closer reconciliation between the figures obtained from different sources at different points in the distribution chain, as well as ensuring greater overall accuracy.

H. Natural gas available for consumption

198. The amount of natural gas available for consumption will, as indicated in the previous sections, consist of gas of home or foreign origin that has been treated to ensure that it has a consistent quality; and it may include gas derived from the treatment or processing of coal, oil, and their respective products (see chap. VIII). It will exclude the amounts destined for direct export and for liquefaction plants prior to export; it will also exclude the quantities consumed in the production and separation industries and at liquefaction plants.

199. The main destinations of this gas are likely to be for electricity generation (both public supply and industrial own-generation), for industrial energy consumption, for industrial non-energy consumption (as a chemical feedstock), and for providing for space-heating and water heating in households, commercial establishments, offices and other parts of the "other" final consumption sector. The extent to which gas is available to these potential users will reflect the piped gas distribution system which is in operation (the "gas grid"). Mention should also be made of gas being utilized in liquefied (LNG) or compressed form (CNG) as a transport fuel: the incidence of such consumption is still very low; where it does apply, similar procedures will have to be followed as those described in chapter IX for LPG (see also sect. K below).

200. Coverage of the separate uses to which natural gas is likely to be put is contained in the following sections.

I. Natural gas consumed for electricity generation

201. Data should be readily available from gas supply companies on the quantities delivered to the public supply electricity generation industry. As is the case for electricity generated from coal or oil, attempts should be made to obtain from the gas companies the separate quantities delivered for the purpose of electricity generation and any delivered for other purposes.

202. Where gas is supplied to other consumers for the known purpose of generating electricity, these amounts should be separately identified by the gas companies in their statistical returns.

J. Natural gas consumed by industry

203. It is not unreasonable to expect gas companies to be able to provide a breakdown of their supplies to different parts of industry. The method they adopt for classifying their customers under separate industrial headings should follow as closely as possible the classification systems adopted for coal, petroleum products and other fuels (ideally all fuels should be based on an identical system). In many countries, where there are relatively few industrial customers accounting for a high proportion of consumption, the introduction of a good system of classification will present few problems. Where gas is more extensively used, and where there is a well-developed grid system for general supply, it is in the gas companies' own interests to develop a sound system of customer classification; for reasons of consistency and economy, from which they too will derive benefits, this system should conform with that required centrally.

204. A breakdown of the supply of gas to particular industries, into that consumed for non-energy purposes and that consumed for energy purposes, may prove difficult or impossible to obtain from gas company records. It will depend largely on whether the meters measuring non-energy flows (which have to exist for industry to control the processes for which the gas is required) are monitored by the gas companies, e.g. for separate charging, or are only accessible to the industrial organization concerned. There will be relatively few - in many countries only one or two - substantial consumers of non-energy gas. Where data cannot be supplied by the gas companies it should be possible to obtain them from the user, showing energy and non-energy use separately, though this will call for adjustments to be made to the aggregated industrial data provided by the gas companies to avoid any double-counting of consumption.

K. Natural gas consumed in transport

205. As noted in paragraph 199 above, CNG and LNG are being used, as yet largely on an experimental basis, in small quantities in certain countries as a transport fuel. Where this occurs it is desirable to monitor the quantities (a) supplied for compression; (b) available after compression (differences between the two being accounted for by consumption and losses within the compression process); (c) the stocks held at compression plants; and (d) the amounts delivered to final consumers. At present it is unlikely that consumers will be found outside the (road) transport sector. Should its use

spread more widely, the end-users would need to be classified in a manner similar to that adopted for other natural gas.

L. Natural gas consumed in other sectors

206. The ease with which gas companies can supply data showing gas consumption for other sectors of the economy (households, public administration etc.) will depend to a large extent on the classification systems which they have introduced for their own purposes. It may be found, as with oil companies, that different gas companies adopt different, and inconsistent, classification systems, making it difficult to quantify any but the crudest overall sectoral breakdown. Classification systems, as for electricity, may be based on a tariff structure whereby different types of user are charged at different rates. Where this applies the tariff breakdowns may sometimes provide proxy measures for the desired sectoral or subsectoral breakdowns.

207. It is not unknown in countries where natural gas is produced and readily available to consumers, for household (and possibly other) customers to be supplied at a flat charge irrespective of their consumption. Apart from encouraging wasteful use of gas it is unlikely that good measurement of the consumption levels can be obtained unless there is some individual or group metering system in place. Resort may have to be made to survey material to provide estimates of consumption per household (or "per other user" if non-household consumers are also involved), which when grossed up by the appropriate figure for the total number of households (or other users) receiving such supplies would provide estimates of the missing values.

M. Losses in natural gas distribution

208. An aggregation of the quantities of gas supplied (or charged) to the electricity industry, other industries and other consumers, may well be slightly less than the quantity available for consumption as defined in section H, above. This arises from the fact that some of the gas theoretically available will be lost in the distribution process. The differences between the two measures may therefore be attributed to "losses in distribution", but they may also include differences arising from errors in meter calibration, slightly different time-scales covered, and other factors that might otherwise come under "statistical differences" (where the sum of one set of measurements is found not to equal the sum of another set with which it should equate).

N. Preparatory work for the collection of natural gas statistics

209. Data collected on natural gas should take into account differences in the chemical (and therefore energy) content of gas obtained from different sources, and the changes in content that occur before entering the final distribution chain. Considerable preparatory attention should be given to the upstream end to ensure that an accurate portrayal is given of the supply and consumption of natural gas. To obtain regular, reliable and consistent information relating to natural gas, it is suggested that the following procedures be followed:

(a) Produce a flow chart identifying the processes which gas from different sources go through before incorporation in natural gas supply to consumers, including other processes involved for internationally traded gas. An example of such a chart is shown at annex VI;

(b) Establish the most appropriate sources of data to represent each identified flow;

(c) Establish from these sources the extent to which it is practicable to collect the desired regular data from them, preferably to be derived from information they already collect and hold for their own management purposes;

(d) Where data are not readily available, devise means for obtaining estimates for such flows from industrial enquiries or other sources. This may include information in respect of the non-energy use of gas.

VIII. DERIVED GASES

A. Production of derived gases

210. As indicated already in the chapters on coal and oil and on petroleum products, energy gases may be produced as products or by-products of the treatment or consumption of a variety of solid and liquid fuels. Some of these gases (blast furnace gas, refinery gas) are likely to be consumed at the point of manufacture. Where this happens data on the quantity produced and consumed should be available from the manufacturer.

211. Where derived gases are absorbed in the natural gas supply the quantity of production will need to be obtained from the manufacturer, together with the amount fed into the natural gas stream. Subsequent consumption will be included in the data supplied for natural gas.

212. Where derived gases are produced for consumption elsewhere than at the point of generation, and which are supplied independently of any natural gas supply, data will need to be collected specifically under a "derived gas" heading, showing the elements of production and consumption consistent with those adopted for other fuels.

213. The supply (or net production) may be defined as the quantity made available for distribution from the plant or plants at which it is generated. The source of data will be the company responsible for such distribution. This quantity may not be in agreement with data supplied by the industry producing the gas (if a different organization is involved), which may hold varying amounts of stock of the gas, or which may flare any production that proves surplus to the demands of the derived gas distribution industry. Differences between the two measures may not be immediately apparent if the gas producer records data in one unit (e.g. in tons for consistency with other data for coal or petroleum products), and the derived gas company keeps records in terms of the unit by which he disposes of the product (perhaps cubic feet or cubic metres).

B. Other data relating to derived gases

214. The categories of data that need to be recorded for derived gases distributed and marketed as an independent fuel are identical with those described for natural gas in the previous chapter.

215. It is unlikely, in practice, that the uses of derived gases will be as extensive as those of natural gas in countries where natural gas is produced. This is partly because the supply of derived gas is likely to be restricted, particularly where it is produced as a by-product, and partly because its cost is less likely to be competitive with other fuels.

IX. ELECTRICITY

A. Production/generation

216. All electricity is of its nature homogeneous, but its production involves the use of one or other of two distinct types of energy source, and by convention electricity is classified according to its source as "primary" or "secondary". Primary electricity is generated from converting some of the energy present in a natural phenomenon, such as wind, tide, other water flow, or underground heat, into the form of electricity. Electricity produced in this way does not reduce the potential for further similar generation from that same source, as the energy content of the source continues (for practical purposes) undiminished.

217. Secondary electricity production involves the consumption of one fuel, e.g. coal, fuel oil, natural gas etc., and utilizing the energy produced from the combustion process in the form of heat to generate another form of energy - electricity. Considerable amounts of energy, mainly in the form of heat, are wasted in the conversion process.

218. The production of nuclear electricity is similar to secondary generation to the extent that heat released in a (nuclear) process is utilized to produce steam for driving turbines which in turn drive generators. However, because the total energy present in the nuclear fuel is insignificantly reduced in this process, nuclear generation is classified as primary energy.

219. It is necessary to distinguish between primary and secondary electricity generation when monitoring national requirements for energy since primary electricity makes no demands on depletable energy resources.

220. The main regular data required from companies generating either primary or secondary electricity are the quantities of electricity generated during a given time period. This represents the starting point of the distribution chain which requires to be monitored at various points before the electricity is finally consumed.

Primary generation of electricity

221. For primary electricity generation it can be useful in the context of energy planning to have a measure of the amount of fuel which would have been used had this electricity been generated by the more widespread secondary process. As well as giving an indication of the fuel "saved" by utilizing primary rather than secondary processes, it also enables more realistic comparisons to be made with other countries of their overall primary energy requirements. This calculation may be carried out by the recipient of primary generation data; it is not something which has to be done by the electricity companies.

222. The amount of conventional fuel required to generate the same quantity of electricity by secondary processes that has been generated from primary sources is determined by a calculation based on the efficiency of converting conventional fuels to electricity. The notional efficiency of conversion which is chosen for this calculation may be that which applies for all, or for

a selected part, of the secondary generation in the country, or it may be based on some overall international standard.

223. For example a country which generates 7,000 gigawatt hours (GWh), or 25,200 terajoules (TJ) of electricity from 2 million tons (83,020 TJ) of fuel oil, and a further 3,500 GWh (or half as much again) of primary electricity, might be said to have a primary energy requirement equivalent to 3 million tons of fuel oil (124,530 TJ). In fact one million tons (41,510 TJ) of this are "saved" by the use of primary sources. Alternatively one might adopt a standard efficiency of, say, 30 per cent (the notional efficiency recommended by the United Nations for use in developing countries which, expressed another way, is that 10 energy units of conventional fuel are required for the production of 3 energy units of electricity: this would lead in this example to a primary energy requirement of 42,000 TJ for the production of the 3,500 GWh (12,600 TJ) of electricity generated from primary sources, or 125,020 TJ for all electricity generation.

Secondary generation of electricity

224. Where electricity is generated from the combustion of other fuels, data need to be collected on both the quantities of fuels consumed and of the electricity generated. For companies engaged wholly or primarily in the supply of electricity for public consumption these data should be readily available.

225. Problems often arise in obtaining equivalent data for the private generation of electricity, usually by large or geographically isolated industrial companies for their own consumption. The first requirement is to identify the extent to which this type of generation is occurring. Self-generation of this sort may be at plant of similar size to that used for the public supply system and its presence well known. At the other extreme self-generation may involve small diesel generators, perhaps only brought into use when the public supply system fails, or perhaps serving small isolated communities without access to the public supply. It is not unusual for countries to underestimate the incidence of self-generated electricity, and the contribution it makes to final energy consumption. Information on self-generation may in some circumstances provide useful indicators of the extent to which the public supply system is failing to meet demand.

226. If the self-generation of electricity is widespread it is unlikely that it can be fully accounted for within the routine electricity statistics with which this chapter is mainly concerned. Where this is the case it will assume greater importance among the additional data which need to be collected from time to time and which is described more fully in chapter XI.

227. The collection of routine statistics on electricity generation is therefore likely to be very much restricted to the public supply generating system, and the larger self-generating industries who are able to provide data in the required amount of detail, from information they already collect and hold. Particular care needs to be adopted when some of the self-generated electricity is supplied in turn to the public supply system; this may be a regular, intermittent or seasonal occurrence. Similarly, when electricity generated in one part of the public supply system, designed to feed one grid, is transferred to another public supply system feeding another grid, this

needs to be covered explicitly in the data collected to avoid the possibility of double-counting. Provision therefore has to be made for the collection of data on the transfers-in and transfers-out of electricity between grids as well as of generation. If comprehensive data are obtained the net transfers should equal zero.

228. Mention has been made of self-generation under the heading of secondary electricity. Though most self-generated electricity comes from secondary processes it can equally well come from primary sources. Where this occurs it will be equally important to obtain data.

B. Exports and imports of electricity

229. Cross-border trading of electricity is gaining in importance. The quantities involved are likely to be well recorded for billing purposes. However, as happens with natural gas similarly traded, there may well be discrepencies between different measures purporting to record the quantities involved: the receiving country's figures for imports may not agree exactly with the supplying country's figures for exports owing to losses in the transmission process.

230. The measures required for energy monitoring purposes are, for exports, the amount transmitted for export, and, for imports, the amounts actually received, as these are the most relevant for showing the impact that such trading is having on the country's energy economy.

231. For imported electricity it may also be of interest to calculate the amount of conventional fuel that is being saved within the country by obtaining supply from outside. As described for primary generation some form of notional generating efficiency would need to be applied, such as 10 units of conventional fuel being required (or in this case saved) for every 3 units of electricity obtained.

232. The treatment of exported electricity is conceptually less clear. One may argue that electricity exported does not form part of the national energy requirement and that any grossing up to give a figure of conventional fuel required would be potentially misleading. This is further compounded by the fact that most electricity exported comes from excess capacity at primary sources (such as large hydroelectric stations) and that the introduction of conventional fuel equivalence is irrelevant. However it may also be argued that the conventional fuel calculation is a measure necessary to explain all electricity generated, whether consumed at home or abroad; also that it is desirable that one country's imports in conventional fuel equivalent terms should be matched by similar figures for its neighbour's exports.

233. As already indicated for other fuels it is likely that more reliable figures of the quantities traded will be obtained from that part of the electricity industry directly responsible for the transactions than from Customs returns.

C. Availability and supply of electricity

234. The quantity of electricity generated forms the basis of what is eventually consumed by final users. However, some of the amount generated will not find its way to end-users: some intermediate measures of the amount of electricity in the system are required, in order that the quantity generated may be fully accounted for.

235. Some of the electricity generated is consumed at power stations and in auxiliary plant. These amounts need to be recorded. One form of such consumption is for pumping at pumped-storage stations: where this occurs it is substantial (and exceeds the amount generated at that station) and will need to be monitored separately. (This excess of station use over station output is "compensated" by the effect of altering the time at which the output is made available. Cheap off-peak electricity is used for pumping, at night, so that a corresponding amount of electricity is available the following day when it is needed. This effect is rather like that of a stock-change in a storable energy source.)

236. In addition, some of the electricity generated will be lost in transmission within the generating industry. For example electricity generated by one supply company and transmitted to a second supply company for onward transmission to the latter's customers will be subject to transmission losses at both stages of distribution.

237. The measures suggested showing how the total amount of electricity generated is progressively reduced are:

(a) Production: the amount of electricity generated by public supply companies and by self-generators;

(b) Electricity supplied: production, less the consumption within power stations and at auxiliary plant (consumption at pumped-storage plants to be shown separately);

(c) Electricity available: public supply generation, plus imports, less exports, plus public supply companies' net purchases from self-generators, less consumption within power stations and auxiliary plant;

(d) Consumption: public supply electricity measured as being finally consumed (through the established metering and charging mechanisms, plus self-generators' consumption of self-generated electricity.

D. Losses in transmission and distribution

238. Losses of electricity invariably occur during the process of transmission. The greater the distance of transmission the greater the loss; the greater the voltage of transmission the lower the loss.

239. If the component measures defined at (c) and (d) in paragraph 237 are all available, then the difference between the two aggregates should be equal to the losses in transmission and distribution.

240. Other factors may be occurring which make this calculation suspect. Unmeasured or uncharged-for electricity (whether legally or illegally consumed) should not be included within "losses in transmission and distribution": in some countries it is erroneously so included. Inaccurate metering of final consumption may also lead to distortion of the estimate of losses. In addition it is likely to be impossible to obtain the separate measures of electricity available and of consumption for identical time periods: to minimize the effects of this, losses should be calculated over a period of not less than a year.

E. Consumption of electricity by end-users

241. The metering and charging system adopted within a country should give an accurate record of total consumption of public supply electricity. There may be problems as to exactly what time period this consumption relates to; not all meter readings are taken on the same day, and when they are taken they give no indication of exactly when the consumption took place.

242. It is also likely that a system for classifying customers is in operation, possibly linked to a tariff structure whereby different types of consumer are charged at different rates. Such a tariff structure may be adaptable to provide separate data on industrial, transport and household consumption if it is not already designed to do so. However the identification of consumption by other sectors - commerce, public administration etc. - may prove impossible without redesign of the tariff structure or of the recording system used by the charging authority. However, joint use of premises for business and domestic use can still present a problem.

243. Separate metering within an establishment, perhaps linked to different charges for different forms of consumption, may on occasion give indications of the end purpose for which the electricity is being consumed. The electricity industry is likely to benefit from having considerable detail on where and why consumption is occurring, in order that it can plan better the further extension of its services. The availability of sectoral and subsectoral classifications of customers is therefore something that is likely to be of considerable interest to the industry, as well as to the energy statistician. Unfortunately it is sometimes the case that the classification systems, which have been installed by different electricity companies within the same country, are not mutually consistent, or are inconsistent with the breakdowns required by Governments.

244. Difficulties arise in the measurement and classification of final consumption (a) if supplies are not fully metered, and (b) if there are significant quantities of self-generated electricity. Where a block supply of electricity is consumed by a variety of end-users each of whom either pay a flat rate or receive their supply free of charge, some method has to be adopted for classifying such consumption. If the consumers are grouped together and fed from a common line that serves no other users, then an overall meter measurement should be possible by the electricity company. Some means of apportioning this supply might be incorporated in the data being supplied by the company to provide separate figures for, say, industrial and household consumption. When however such special customers are fed

electricity from the same lines that supply normal metered electricity to other consumers, some other way of estimating their consumption would be necessary. Where small customers are deliberately provided with a restricted amount of electricity at a flat rate (or free of charge), survey data or electricity company records may provide sufficient detail on the extent of usage for reasonable grossed-up estimates of such consumption to be produced.

245. While every effort should be made to obtain data from large industrial self-producers to match those being supplied by the public supply industry, this may be impossible to achieve comprehensively. It has already been suggested in section A, above, that small-scale self-generation may have to be omitted from regular statistical coverage. Before omitting any larger organizations one should consider whether, in the absence of data in the form one would like to have, some proxy measure of consumption (which might have to equate with generation) might be acceptable. If it is possible to obtain measures or estimates of the quantities of fuel being supplied or consumed for the purpose of electricity generation then an approximate measure of the quantity of electricity being generated and consumed could be calculated (on the basis that the energy content of the electricity produced will be, say, 25 or 30 per cent of the energy content of the original fuel). Alternatively measures of a group of companies' output in relation to metered electricity consumption might provide indications of the amount of electricity a self-generator in the same industrial category is likely to be consuming. Such calculations are unlikely to be possible more frequently than annually: they will not form part of the returns from electricity companies.

F. Preparatory work for the collection of regular electricity statistics

246. The requirements for electricity data described in this chapter have been restricted to those categories that have counterparts in the coverage of other fuels. Data specific to the electricity industry designed to give further background material for the planning of future supply are covered in chapter XI.

247. Electricity is likely to be supplied in the greater part by one or more public supply organizations, and to a lesser extent by self-generators. The relative importance of these two sources will vary from country to country, as will the ability to monitor them separately. The following procedures are suggested for determining how regular, reliable and consistent information may be obtained, elaborated or improved upon:

(a) Produce a flow chart showing the generation and distribution infrastructure which applies in the country. This may require regular updating, particularly among those countries where radical changes are taking place in the general availability of electricity as an energy form. An example of such a chart is shown at annex VII;

(b) Establish from public sector supply industries the extent to which they can readily make available a comprehensive range of data, from the quantities of fuel being consumed in the generation process to sectoral and subsectoral breakdowns of final consumption, preferably to be derived from information they already collect and hold for their own management purposes;

(c) Define the extent to which self-generation is thought to prevail, and determine what portion of it could be expected to be covered with the resources available;

(d) Establish from selected major self-generators the extent to which they can readily make available a range of statistics consistent with (but not necessarily in the same detail as) that being obtained from public supply industries;

(e) Determine what significant gaps are likely still to exist in the required regular electricity statistics and which of these could be filled by use of proxy measures or by survey material;

(f) Prepare a programme of data collection that reflects the relative priorities for different forms of data, including any identified from chapter XI, which can be accommodated within the resources available.

X. BIOMASS FUELS

A. Biomass fuels in general

1. Non-commercial fuels

248. All the energy sources discussed in the preceding chapters are commonly classified as "commercial" because they are all nearly, but not quite, always marketed. (The exceptions are self-generated electricity used by the establishment generating it and - in some establishments in the chemical and other industries - recovered heat.) All traditional sources of energy in developing countries (such as fuelwood, charcoal, twigs, leaves and sticks, husks and shells, dung and other crop and animal residues) are often called "non-commercial" fuels, even though in most developing countries significant quantities of some of these fuels (particularly fuelwood and charcoal) are in fact marketed. An alternative and more helpful term to designate these energy sources, whether market or not, is "biomass". There are other traditional energy sources in developing countries but these are rarely if ever covered in energy statistics (namely, animal and human muscle-power, solar heat used for natural air-drying, small-scale wind and water-power used for pumping, milling and other rural applications, and wind-power used for sail-power in water transport). (See annex I for a more detailed listing of biomass and other forms of energy.)

249. Biomass fuels in general have no large established suppliers who collectively account for all, or almost all, quantities supplied, and who might be called upon to provide regular statistics. As a result the approach that has to be used for the collection of data has to be radically different from the one adopted for commercial fuels. Instead of reliance on the supplier to provide data, information has to be built up from measures of final consumption obtained directly or indirectly from the consumer. This process has been developed and refined over the years to such an extent that reasonable estimates of the quantities of biomass fuels consumed may be regularly obtained and updated. An exception to this approach is possible in the case of residues from commercial crops such as sugar-cane and oilseeds and nuts. In these instances, residue production may be adequately estimated by applying an appropriate factor to the quantities of output of the principal product.

2. Household surveys of non-commercial fuel usage

Incidence surveys

250. The information required from surveys covering the use and consumption of fuelwood and other biomass fuels falls into two main categories. The first category embraces "incidence" information, such as measurements of the numbers in a given population of households which consume fuelwood for cooking, the numbers with access to competing fuels (both commercial and traditional), and the numbers who have requirements for space-heating (seasonal or year-round). The findings need to be analysed by urban and rural areas and by households of different sizes.

251. Such survey information requires good questionnaire design, and should be based on soundly constructed samples. The sampling technique used will depend on the population or populations being sampled, e.g. whether the survey is designed to cover all households, or only rural ones; whether all rural areas can be represented or whether some have to be excluded on economic or other grounds. Such problems are likely to be encountered to some extent in all surveys conducted in the country. The national statistical office will be familiar with local conditions and the sampling problems that they give rise to and how these may be best addressed.

252. It is sometimes found however that it is of considerable importance to attempt to cover more remote rural populations, where a significant proportion of biomass fuel usage may be concentrated, which are usually omitted from national surveys covering other subjects. Where it is found impractical to include in the survey coverage all the sub-populations that one would like to see represented it may still be realistic to produce estimates for them. Such estimates may be based either on the results the survey shows for other sub-populations with similar (geographical or socio-economic) characteristics, or they may be based on realistic assumptions about the pattern of energy consumption (e.g. that all forest-dwelling households omitted because of inaccessibility consume fuelwood for cooking, and, say, have a requirement for space-heating for one quarter of the year).

253. Information derived from incidence surveys, is essentially based on "Yes" or "No" answers to questions (e.g., Do you use fuelwood for cooking? If so, is it the only fuel you use for this purpose? or the main fuel? or an occasional fuel?). Such questions are easily asked and easily understood. Though such surveys, like any other, will be subject so sampling error, they will not suffer significantly from systematic errors arising from misunderstandings or miscalculations on the part of interviewers or respondents.

254. As well as offering good accuracy for a restricted amount of information, incidence surveys are relatively inexpensive to conduct. The questions may indeed be appended to a general household survey already being conducted; analyses are likely to follow closely those adopted for other surveys; and they require little in the way of interviewer training.

<u>Consumption surveys</u>

255. The second type of survey is one designed specifically to measure the quantities of consumption of fuelwood and of other traditional and commercial fuels. The sampling unit is again likely to be the household and maybe other sites of small-scale rural industry below the normal threshold for sample enquiries. The data to be sought will cover the weights (or volumes, if realistic conversions to weight can be made later) of different fuels consumed for different purposes. If there is a seasonal pattern of fuel usage then interviews will have to be spread over the year to be representative of all seasons. Results will need to be analysed by size of household in order that a range of per capita consumption figures may be obtained.

256. Consumption surveys require assessments or physical measurements of fuels actually consumed, which are often derived from the differences in "stock" measurements taken at two different points of time; these differences, after

allowing for any further acquisitions, being equated with consumption. This involves a fairly elaborate, and costly, interviewing procedure. The length of time taken to obtain the data sought from each respondent, and the specialized techniques being adopted during the interviews, prevent such data collection being added realistically to an already existing household survey. Interviewers need to be carefully trained in the techniques to be adopted for measuring different fuels - particularly difficult if "fuelwood" embraces wood in the form of logs, branches, twigs, palm-fronds, etc., which may not all be readily weighed and which are more likely to be measured in bundles, headloads, backloads or cartloads.

257. It is virtually impossible to avoid some systematic errors in consumption surveys, e.g. arising from fuelwood at the time of consumption being drier, and therefore of different weight and energy content, than at the time its weight was recorded.

258. Analysis procedures have to be designed to show household aggregate consumption in common energy units (perhaps megajoules). This will require conversion of the data obtained for different fuels (e.g. kilograms of fuelwood, litres of kerosene etc.) by applying appropriate conversion factors.

259. Although there may be very good reasons for a country to obtain information from a tailor-made consumption survey, it should be noted before embarking on such an approach that the material likely to be of the greatest benefit to energy planners relates to the changes in consumption patterns that are taking place. These can only be measured by regularly repeated surveys. Bearing in mind the high cost, in financial and other resource terms, of conducting such surveys, one has to be confident that the design is sufficiently sound to be capable of being repeated at some time in the future with consistency in measurement techniques, sample design and analysis methodology.

Integration of incidence and consumption surveys

260. Information obtained from consumption surveys, repeated at infrequent intervals, will show among other things the consumption of fuelwood, charcoal and other biomass fuels per user of each fuel (i.e. expressed on a per capita basis, in different sizes of household). For example per capita consumption of fuelwood might be found (after appropriate adjustment to show annual data) to be 600 kg per annum in households using it as the main or only fuel for cooking and which have no space-heating requirements; 1,500 kg per annum in similar households which do have space-heating requirements; and 100 kg and 300 kg per annum respectively for households which only use fuelwood as a secondary fuel. These quantities are only quoted by way of illustration, but whatever figures are obtained from a consumption survey, when expressed in terms of consumption per type of user, they will not change significantly from one year to the next.

261. Incidence surveys will show how many households fall into each category of user more accurately than would be obtained from a consumption survey. In the above example there are four categories: "main/only" and secondary users of fuelwood, with and without space-heating requirements. Incidence surveys, because of their relative simplicity and low cost, are more likely to be repeatable. Repeat surveys will show the changes in numbers of users in defined categories.

262. In most countries changes in fuelwood consumption specifically, and in biomass fuel consumption in general, are occurring more because of changes in the incidence of use than because of changes in the levels of consumption per user. For this reason it is more important to be monitoring changes through regularly repeated incidence surveys, though the possibility of obtaining further consumption survey material from time to time must not be entirely ruled out. A further attraction of this approach is that incidence data takes less time to obtain and therefore does not require the same level of advance planning and preparation that a consumption survey needs.

263. From observation of what has happened in various countries it would appear that the strongest case put forward for mounting a large-scale biomass energy consumption survey is often that the last survey was not conducted as well as one that could now be mounted. On further inspection it might be found that, rather than discounting the information already obtained and starting again from a new base, it would be preferable to repeat the earlier survey, accepting its limitations, in order to establish what major changes have taken place.

3. Non-household surveys of biomass energy usage

264. Although the majority of fuelwood and other biomass fuel consumption is likely to be taking place in the household sector, many countries consume significant quantities in the industrial sector also. Obtaining statistics on consumption in the industrial sector should be based on principles similar to those adopted for the household sector - that is, to approach the problem in terms of separate measurements for incidence and consumption levels.

265. It can be dangerous to make generalizations which are intended to apply to all countries equally, but it is relatively safe to say that fuelwood and charcoal consumption is concentrated among the smaller establishments and organizations within defined industries.

266. In a particular industrial process the amount of fuel consumed is directly related to the physical output of that process. Physical outputs may already be measured in the compilation of statistics of industrial production. Incidence surveys should therefore seek to obtain data on the number of establishments using fuelwood (or other relevant biomass fuel) together with measures of the physical outputs of those establishments. From these measures it may be possible, using agreed fuel-to-output ratios, to estimate the quantities of non-commercial fuels likely to have been consumed in the production process.

267. Where it is impossible to obtain good measures of physical output, it may be that some other proxy measure may be found, such as number of staff employed, which might be incorporated with incidence measures to obtain rough estimates of the likely biomass fuel consumption.

268. Consumption surveys covering the industrial and other non-household sectors will, as a general rule, present considerable problems in design and execution. It is necessary to define the populations that such surveys would be designed to cover, the sampling methodology, the most appropriate way of recording consumption (which might be based on deliveries over a certain

period, or on changes in stock levels, or which might be taken in proportion to an establishment's physical output), and how one should apply grossing factors to sample data to provide national estimates.

269. In view of the considerable difficulties to be faced in seeking reliable data, it is not surprising that many countries choose to rely on intelligent guesswork to quantify the likely consumption of biomass fuels in large parts of the non-household sector. Although it would be possible to design a methodology for measurement based on incidence and consumption measures which would reflect any one country's pattern of consumption, it is debatable whether the high cost of pursuing this course should be of high priority if there are other significant gaps in national energy statistics.

4. Notional measures of biomass fuel consumption

270. As suggested in paragraph 266, it is often possible to establish the trend in biomass energy consumption from measures of how many consumers there are, without resort to frequent, or regular, measures of consumption itself. This can be taken a stage further if the main aims are to establish only a rough indication of the proportion of national energy requirements being filled by biomass fuels, together with indications of trends.

271. Surveys conducted in a large number of developing countries that have been analysed to show per capita consumption of biomass energy tend to show remarkably similar results. The energy required per household for cooking purposes is dependent on the size of household, the dietary requirements, the efficiency with which fuel is utilized, and, to a lesser extent, the moisture content of the fuel used. In some countries, such as in many in the Pacific, large quantities may be consumed at celebratory feasts, but when this occurs it has the effect of concentrating fuel consumption at one point with small compensating reductions at many other points. It is found that in spite of all these influences that something in the region of 6,500 megajoules (MJ), equivalent to half a ton of fuelwood or 150 kg of kerosene, is required per capita per annum for basic cooking purposes. In countries without significant space-heating needs this also approximates to their total energy requirements.

272. The per capita requirement for energy for space-heating varies from zero to a figure greater than that for cooking, depending on the temperatures encountered. For most tropical and subtropical countries the requirement for space-heating is likely to be small compared with the cooking requirement, and the latter may therefore be taken to include any space-heating needs. In other countries more specific survey data are likely to be required before average notional energy requirements, embracing both cooking and space-heating, can be determined: these will vary significantly among different countries.

273. Where a country has no specific data on biomass energy consumption it may obtain estimates either by reference to all countries, or to neighbouring countries, or to specific other countries which are thought to have similar per capita requirements. The estimates produced will be the product of the per capita consumption per user of biomass fuels in the comparator country or countries, and the number of people in the home country consuming, or thought to be consuming, biomass fuels.

274. In the industrial sector there are cases where notional estimates of consumption may be the most valid ones to obtain. These are often concerned with the generation of electricity. When, as happens in the sugar and palm-oil industries, bagasse or other crop residues are consumed, either for the production of processing heat or for the generation of electricity, it is unrealistic to expect that accurate measures will be obtainable of the amounts actually consumed. Where the quantity of residues immediately available at no additional cost exceeds the needs for energy pruposes there is little concern for the amount actually being consumed. Under such circumstances it may be preferable to produce notional figures of residue consumption based on (a) the amount of fuel needed to produce the level of electricity actually generated (based on a notional efficiency of generation), and (b) the amount of fuel needed to provide the heat actually utilized in other processes (based on notional fuel per unit of output estimates). In such cases, an indication of the quantity of conventional fuel that is being "saved" by the use, instead, of agricultural residues is another statistic that may be of interest to energy analysts and planners.

B. Biomass fuels likely to be encountered

1. Primary and secondary fuels

275. This section examines the more common biomass fuels, which may be grouped together under various headings. The first, and most widely utilized, is fuelwood in various forms: in addition there are vegetal (or crop) residues, animal wastes and biogas. These are all treated as primary fuels. Although biogas is derived from other potentially energy-producing products it is not obtained through an energy conversion process in the usual sense of the term. Fuel alcohols (ethanol and methanol) are also derived from vegetable materials that could be used directly as fuels, but by convention and for simplicity these fuel alcohols, together with coconut oil treated for use as a fuel "stretcher", are all regarded as primary fuels. Charcoal is treated as a secondary fuel.

276. Much of the charcoal consumed, and to a lesser extent fuelwood also, will have been traded as commercial products. The marketing and distribution will however be unsophisticated compared with those for more conventional commercial fuels. For the statistician they need to be separately distinguished, in recognition of the different data collection techniques required. These fuels are considered separately in the following paragraphs.

2. Fuelwood

277. Fuelwood is collected and consumed in the form of logs, branches, sticks and twigs. It can come from trees, shrubs or bushes, and may be burned with or without its leaves. It may be obtained from a tree in the form of fallen twigs or branches; it may be removed from the tree by "cropping", without damaging the tree's future growth; it may also come from felled trees that have been grown for the purposes of producing fuel; and it may come from trees that have been felled for other purposes. It may also come from forest trees or from scrub or bushes whose destruction will have potentially serious consequences for the environment locally if not on a larger scale in the

longer run. The term "fuelwood" embraces all these forms of woody material. The term "renewable" only applies to fuelwood grown and replaced at a rate at least equal to the rate at which it is cut.

278. Only when wood is grown specifically for consumption as an energy product, usually in plantations set aside for this purpose, does the term "production" have any real meaning. However, where wood is grown in this way it is likely to contribute only a proportion of the fuelwood actually consumed. As a result measurements of production should be restricted to the monitoring of specific plantations; they do not provide a realistic source of comprehensible data for incorporating in national energy statistics.

279. Fuelwood at the time of collection is likely to have a high moisture content. When wood is very wet half or more of its weight will be accounted for by moisture; when dried in air the moisture content will reduce eventually under good drying conditions to perhaps one eighth of its total weight; oven drying would be necessary to remove the remaining moisture. In any statistical measurement of fuelwood consumption it is necessary to make specific allowance for the moisture content at the time of consumption. A ton of fuelwood when completely dry yields approximately 19 GJ: a ton of fuelwood whose moisture content accounts for half of the weight yields little over 8 GJ. Variations in the calorific values for fuelwood of different moisture contents are shown in annex II.

280. In addition to the variability in moisture content which fuelwood may possess at the time of burning, it is also important to note that the efficiency with which it is consumed also varies widely. By "efficiency" one here means the proportion of heat generated in the combustion process which is utilized for the purpose for which it is being consumed. In open fuelwood fires used for cooking, less than 10 per cent of the heat generated is effectively harnessed for cooking purposes; in specially designed, fuel-efficient stoves this proportion may be nearer 20 per cent.

281. As a result of these variations, measurements of the weight of fuelwood being consumed give only one part of the information it would be desirable to have. In order to forecast the likely future consumption of fuelwood, or to forecast the amount of commercial energy required if there were a switch from fuelwood use, one would wish to have forecasts also of the efficiencies with which the fuels are likely to be used.

282. The sources of data on fuelwood consumption are likely to be a mixture of consumption data and "incidence" data derived from surveys (see sect. A above). Data concerning such things as the moisture content of wood being consumed would only be available from a consumption survey; data on the type of stoves being used might equally well come from an incidence survey.

283. In consumption surveys the unit of measurement for fuelwood should be kilograms (or tons). It would be impractical to measure the moisture content of the wood being burned by each household interviewed; an assumption has to be made that this conforms with an average derived from a small number of measurements. In some surveys it is assumed that wood is consumed on average with 30 per cent moisture content ("dry basis" - i.e. 30 per cent of the weight of the wood when dry is present as additional moisture). The net calorific value of such fuelwood is approximately 14 MJ/kg (or 3,300 kcal/kg), though there will be variations round this for different species of wood.

3. Charcoal

284. Consumption survey findings should show data for charcoal in terms of the weight (kg) consumed. When assessing the primary energy requirement, in the form of fuelwood required to provide a given amount of charcoal, reference has to be made to wood density, the efficiency of converting wood to charcoal, and the moisture content of the wood at the time of its conversion. Because wood varies in density, but charcoal does not, the volume of wood needed to generate a given weight of charcoal varies considerably: two and a half cubic metres of dry white pine (density 433 kg/m^3) produce much the same weight of charcoal as one cubic metre of mangrove (rhizophora) (density 1,176 kg/m^3).

285. Some idea of the variations which may be experienced is shown in the following examples:

(a) To produce a given weight of charcoal requires three times more wood (in weight terms) if it has 100 per cent moisture content (dry basis) than if it has 10 per cent moisture content;

(b) For any given quantity of fuelwood, whatever its moisture content, the efficiency of conversion may be three times greater in some retorts than in crude earth kilns.

286. In the absence of factors based on observed practice, an assumption has to be made on the rate at which wood is converted to charcoal. Between 4 and 10 m^3 of air-dried wood may in fact be utilized to obtain 1 ton of charcoal, depending on the type of kiln. An average figure of 6 m^3 of wood to produce 1 ton of charcoal is often adopted.

287. The calorific value of charcoal is approximately 30 MJ/kg. Thus 6 tons of wood of calorific value 14 MJ/kg and total energy content 84,000 MJ might convert to 1 ton of charcoal of energy content 30,000 MJ. The balance of 54,000 MJ is lost in the conversion process. This loss of energy at the conversion stage may be made up for by the greater efficiency with which the charcoal is finally consumed. In addition the handling, storage and transport of charcoal are easier and cheaper than for wood.

288. Charcoal may be produced from vegetal residues as well as from wood. Such charcoal tends to have a higher ash content, and as a result, a lower calorific value than that produced from fuelwood. A value of 25 MJ/kg is more likely to apply, though this will depend also on the efficiency of the conversion process (in particular, whether there has been a complete conversion to charcoal).

4. Vegetal residues

289. Many vegetal residues, when dried, form a convenient source of energy. They have a comparatively low energy content and so it is unlikely to be economic to transport them over long distances and market them in competition with commercial fuels. However they often offer a free, or very cheap, source of energy if they can be utilized locally for specific purposes. Examples are the consumption of bagasse (sugar-cane residue) at sugar refineries, palm-oil residues (fibres and husks) in the palm-oil industry, and the use of rice and wheat residues (husks and straw) by local farms and households.

290. The quantities of residues available usually exceed the amount required to meet the specific local energy needs which they are capable of serving. In some cases it has been possible to site additional energy-consuming activities, often the generation of electricity, where surplus residues are available, but the seasonality of the availability of residues may be a drawback in this respect. Thus both bagasse and palm-oil residues are both consumed for electricity generation at certain times of the year. The electricity is distributed to a wider area, and consumed as a more convenient energy form and for a wider range of purposes, than would have been economic or practicable for the residues themselves. In the absence of reliable measures for the quantities of residues consumed for the purposes of electricity generation, resort should be made to producing estimates based on the quantity of electricity generated and the likely efficiency of the generation process. The measurement of the amount of electricity generated must of course include both that consumed within the company generating it, and that disposed of to other customers.

5. Animal wastes

291. Animal wastes, usually in the form of dung cakes, are consumed to meet essential energy needs in many parts of the world where there is no ready supply of vegetal matter. They form a valuable product of the agricultural sector which may be used (after drying) as a fuel for cooking and heating purposes, though such use detracts from what might be their more profitable utilization as fertilizer. They may also form the input to biogas digestors.

292. As with the other forms of non-commercial energy already described, the measurement unit will be one of weight, preferably representing the moisture content usually present in the product at the time of combustion. Information on the incidence and quantities of consumption will be derived from surveys of the sort described in chapter X.

6. Biogas

293. Biogas consists mainly of methane derived from the natural decay of animal wastes. The original product, in solid or semi-liquid form, produces the gas which may be utilized for cooking, heating or lighting purposes. The residues from the process, particularly when certain types of biogas digestors are used, may be utilized as fertilizer.

294. Estimates of the biogas consumed have to refer to the gas production capabilities of the generators installed. This may be obtained in the process of conducting specialized energy consumption surveys, or from notional figures based on the designed gas output of particular types of digestor. Because the incidence of biogas generation is on the whole still quite low, and its representation in any survey designed to cover all non-commercial energy too low to provide reliable national estimates, it is possible that another survey designed specifically to cover the use of biogas may be required. Such a survey, where the sample is drawn from recorded biogas installations may well be primarily concerned with the uses to which digestors are being put, the ease and efficiency of their utilization (actual output is often found to be significantly below designed capacity), the amounts of alternative fuels being

saved and their potential for more widespread installation. At current stages of development these factors may be more relevant than the assessment of what they are contributing to national energy requirements.

7. Vegetal liquid fuels

295. Fuel alcohol for admixture with gasoline may be produced by distillation from sugar-cane syrups and other vegetal materials. Coconut oil may be treated for admixture with diesel oil. In both instances the objective is to "extend" fossil fuels. Although sugar-cane alcohol is clearly the product of a transformation process, its raw material is a potential food source rather than a primary energy source, and consequently cane-based alcohol for fuel use can be treated as itself a primary fuel. Similarly, coconut oil, although the result of an extraction process, can be regarded as a primary fuel since its alternative use is as a food.

XI. SUPPLEMENTARY DATA FOR USE IN ENERGY ANALYSES

A. General

296. The foregoing chapters of Part One of this Manual have been primarily concerned with the collection of regular statistics relating to the production, conversion and consumption of different fuels. Such data are designed to produce consistent time-series information which show changes in the supply and demand for these fuels. They also provide the basis for making comparisons and observing interrelationships between different fuels, and, when information is expressed in common units, provide the material for the regular monitoring of national energy patterns and the preparation of energy balances.

297. Subject to the availability of resources much of the information already described will be collected with greater than annual frequency, and will therefore be the means of quarter-to-quarter (or month-to-month) energy monitoring.

298. To obtain a more complete understanding of the developments in energy which are taking place, other background and related data will also be necessary. Before many policy decisions can be confidently taken, this further background information may need to be incorporated with data concerning other social and economic factors.

299. The type of additional information relevant to energy monitoring which any one country will need to collect will depend very much on local factors, e.g. the extent to which the country is a net energy producer, the availability of specific fuels - whether imported or locally produced, the degree of industrialization etc. The suggestions which follow may therefore not apply in their entirety to many countries, but it is hoped they will provide assistance in identifying particular national needs. They may on the other hand omit certain specific issues which have direct relevance to a small number of countries where energy matters are of an unusual nature.

300. In addition to supplying important background information for decision-making, these supplementary statistics are likely also to highlight where there are significant omissions in the data collected routinely, and where improvements in accuracy or coverage are to be desired.

B. Coal and other solid fuels

301. The potential for the future use of coal will depend on how much is available from within a country (its reserves of coal), the present and future infrastructure of the coal production and distribution industries, the different qualities of coal available, the geographical proximity of production (or importation) points to consumers, the size of the potential consumer market, and the prices that are likely to be charged. For coal planning, or for energy planning, information must be assembled on such characteristics.

302. The following statistics are likely to provide background material of the sort required in addressing such issues. The relative extents to which central Government, regional or local government, and the coal industry itself will be charged with utilizing the information obtained will, of course, reflect the division of responsibilities which apply. Overall national energy planning, by definition a central function, will require part, but not necessarily all, of the data outlined below.

(a) Coal availability

The estimated reserves (proved and possible) of coal under the ground, in total, and by geographical area; the depth below the surface (to indicate potential for deep-mining and surface-mining); the quality of reserves (impurities, ash content, calorific values); the thickness of seams. (In addition indications on the difficulties of coal extraction, including the disposal of any surrounding rock, will be needed to determine the overall likely costs of the coal eventually extracted and its economic viability.)

(b) Infrastructure of the coal production and distribution industries

The number and type of ownership of deep-mines and surface-mines; their geographical locations; the reserves each holds; the current sizes (production levels, numbers employed) of individual mines, their qualities of coal, and costs of coal extraction. (From such information it can be determined when any one mine may be found uneconomic, and where the most cost-beneficial development should be concentrated.)

The handling of coal after mining; quantities transported by road, rail or water; public and private sector involvement in distribution; methods of handling and distributing coal for export and local consumption

The number of import/export points by geographical location; their handling capacities; the delivery systems for imported/exported coal (road, rail, water); the loads and capacities of such distribution systems

The environmental effects of production (e.g. loss of tree cover, chemical impurities in the air and on the ground, future land reclamation requirements); costs of environmental amelioration

(c) Qualities of coal available

Outputs by geographical area under broad headings of quality appropriate to the country (e.g. coking coal, steam coal, domestic lignite etc.); the reserves and distribution systems by similar breakdowns. (Much of this information will be extracted from data collected under (a) and (b).)

(d) Geography of production and distribution

The geographical distribution of consumers, by size (quantities consumed) and quality of coal consumed; the potential distribution systems for reaching consumers (capacities of road, rail and water networks)

(e) Potential consumer markets

The numbers of establishments by type of industry, by size and geographical area, by coal or other specified fuel usage; numbers of households (and other specified potential users), by area and current fuel usage

Efficiencies with which coal is consumed in different sectors by different types of equipment (boilers, kilns, open fires etc.); efficiencies of new equipment; local environmental restraints on consumption

(f) Prices charged

The prices of different quantities of the types/qualities of coal available at pitheads, at intermediate distribution points, and those paid by final consumers; distribution costs (per kilometre) of road, rail and water transport systems

Import (c.i.f.) prices from different countries of origin for different types/qualities of coal; export (f.o.b.) prices for types/qualities of coal potentially available for export

(g) Coal products

The numbers and capacities of plants producing coke, briquettes and other coal products; their geographical locations; environmental effects of different coal conversion processes; other data equivalent to that obtained for coal at (d) to (f) above

C. Crude oil

303. Where a country is a producer of crude oil it is likely to play a significant, if not dominant, role in the national economy. Regular and relatively frequent data will almost certainly be required for general micro- and macroeconomic purposes as well as for energy monitoring. The same would apply if a country handled substantial quantities of crude oil imports for domestic refining and the subsequent export of much of the output of refined products.

304. Because background data will almost certainly be required regularly, some of it has already been covered in chapter VI, on the assumption that it will form an integral part of routine statistics. However, there may be some cases where it is considered inappropriate, or impossible, to integrate all crude oil statistics, perhaps because of the division in control over different upstream functions, in which case some additional coverage is likely to be needed in the following categories:

(a) Crude oil availability

The reserves (proved and possible) of crude oil, by field and type of ownership; the (chemical) quality of oils "under the ground"; the presence (or absence) and extent of associated gas; the depths of oil in different fields and other field characteristics; the numbers and production capacities of wells; the production of individual wells

The number of fields/wells under development or planned for development; their likely production levels and start-dates; the incidence of condensate availability from natural gas fields/wells (existing and planned for development)

The ownership, locations, and handling capacities of crude oil export/import handling facilities

(b) Infrastructure of crude oil production and handling industries

The ownership of different fields/wells; details of production contracts/agreements; characteristics, including capacities and usage, of pipelines and other ex-wellhead distribution facilities; equipment and facilities used onshore and offshore (e.g. fixed and floating platforms, flare towers etc.), including those for the handling of condensates

Origins and destinations of internationally traded crude oil; refinery destinations of crude oil from different fields or importation points

(c) Crude oil prices

Ex-wellhead prices; import and export prices; taxes levied on crudes of different origin

D. Petroleum products

305. The requirements for supplementary information relating to petroleum products largely mirror those required for coal and coal products. However, because of their generally greater contribution to energy needs, and because of the wide range of products and the greater number of disparate uses (including those for non-energy purposes), considerably more resources are likely to be warranted for assembling background information on petroleum products than on coal.

306. Of particular importance is the need to relate transport fuel demand to the changes taking place in the national vehicle fleet, generally speaking a major issue in national energy planning. Additional data should be concentrated in the following areas:

(a) Refinery data

The age and capacity of different refineries, by different type of refinery (e.g. with/without reforming and cracking or conversion capability) and location; similar details for plant due for closure and plant under development; ownership of different categories of refining capacity

Refinery output in greater (annual) detail than that obtained in routine statistics; refining costs; refinery efficiencies

(b) Infrastructure of petroleum product distribution industry

Number, lengths and capacities of pipelines for distribution of different products; quantities of individual products (or groups of product) distributed by pipeline, road, rail or water; ownership of distribution systems, including intermediate storage/distribution facilities; ownership, location and other characteristics of port handling facilities for international trade in different petroleum products

Bottling plant production and storage capacities; incidence and designed use of different bottle sizes; numbers and locations of bottling plants and intermediate storage facilities; bulk LPG storage and distribution facilities

(c) Actual and potential markets for different petroleum products

For each main petroleum product, the numbers of product-consuming equipment (including aircraft, lorries, pick-ups, cars etc.); numbers of establishments using different forms of energy-consuming equipment (boilers, furnaces etc.) for which alternative fuels might be substituted; sizes/capacities of equipment installed; efficiencies of usage of different fuels in different types of equipment (e.g. average kilometres per litre for different types of vehicle, energy consumed per unit of output for different forms of industrial equipment)

Numbers of establishments, including households, consuming LPG for defined purposes; numbers of vehicles, by type, converted to LPG usage; consumption of LPG per user

Numbers and capacities of plant (existing, under development and planned) calling for petroleum (energy) products for non-energy use; numbers and capacities of plant utilizing non-energy products (bitumen etc.)

Note. In many countries no accurate information is yet available relating to the numbers of vehicles, by type, actually in use on the road. Figures based on the numbers of vehicles ever registered, which tend to be used instead, make no allowances for those that have fallen into disuse or have been scrapped. As a result a misleading impression is often given of the speed of growth in vehicle ownership, and of the trends in energy consumption per vehicle. This in turn has led to unreliable forecasts and plans for future transport energy requirements. It is of considerable importance to energy planners that reliable statistics should be regularly available on the numbers of vehicles on the road. Strictly speaking, these are not "energy" statistics; and are more likely to fall to a transport ministry to collect. This should not prevent pressure from energy ministries being employed to bring about any urgent improvements in data necessary.

(d) Prices charged

Ex-refinery, intermediate and final consumer prices of different petroleum products; taxes levied on different products nationally and locally; international and internal distribution costs

Import/export prices for bulk LPG and for different bottle sizes; ex-bottling plant, intermediate and final consumer prices (for bulk LPG and for different bottle sizes); taxes levied

E. Natural gas

307. Where both natural gas and crude oil are produced, the information obtained for each must be mutually consistent, as must the information derived on the infrastructures of their respective production industries, including fields/wells, pipelines, storage, cleaning and separation plants etc.

308. Because the ability to market and consume gas in quantity requires considerable investment in pipelines and grid distribution facilities, planning attention is likely to be focused on the potential markets for further gas distribution. This may lead to more interest being shown in aggregate demand, and potential demand, within geographical areas than in sectoral demands.

309. Information over and above that obtained from the routine data collection described in chapter VII is likely to be concentrated under the following headings:

(a) Natural gas availability

The reserves (proved and possible) by gas field; the chemical characteristics of identified reserves (impurities present, overall energy content); the physical characteristics of different fields (established, under development or awaiting possible future development) in terms of depths, surrounding rocks etc.; the numbers, production, and capacities of individual wells; production capacity and start-dates for wells under development or planned for future development; incidence and quantities of gas flared or reinjected at gas wells

The reserves (proved and possible) of associated gas; chemical characteristics of reserves; incidence of natural gas production at oil wells (producing, under development and planned); their individual production and (gas) capacity; incidence and quantities of gas flared and reinjected at oil wells

(b) Infrastructure of natural gas production and handling industries

The ownership of fields/wells; production contracts/agreements; characteristics (including capacities and usage) of pipelines (including associated gas pipelines); equipment and facilities utilized onshore and offshore (fixed and floating platforms, cleaning plant etc.)

Ownership, capacity and usage of liquefaction plant; ownership, capacity and usage of separation plant; ownership, capacity and usage of transborder pipelines; incidence of pipeline pumping facilities

Ownership, capacity and usage of final distribution pipelines (grids); defined geographical coverages of different grids

(c) Existing and potential consumer market for natural gas

Numbers of consumers connected to different grids, by sector and/or tariff; numbers of potential consumers within areas covered by each grid, by sector (and/or tariff); numbers of potential customers in areas not covered by grids, by sector (and/or tariff); numbers consuming gas in different forms of equipment for defined purposes

Numbers and capacities of plants (existing, under development and planned) requiring gas for non-energy use

(d) Prices charged

Ex-wellhead, intermediate and final prices charged for natural gas; taxes levied; import/export prices (in liquid or gaseous form); international and internal distribution costs (including maintenance costs of pipelines, pumping stations etc.)

F. Derived gases

310. The information required (and that available) will reflect the structure of any derived gas industry which exists, and will vary much from country to country. In certain places derived gas will contribute only a small proportion of national energy requirements; in others it may take the form of a well-established and widespread industry contributing significantly to national requirements and able to compete with other fuels on equal terms.

311. Whatever the circumstances, the requirements for information will in principle be the same: to define the structure of the industry, the distribution system, and the actual and potential markets. To achieve this involves following the same approach as that outlined above for natural gas.

G. Electricity

312. The majority of electricity is supplied through the established grid network from a number of easily identifiable generating stations. As with natural gas the supply system has been installed permanently at high investment cost. Distribution grids, in more and less developed forms, have been in operation for many years, and almost certainly longer than any gas grid. The technology by which electricity is supplied through grids is almost identical the world over. This has led to considerable international conformity in the information collected and used regularly for the day-to-day management of electricity supply, and which is available as a result to central Government.

313. In most countries electricity supply is growing rapidly, as increases in production and wealth tend to make disproportionate demands for this convenient form of energy. In addition, the supply of electricity is often regarded as a social need, and programmes to extend supply to remoter rural areas, not necessarily at economic cost, have been adopted in many countries.

314. Meeting the demand for electricity in the longer term is achieved by increasing the supply capability through the introduction of new generating stations. When demand exceeds the supply immediately available, either the electricity has to be spread more thinly (i.e. through lowering the voltage) or, in more extreme circumstances, it has to be discontinued through cutting the supply to parts of the grid. Such power cuts may be due to breakdown or to water shortage in the case of hydroplant.

315. Not all potential consumers of electricity have access to a supply. It is debatable therefore whether actual electricity consumption realistically reflects the demand for it, or whether it should be taken purely as a measure of supply. Increases in the availability of supply, as new power stations come on stream, involve long lead-times, high investment and careful planning, the determination of which requires a considerable quantity of background information and detailed routine monitoring.

316. Unlike many large-scale investment decisions that involve a Yes or No decision (and if Yes, When?), a variety of possibilities exist for electricity supply investment. The form the investment might take could be in an increase in primary generated electricity, or in secondary generation from a choice of fuels and a choice of technologies; alternatively a gain in supply capability could be achieved by reducing the level of losses in transmission, perhaps by upgrading the grid: this too is likely to be capital-intensive and require significant lead-time.

317. The background information required before good investment decisions can be taken goes considerably beyond that described in chapter IX. It is likely to involve obtaining data on the characteristics listed below.

(a) Electricity availability (public supply)

Installed and operational capacity; capacity in the process of being installed with start-date(s); installed and operational capacity of individual stations, by age and type (hydro, coal-fired, oil-fired, diesel, natural gas fired, combined cycle, etc.); geographical locations of stations in relation to supply of fuels used in generation (or to hydro and other primary sources)

Plant load factors (average output, hourly or daily, expressed as a percentage of the operational capacity of each station); system load factors (average output of the system, hourly or daily, expressed as a percentage of the peak system demand); plant maximum load (the peak level of output achieved at each station); system maximum load (the peak output on each grid system achieved at one time); peak system demand (the system maximum load plus an allowance for any load shedding through voltage reduction or disconnection of supply); capacity of plant out of commission owing to breakdown or planned maintenance; frequency and duration of load shedding through lowering voltage; frequency and duration of power disconnections by area served

Electricity generated by each station; the quantity of specified fuel consumed at each secondary-generation station; the generating efficiency of each secondary-generation station (the calorific value of the electricity produced expressed as a percentage of the net calorific value of the fuels consumed)

(b) Electricity availability (self-generation)

Installed and operational capacity of each (major) plant; capacity being installed and planned; age of each plant and method of generation (hydro, coal, diesel etc.); geographical locations of major self-generating plant (in relation to availability of grid supply)

Electricity output by each plant; quantity of fuel consumed at each plant for the generation of electricity in secondary-generation plant; the efficiency of secondary-generation plant

Quantity of electricity supplied to public-supply grid from each plant; consumption of public supply electricity at each establishment with major self-generating capacity

Relationship between self-generation and public supply; pattern of generation (seasonality, time of day)

(c) Infrastructure of electricity transmission and distribution

Grid lengths (kilometres), by different voltages of transmission, for each independent grid; numbers of substations, by grid; details of inter-grid linkages (including those utilized for international trade)

Numbers of final consumers, by type (under sectoral, subsectoral or consistent tariff headings) and by grid; numbers of households connected to public supply as a percentage of all households in the area covered by each grid; number of domestic meter points (if different from number of connections), by grid

(d) Potential consumer market for public supply electricity

Numbers of households in areas with no public supply coverage; socio-economic characteristics of such households; number and sizes (turnover, output etc.) of industrial self-generating establishments

Equipment/appliance ownership and utilization, by sector

(e) Costs and prices charged

Ex-works price of electricity generation (i.e. cost per unit (kWh) generated) for each public supply station, and aggregated for different types of station; fuel costs per unit of generation, for each public supply station; maintenance, repair, and staff costs per unit of generation, for each public supply station; fuel costs of generation at self-generating plants

Import and export prices; prices charged to different types of consumer for different quantities of electricity (tariff structure), by grid or charging authority

Numbers of consuming establishments with access to free (or significantly discounted) supplies of electricity, by grid, charging authority or area

H. Biomass fuels

318. Information for biomass fuels equivalent to that derived for commercial fuels is unlikely to be obtained with any accuracy from fuel suppliers. The type of data to be collected, with suggestions on the methods to be used, has been described in chapter X. That chapter covers both the obtaining of estimates of consumption levels, and what, in other contexts, might be regarded as supplementary data (estimating numbers utilizing different fuels for different purposes, usage of different types of stoves and other appliances etc.).

Part Three

PRESENTATION OF ENERGY STATISTICS

XII. FUEL AND ENERGY STATISTICS FOR THE USER

A. General

319. The users of energy statistics will include both those who are primarily interested in seeing information relating to only one particular fuel, and those with wider overall energy interests. Within the first category of user are the ministries (or divisions of ministries) responsible for the planning, funding and monitoring of individual fuel developments. Traditionally such users have made reference to information concerning only the fuel they are responsible for; many may have regarded themselves as being more concerned about topics other than energy, such as general economic development, balance of payments matters, or social and regional issues. This is particularly prevalent where energy policy is handled by a ministry separate from those responsible for formulating and implementing policies in respect of individual fuels. Notwithstanding such problems there will always be a group of users whose interests in energy statistics are very much confined to one particular fuel.

320. The second category of user, with a main interest in overall energy issues, includes both those responsible for energy planning, and those whose functions cover a narrower range of subjects, but who will only decide and implement their policies after placing them in a wider energy context. Because of the importance of energy to the stability and development of national economies, particularly during the last 20 years or so, this second category of user has become more prominent within the central structure.

321. There are of course other important users of energy statistics, within and outside Government. Energy, or components of energy, are likely to be of major interest to ministries responsible for levying taxes, transport infrastructure development, and social and regional development, as well as to energy institutes and other miscellaneous academic institutions. A considerable amount of attention is likely to be given to longer term issues, partly because of the high costs and long lead-times of major energy investments which countries will be undertaking, and partly because of the vulnerability of economies to outside forces affecting the availability and prices of different fuels.

322. The users of both individual fuel and overall energy statistics will be concentrated in the country to which the information relates. However, from time to time these users will need to make comparisons with developments in other countries, and there will be some users whose interests go beyond national boundaries and extend to regional (or other country groupings) and global issues. Conformity in approach to the collection and presentation of statistics is therefore to be desired for both national planning and international monitoring.

323. Because of the wide variations in countries' energy resources, trade and consumption patterns, it would be counter-productive to attempt to prescribe a definitive list of statistics which all countries should be attempting to compile from data they have collected. In addition, the size of the country, in geographical or population terms, will have a considerable influence both on the ease with which data may be collected and the detail in which

statistics need to be presented. One cannot expect a country with an area of 1 million km^2 and a population in hundreds of millions, to require (or to be able to obtain) the same detail as, say, an island state of 100 km^2 and population of less than 1 million. It is not impossible however for all countries to seek and obtain information that is consistent in terms of definitions and conversion factors, and which follows the same general principles in collection and presentation.

324. One general point, which applies to the production of all tables wherever they are produced, is that presentation of figures consisting of more than a few digits makes them hard to read and understand, and gives a misleading impression of their accuracy. For most purposes four digits are enough to express most aggregated information (they imply an accuracy of 0.1 per cent, which is rarely achievable in practice), though this may have to be exceeded where a table consists of different components of widely differing size.

325. This smaller number of digits than one often finds in official (and other) statistics can easily be attained by using a higher-order multiplier of the basic unit. The lower-order multipliers or prefixes "kilo" (10^3) and "mega" (10^6) are familiar from electricity statistics. These prefixes form part of an ascending family that are most easily thought of as successively higher powers of 10^3 thus:

$(10^3)^1$	10^3	Kilo
$(10^3)^2$	10^6	Mega
$(10^3)^3$	10^9	Giga
$(10^3)^4$	10^{12}	Tera
$(10^3)^5$	10^{15}	Peta
$(10^3)^6$	10^{18}	Exa

These last two prefixes will almost certainly not be needed in the smaller countries. Using the appropriate prefixes, a quantity of 7,654,321 kilojoules can be tabulated as 7,654 megajoules. In many narrative commentaries, 7.65 or even 7.7 gigajoules will be quite sufficient.

B. Individual fuel statistics (commodity tables)

326. Chapters V to XI have described at some length the data to be collected for different fuels, for local, regional or central management, monitoring and planning. The statistics that need to be centrally available will depend largely on the degree of authority and control exercised by central ministries. It has been assumed, for example, in chapter IX on "Electricity", that central Government will have far less authority and control over self-generation that it has over public supply, and that as a result information on self-generation cannot be expected to contain the same amount of detail.

327. The extent of central intervention in the management and control of individual fuel companies will also affect the frequency with which data should be collected. For example data from a fully or largely centrally controlled oil production company might be required daily, though for overall monitoring and planning (for both oil specifically and for energy in general) monthly, quarterly or even annual collection might be sufficient.

328. Whatever actual circumstances exist in a country, the general principle will apply that some energy data need to be collected and presented more frequently than others. The guidelines set out in the following paragraphs use the terms "more frequent", "annual", and "less frequent". These will need to be interpreted as the time periods which balance the need for information with the resources available for their collection and compilation, and the importance of the policy decisions (to which they contribute) actually made. The term "more frequent", i.e. more frequent than annual, may in some cases be quarterly, in others monthly, and in exceptional circumstances weekly. Countries showing a high degree of seasonality in their energy requirements are likely to place particular importance on obtaining data series with sufficient frequency to highlight the seasonal patterns.

329. "Less frequent" statistics, i.e. those collected and presented less frequently than every year, may be in this category because of their relatively low importance, the unlikelihood of their changing significantly from year to year, or because of the prohibitively high cost of seeking to obtain them with annual frequency.

C. "More frequent" commodity tables

330. The following tabulations are the most likely candidates for presentation more frequently than annually, for short-term monitoring, and for the fine-tuning of energy planning.

(a) Coal and coal products

Production from main mines (i.e. those from which data may be collected regularly), broken down where relevant by area, type of mine (e.g. deep-mines/surface-mines) and broad quality of coal (e.g. steam coal/lignite)

Imports/exports of coal (and coal products), broken down where relevant by quality of coal (e.g. steam coal/lignite)

Stocks of coal at main stocking points (e.g. pitheads, power stations etc.)

Deliveries of coal and coal products to power stations, main industrial users and other customers

Original units in which data collected: tons

Units in which statistics presented: tons and/or standardized tons (allowing for different calorific values for different qualities of coal)

(b) Crude oil

Production of crude oil, broken down where relevant by oilfield, on-shore/off-shore etc.

Production of condensate

Imports/exports of crude oil and condensate

Stocks of crude oil and condensate at main stocking points (ports, refineries etc.)

Disposals of crude oil and condensate to refineries

Original units in which data collected: barrels or tons

Units in which statistics presented: tons (taking account of specific gravities of barrel quantities from different origins)

(c) Petroleum products and LPG

Quantity of crude oil refined

Refinery production of:

Gases and fuel consumed at refineries

Liquified petroleum gas (propane and butane)

Other gases

Motor gasoline

Aviation gasoline

Jet fuel

Kerosene

Naphtha/middle distillate feedstock (MDF)

Gas-diesel oil (broken down by subcategory if relevant)

Residual fuel oil

White spirits

Lubricating oils

Bitumen

Petroleum waxes

Petroleum coke

Imports/exports of petroleum products broken down by:

- Butane and propane (LPG)
- Naphtha/MDF (Middle distillate fuel)
- Motor gasoline
- Aviation gasoline
- Jet fuel
- Kerosene
- Gas-diesel oil, broken down by subcategory if relevant
- Residual fuel oil

Disposals of petroleum products to power stations, broken down by gas-diesel oil, residual fuel oil, other products

Disposals of petroleum products to other energy consumers, broken down by same categories as for imports/exports but excluding bitumen and other non-energy products

Disposals of petroleum products to petrochemical plants as feedstock or for other non-energy uses broken down by:

- LPG
- Naphtha
- Other specified energy products, if applicable
- White spirits
- Lubricating oils
- Bitumen
- Petroleum waxes and coke

Original units in which data collected: kilolitres/tons

Units in which statistics presented: tons

(d) Natural and derived gases

Production of natural gas (after deduction of any non-energy gases produced at the same time), broken down by associated/non-associated, and where relevant by field, onshore/offshore etc.

Imports/exports of natural gas broken down by liquid/gaseous

Production of derived gases

Disposals of natural and derived gases to power stations

Disposals of natural and derived gases to other energy consumers

Disposals of natural and derived gases as feedstock to non-energy consumers

Original units in which data collected: cubic feet or cubic metres and joules multiplied by the appropriate prefix

Units in which statistics presented: cubic metres

(e) Electricity (public supply)

Electricity generated at public supply stations, broken down by hydro, other primary, coal-fired, fuel oil-fired, diesel, natural gas, other

Imports/exports of electricity

Measures of electricity supplied and available - (see chap. IX, sect. C)

Fuels consumed at secondary generation plant, broken down by coal, fuel oil, diesel, natural gas, other

Final consumption of electricity (sales) broken down by main categories of user (or by tariff)

Note. In countries where self-generation is of particular importance, and data are collected with the same frequency as those for public supply generation, statistics regarding this self-generation should also be presented. In other cases self-generation statistics should only be incorporated annually (see sect. D (e) below).

Original units in which data collected: megawatt hours/gigawatt hours (MWh/GWh)

Units in which statistics presented: gigawatt hours (GWh)

(f) Biomass fuels

Data are not likely to be economically assembled more frequently than annually

D. Annual commodity tables

331. Annual tables should, first of all, cover all the information described under the "more frequent" categories listed above. There may well be omissions in "more frequent" information, either because they have been considered of too low relative importance to warrant collection more

frequently than annually, or because they have proved impossible to obtain economically and with the resources available.

332. In addition to rectifying these omissions it is also necessary to take account of the likelihood that some annual returns of data will not agree with the annual summation of more frequent returns purporting to give the same results. This may be due to errors and omissions in more frequent returns or to slight differences in definitions or coverage. Solutions to any such discrepancies, incorporating the facility to revise more frequent information already published, will need to be identified and implemented.

333. Statistics excluded from section C which are likely to warrant annual presentation will include the following categories:

(a) <u>Coal and coal products</u>

The number of mines in production, broken down by "main mines" and others, by quality of coal mined, and by area

Production from all mines (including any omitted in more frequent data), broken down by main mines and others, by type of mine (e.g. deep-mines/surface-mines), by quality of coal produced and by area

Imports/exports of different qualities of coal, by countries of origin/destination

Stocks of coal, broken down by main stocking points (pitheads, ports, power stations, coke ovens etc.)

Quantity of coal converted to secondary coal products (briquettes, cokes etc.), broken down by product

Consumption of different qualities of coal and coal products (separately), broken down by category of user (power stations, specified industries, other industries, transport, domestic, other)

Coal and coal product prices at point of production; import/export prices; final prices to different categories of industrial consumer; final household prices

Commodity balances for different qualities of coal and for specified coal products, grouping together data from other tables to show:

<u>Production</u>

\+ Imports

\- Exports

+/- Stock change

= Availability

Consumption, broken down by

Power stations

Other conversion

Specified industries

Other industries

Non-energy use

Households

Other consumers

Note. Differences between calculated "availability" and "consumption" may arise for identifiable reasons (e.g. from the way any conversions to standard coal are actually calculated. Differences arising for unexplainable reasons should be expressed in the table as "Statistical differences").

Units: as at section C (a)

(b) Crude oil

Production of crude oil from each oil field

Production of condensate from each (gas) field (or group of fields) producing condensate

Imports/exports of crude oil and condensate by countries of origin/destination

Stocks of crude oil and condensate, broken down by main stocking points (ports, refineries etc.)

Average prices for imports, by country of origin, and exports

Units: as at section C (b)

(c) Petroleum products and LPG

Summary information regarding individual refineries, e.g. age, throughput, capacity with/without reforming and cracking/conversion etc.

Annual "refinery balance" showing crude oil input, detailed product output (as at sect. C (c) above), backflows including backflows from petrochemical industry (output put back for re-refining), refinery losses, refinery efficiencies

Imports/exports of petroleum products (as shown at sect. C (c) above), by countries of origin/destination

Stocks of grouped or selected petroleum products, broken down by main stocking points (ports, refineries, power stations etc.)

Disposals of petroleum products, by product, for energy and non-energy use (as at sect. C (c), but with any gaps in data filled); disposals of each petroleum product for final consumption by sector (industry, transport, household, other); for transport fuel products a further breakdown by motor, rail, air and sea transport, distinguishing separately disposals for international aviation and marine bunkers

Petroleum product prices, broken down by product, showing ex-refinery, intermediate and final consumer prices (with and without taxes)

Commodity balance table for crude oil and petroleum products grouping together data from other tables to show:

<u>Crude oil production</u>

+ Condensate production

+ Imports of crude

- Exports of crude

+/- Stock change

= Availability of crude oil

<u>Crude oil input to refineries</u>

= Petroleum products output

+ Refinery losses

Refinery output

+ Imports of products

- Exports of products

- Refinery consumption (own-use)

+/- Stock changes

+ Transfers in (LPG from natural gas etc.)

- Transfers out (gases into natural gas flows etc.)

= Availability for consumption

Deliveries for consumption, broken down by:

Power stations

Specified industries

Other industries

Transport

Households/Other

Note. The second half of this listing, from "Refinery output" onwards, will be repeated for each major petroleum product or groups of products.

Note. Where differences exist between measures of availability and deliveries, possibly collected from different sources, or relating to slightly different time periods, explanations for the discrepancies should be sought and mentioned in notes accompanying the tables. Unexplainable differences should be attributed in the tables to "Statistical differences".

Units: as at section C (c)

(d) Natural and derived gases

Production of natural gas from each gas field

Production of natural gas from each gas-producing oil field

Natural gas flared, by field

Natural gas reinjected, by field

Imports/exports of gas, broken down by liquid/gaseous, and countries of origin/destination

Volume of gas input to and output from liquefaction plants

Gas stocks at main storage points

Production of derived gases by type of gas

Disposals of gas to power stations, other energy users, and non-energy users (as at sect. C (d) above but with any gaps in data filled)

Disposals of gas for final consumption, by sector (specified industries, other industries, transport, households, other etc.)

Prices of gas at point of production, intermediate and final consumer prices, broken down by sector or tariff (with and without taxes)

Note.

(i) In the above tables "natural gas" or "gas" should refer to gas after the removal of impurities: if for any reason it does not, accompanying explanations should be included in the text.

(ii) Where reference is made to "gas" in the above suggested tables, this term applies equally to both natural and derived gases.

Commodity balance tables for each gas (natural and derived), grouping together data from other tables to show:

Production (after elimination of unwanted gases, including LPG)

+ Imports

\- Exports (or "destined for export", if LNG)

+/- Stock change

= Availability of gas

Disposals for consumption, of which

Power stations

Other energy users (by sector)

Non-energy users

Note. Unexplainable differences between availability and disposals may be partly attributable to losses in distribution, and partly to "statistical differences".

Units: as at section C (d)

(e) Electricity

334. It has been suggested at section C (e) above that "more frequent" statistics should be restricted to those relating to the public supply industry. As a result the annual collection procedures include a variety of data concerning self-generated electricity, both for presentation independently and for integration with public supply information.

Self-generated electricity

Electricity generated, broken down by hydro, other primary, coal-fired, fuel oil-fired, diesel, natural gas, other

Quantities of fuel consumed at self-generation plant, broken down by coal, fuel oil, diesel, natural gas, other

Electricity supplied to, and obtained from, public supply systems

Own use of own generation

Electricity consumed by self-generating industries, by industry grouping (e.g. iron and steel, food processing etc.)

Number of self-generating establishmants, broken down by size (generating capacity) and industry grouping

Public supply and total electricity

Installed and operational capacity of public supply system and of self-generators, showing individual stations' capacity, age, method of generation (primary/fuel used)

Location, and annual output; quantities of fuel consumed; generating efficiency

Public supply system electricity: individual plant load factors; system load factors; plant maximum loads; system maximum instantaneous loads; peak system demands

Imports/exports of electricity

Aggregated generation of electricity, broken down by public supply system (by type of generation) and self-generation (by type of generation); aggregate fuel consumptions; aggregate efficiencies

Using either the measured efficiencies of generation at conventional secondary plant, or a notional efficiency of, say, 30 per cent, the quantity of conventional fuel that would have been required to generate the same quantity of electricity as was generated from primary sources

Public supply electricity generated, station use, electricity supplied, electricity available, final electricity consumption, losses in transmission and distribution (see chap. IX, sects. C and D above)

Final consumption of electricity (public supply and self-generated), broken down by tariff and by sector (e.g. industry by main type, transport by type, household, public administration (including street lighting); commercial sector; other)

Numbers of connections to public supply system, by tariff and by sector; number of connections to free or ex-tariff supply; numbers of establishments benefiting from supply at discounted price or free supply

Total number of household connections; percentage of households connected, broken down by area

Characteristics of each grid system; line lengths, by voltages of transmission, numbers of connections, percentages of households connected: characteristics of areas not covered by grids (numbers of households, industrial establishments etc.)

Cost per kWh of electricity generated, by type of plant (public supply system)

Prices charged (per kWh), broken down by sector, tariff and area

Commodity balance table for electricity showing:

Public supply generation

\+ Imports

\- Exports

\+ Self-generation

\- Consumption within public supply system

= <u>Total electricity supplied</u>

\- <u>Self-generators' consumption</u>

(= self-generation

\+ self-generators' purchases from public supply

\- public supply purchases from self-generators)

= Total electricity available

\- Losses in transmission and distribution

= <u>Public supply consumption</u>

\- Electricity provided free to consumers

= Sales of public supply electricity, of which:

Specified industries

Other industry

Transport

Households

Public administration

Commerce

Other

Units: as at section C (e)

(f) Biomass fuels

335. The approach to adopt, as explained in chapter X, for obtaining regular estimates of biomass energy consumption involves two processes. First, to obtain estimates of "per user" consumption for different categories of consumer: this is likely to be available only at infrequent intervals. Secondly, to obtain more frequent (but not more frequently than annual) estimates of the numbers of consumers falling into each category. Such categories may be relatively crude, such as "households" or "industrial establishments"; or they may be more specific, e.g. households of different sizes and different income levels, industries by type and size (based on output, turnover or employment levels).

336. Per capita consumption data collected infrequently, whether in greater or lesser detail, will only be capable of being updated if there is more frequent collection of the information to be used for the purpose of updating - in this case information on the numbers of users. It is unlikely that good information will become available each year to enable annual updating, but when two or more consistent measures of incidences of usage have been established it may be possible to extrapolate figures for more recent years.

337. For example if in year 1 it were found that there were 800,000 people in households using fuelwood and 200,000 in households using charcoal; and in year 6 these had changed to 600,000 and 280,000 respectively, it might reasonably be assumed that fuelwood users were declining at about 5Å per cent per annum, and charcoal consumers increasing at about 7 per cent per annum, and that such changes would continue during the next, say, 5 years. If the reference (consumption survey) information shows that fuelwood users consume on average 600 kg of fuelwood (8,400 MJ) per capita per annum, and charcoal users 200 kg of charcoal (6,000 MJ), one would be able to extrapolate the figures for years 7 and 8, as in the following table (in terajoules (= million megajoules)):

	Year 1	Year 6	Year 7	Year 8
Fuelwood consumption	6 720	5 040	4 760	4 500
Charcoal consumption	1 200	1 680	1 800	1 925
Total consumption	7 920	6 720	6 560	6 425

338. Calculations such as this, with accompanying explanations of the procedures adopted, might be used to provide information of the following sort:

Household consumption of biomass fuels, broken down by type of fuel (fuelwood, charcoal, dung cakes etc.) and geographical area

Industrial consumption of biomass fuels, by type of fuel, industry type, and area

(Note. Because industrial use is likely to be concentrated in a few specialist industries, formal industrial classification systems may be less informative than those designed specifically to represent the prevalence of biomass energy use in the country.)

For charcoal consumption: the quantities of primary fuel (fuelwood) estimated to have been required to provide the quantities of secondary fuel (charcoal) consumed

339. Because of the much lower efficiencies of appliances consuming biomass energy, and because of the underlying inclination to switch from traditional to commercial fuels when economic circumstances (and fuel availability) permit, a further measure concerning traditional energy consumption should also be presented. This covers the (approximate) quantity of commercial fuel(s) which would be required to replace existing biomass energy consumption. For the above example the following tabulation might apply:

	Efficiency	(terajoules)			
	Of use (%)	Year 1	Year 6	Year 7	Year 8
Fuelwood	10	6 720	5 040	4 760	4 500
Kerosene equivalent*	50	1 344	1 008	952	900
Charcoal	25	1 200	1 680	1 800	1 925
Kerosene equivalent*	50	600	840	900	963
Fuelwood and charcoal	n.a.	7 920	6 720	6 560	6 425
Kerosene equivalent*	50	1 944	1 848	1 852	1 863
Kerosene requirement (tons)		45 000	42 800	42 900	43 100

* Kerosene net calorific value = 43.2 MJ/kg.

E. "Less frequent" commodity information

340. Statistics which need to be presented, but which are unlikely to warrant, or are unlikely to be available for, collection annually, may be put into three categories.

(a) Descriptive background statistics relating to national energy resources;

(b) Statistics, which though desirable annually, cannot for practical or economic reasons be collected with that frequency;

(c) Information relating to individual fuels obtained from infrequent and ad hoc surveys.

341. It is impossible to provide firm guidelines on what should be included in each of these categories. This will be determined by what is considered the most relevant information to have, the resources required to obtain such information, and the gaps in annual or more frequent information requiring to be filled. Examples may be given, however, by way of illustration.

Background descriptive statistics

342. This category might include the reserves (proven, probable and possible) of coal (by grade and area); crude oil and natural gas (each by chemical characteristics and area); energy production plant under development (both primary and secondary); other basic characteristics of the infrastructure of fuel production, conversion and consumption. Chapter XI lists topics which might fall naturally under this category. Detailed definitions of the concepts "proven", "probable" and "possible" are given in Energy Statistics: Definitions, Units of Measure and Conversion Factors. 2/

Statistics that might otherwise be collected annually

343. Sections C and D above have considered the statistics that it would be desirable to collect more frequently than annually and those that might be collected annually. Owing to lack of resources, or to the low priority given in a particular country to particular fuels, there is a likelihood that some of the data it is considered desirable to collect and present will not in fact be available. Where this happens periodic measurements of the missing data are likely to be needed in order that greater comprehensiveness may be achieved. In the years in which no measurements are actually taken, information derived at the time of last measurement may be re-presented in some form, or it may be extrapolated in the light of other developments and other assumed changes.

Information derived from periodic and ad hoc surveys

344. Energy surveys, whether comprehensive or confined to a number of sectors or subsectors, are likely to provide information relating to individual fuels (and to energy in total) which may well not be available from any alternative source. In particular they may show, better than the analysis of fuel supply companies' records, the sectoral and subsectoral pattern of consumption of particular fuels, and the purposes for which those fuels are being consumed.

345. Information derived from these surveys will be presented initially in reports of those surveys; however it should not be overlooked that such information may also be incorporated in the presentation of annual statistics. For example, they may provide appropriate sectoral or subsectoral apportionment measures which may be applied to overall consumption figures supplied by fuel companies. Particular care has to be adopted when survey information appears inconsistent with that obtained from supply companies.

346. In addition to supplying analyses of consumption, surveys may also throw further light on the stock of energy consuming equipment, e.g. the numbers of boilers, kilns, vehicles, household appliances etc. Such information might also usefully be appended to annual publications to provide further background information for the user of the statistics.

F. Energy and inter-fuel comparison tables

347. For simplicity, information concerning energy and inter-fuel comparisons is here considered as part of the annual compilation exercise. Summary energy data, and basic inter-fuel comparisons, will almost certainly be required to accompany fuel statistics in more frequent, but less comprehensive, publications.

348. It is not unusual to find that some information on one fuel, e.g. electricity, is available monthly (and possibly published by the industry concerned); for another fuel the information may be available quarterly, and others only annually. While it may be possible to overcome this problem by restricting more frequent assemblies of information to a limited range of fuels, information on total energy and on meaningful inter-fuel comparisons will only be available with the lowest frequency for which individual fuel information is available.

349. Because of the likelihood of there being less reliability in information on traditional (primarily biomass) fuels, energy information is sometimes compiled in respect of commercial fuels only. This is unfortunate, and often misleading, particularly when assessments of total energy requirements, and international comparisons of these, are involved.

350. The most important compilation of summary information on energy in total is the energy balance, which also provides the basis for making overall inter-fuel comparisons. This warrants detailed consideration in its own right: energy balances are therefore considered separately in chapter XIV. Other tables, derived from, or contributing to, the energy balance, also need to be compiled. The main aim of such tables is to highlight components of the energy balance (which relates to one year only) in time-series format. This is likely to involve the following assemblies of information:

> The contribution of each fuel (coal, oil/petroleum, natural gas, primary electricity, non-commercial fuels) to total energy requirements, expressed in common energy units such as terajoules, and their percentage shares
>
> The components of total energy requirements (production, imports, exports, marine/aviation bunkers, stock changes), by fuel (as above), in common energy units
>
> Imports expressed as a percentage of total energy requirements (the import dependency for energy)
>
> Final energy consumption by fuel (as above), in common energy units, and as a percentage of total energy requirements

(Note. Final consumption of electricity, derived from all forms of generation, will probably considerably exceed the electricity component of primary energy requirements, which is concerned only with that obtained from hydro, nuclear, etc.; it may therefore be preferable to omit this percentage for electricity.)

Conversion industries' consumption of different fuels, expressed in common energy units, and percentage share accounted for by each fuel

Industrial final consumption of different fuels, in common energy units and percentage shares

Transport final consumption of different fuels, in common energy units and percentage shares

Household final consumption of different fuels, in common energy units and percentage shares

Other final consumption of different fuels, in common units and percentage shares

G. Energy and the national economy

Total primary energy requirements as a proportion of GDP at constant prices (e.g. megajoules per United States dollar)

Energy imports expressed as percentage of all imports, and as a percentage of GDP (in value terms)

H. Presentation of seasonally adjusted data

351. Many of the time series described in section C will, in some countries, show significant seasonality. Tables showing seasonally corrected information may therefore be of considerable relevance, particularly those relating to fuel and energy requirements and to final consumption.

I. Presentation of temperature corrected data

352. In some countries seasonal correction caters inadequately for abnormally cold (or mild) weather conditions which occur within the normal overall seasonal pattern. Without allowance for these extreme conditions, which can have a marked effect particularly on space-heating requirements, and a lesser effect on other requirements (water-heating, industrial output, transport etc.), a misleading impression of month-to-month, or even year-to-year, trends may be given.

353. Two basic methodologies are designed to correct for such abnormalities. The first method involves measuring how much the actual average daily temperature recorded departs from a "standard" (often 15 or 16 degrees Celsius) at which it is considered that there is no demand for space-heating or space-cooling, and that other energy demands are "normal". This method, "degree-day adjustment", provides for fuel requirements or consumption to be adjusted, either in linear fashion ("x" per cent additional fuel is consumed for each degree different from the standard), or it can incorporate different adjustments for different recorded temperatures (e.g. "x" per cent per degree for temperatures between 16 degrees and zero, "y" per cent per degree for tempteratures below zero). This method is designed to correct for both

abnormal temperatures and for general seasonality at the same time. The method adopted is to obtain a measure for "degree-days" by accumulating daily departures from the standard over the period to which the statistics relate (say, one month or one quarter), and obtaining the appropriate adjustment factors from look-up tables. These adjustment factors are likely to vary considerably for different fuels, depending on how much the consumption of each is judged to be sensitive to weather conditions.

354. The second method is designed to correct for abnormal weather conditions, but to retain overall seasonality in the data. Instead of referring actual daily recorded temperatures to a standard measure, they are referred to the long-term average temperature for each day. Again different adjustment factors may be utilized for different prevailing temperatures, or for different levels of departure from the average for different fuels.

355. Both methods require agreement on how best to measure actual temperatures (How many recording points are needed to be representative? Should "actual" be the average of the maximum and minimum temperatures recorded? etc.); both assume that it is temperature rather than wind or lack of sunshine that influence energy requirements; and both require daily measures to produce meaningful series. Because of differences in temperature within a country on any particular day, separate adjustments should be made for different areas of the country. Degree-day adjustment is easier to apply, but is conceptually less sound.

356. Sophisticated adjustments to daily energy figures require sophisticated (computerized) temperature recording and adjustment procedures. They are unlikely to have a place in the adjustment of energy flows which do not lend themselves to daily measurement: in practice metered gas and electricity are the only fuels where the adjustments may be effectively applied.

357. In the absence of temperature corrected statistics countries whose energy consumption is sensitive to prevailing weather conditions will need to form an opinion on the extent to which changes in some of their energy time series may have been brought about by abnormal weather conditions. In the short term, quarter-to-quarter and year-to-year weather conditions may easily account for changes of similar order of magnitude to those brought about by general economic growth.

XIII. ENERGY BALANCES

A. General

358. The preparation of energy balances, the history of their development, and their role in energy planning are treated at greater length in another United Nations publication, Concepts and Methods in Energy Statistics, with Special Reference to Energy Accounts and Balances. 1/ Their description here, based on the method of compilation and presentation currently adopted by the United Nations, is primarily concerned with the translation of energy commodity accounts (which have been compiled according to the guidelines described in earlier chapters) into energy balance format.

359. The main purpose of compiling energy balances is to show in one table the overall picture of energy production, conversion and consumption for each fuel utilized in the country. Without such an overall comprehensive picture the consequences of policy and investment decisions are unlikely to be as well understood, and the effects of past decisions on total energy provision will not be monitored as effectively.

360. For countries where a substantial proportion of energy requirements are met by consumption of traditional fuels (mainly biomass), that is for most developing countries and some developed ones, it is essential that the balance includes as much relevant data as possible on these fuels. Indeed, the compilation of balances which exclude biomass fuels can be highly misleading because of their incomplete coverage, both for providing a picture of national energy characteristics and for planning future developments. International comparisons of such incomplete balances may serve to provide some information on relative demands for particular commercial fuels, such as petroleum products used for transport, but these might equally well be obtained from tables restricted to these fuels: they have no place in providing meaningful overall comparisons.

361. The compilation of energy balances also serves as a useful way of checking that all major energy flows are being properly accounted for (neither being omitted nor double-counted). This may also be achieved for individual fuels by the preparation of commodity balance tables, such as those described for individual fuels in chapter XII. However energy balances show on one page that the production, conversion and consumption information compiled for each fuel (in different columns of the table) are mutually consistent; and that all transformation between fuels (e.g. crude oil to petroleum products, primary fuels to electricity generated from them) has been correctly handled.

B. Conversion of individual fuel data to common energy units

362. It is only by converting figures for different fuels, compiled in the units normally associated with those fuels, into common energy units that overall energy statements and comparisons between fuels may be obtained. The common energy unit recommended by the United Nations for general application is the joule, ususally expressed in terms of multiples of 1,000 (as described in chap. XII). This is the only basic energy unit of measurement recommended in the International System of Units, usually referred to by the first two initials of its French title (SI).

363. For a variety of reasons, some of them historical, other common units are sometimes used, such as the kilocalorie (and higher multiples thereof), the metric ton of coal equivalent (TCE), the metric ton of oil equivalent (TOE), the barrel of oil equivalent (BOE) and the barrel per day of oil equivalent (BDOE). These commodity-based units can be regarded as "presentation units" that are more easily visualized by some people than the more rigourous energy-based units, whether the calorie or the joule - of which, as already mentioned, only the joule is recommended by the Statistical Office of the United Nations Secretariat. (The joule and the more familiar watt are directly related to each other: one watt is equal to one joule per second so that 1 watt-hour equals 3,600 joules and therefore, 1 kilowatt-hour equals 3.6 megajoules.)

364. When compiling commodity (and other) tables relating to coal, it has already been suggested that adjustments should be made to allow for the different calorific values of different grades of coal. Rather than add a ton of steam coal, calorific value, say, 7,000 kcal/kg, to a ton of lignite, calorific value 3,500 kcal/kg, to give two tons of coal, it is more meaningful (in this example) to say that the total is 1Å tons of "standard" coal (calorific value 7,000 kcal/kg).

365. The same problems exist, but to a lesser extent, with other fuels: crude oil occurs with a wide variety of chemical constituents, specific gravities and calorific contents. One barrel of crude oil may weigh between 125 and 155 kg depending on its origin, but because lighter crudes have higher energy contents per unit of volume than heavier ones, there is far less variation when their calorific values are expressed in weight terms. The barrel may be the most desired measure for oil engineers, but the ton is more appropriate for those concerned with the energy to be derived from oil. A table showing net calorific values (NCVs), per ton, for crude oil and petroleum products, based on the average values which apply world-wide, is given in annex II. Any country may wish to modify these if other (NCV) figures are available which apply specifically to that country. The importance of using NCVs is further covered in section C below.

366. Because of the wide variations in the specific gravities of different petroleum products (e.g. propane 0.51, residual fuel oil 0.95), calorific values expressed in terms of volume range from 23.3 MJ/m^3 for propane to 39.4 MJ/m^3 for residual fuel oil. In terms of weight, the calorific values are not very great: they range from 45.59 MJ/kg for propane, and 43.97 MJ/kg for refined gasolines to 41.51 MJ/kg for residual fuel oils. Some countries disregard these differences in their presentation of petroleum product commodity tables, adding tons of one product to tons of another. They should however make allowances for the differences when converting figures to the units in which balances are compiled.

367. For natural gas the energy of what comes out of the ground will depend on the quantity of non-energy gases contained in the flow (which will reduce the calorific value) and the extent of other energy products (which may raise it). Natural gas, as finally consumed, consists mainly of methane, but may also contain quantities of ethane. The energy contents of these two gases are different, and as their proportions within "natural gas" may vary over time and between fields, there will be small variations in the actual calorific values of different natural gases supplied. For consistency the United

Nations recommends that, in the absence of more appropriate country-specific factors, the NCV of natural gas should be taken as 39.0 megajoules per cubic metre, broken down as follows:

	MJ/m^3
Natural gas (average) composed of:	39.0
Methane (79% by volume)	33.5
Ethane (21% by volume)	59.5

368. Variations thus exist, within a country and between countries, in the actual energy contents of the coal, crude oils, petroleum products and natural gases consumed, because each is in fact a mixture of different chemical products each with a different calorific value. Electricity on the other hand is an energy product in its own right and incapable of variation: its measurement, in multiples of watt-hours, is an energy measurement in itself and might equally well be expressed in multiples of joules, at a conversion rate of 3.6 MJ/kWh.

369. The conversion of figures relating to non-commercial fuels has already been covered in chapter XI. The wide variations which can in fact apply for these fuels is further shown in annex II.

C. Gross and net calorific values

370. The gross calorific value (GCV) of a fuel measures the total amount of heat that will be produced by combustion of that fuel. Part of this heat, however, will be utilized to evaporate any moisture present in the fuel initially or produced during the combustion process and will not normally be available for the purposes for which the fuel is being consumed. The net calorific value (NCV) is the amount of heat which is actually available from the combustion process for capture and end use, after the evaporation of moisture.

371. The difference between GCV and NCV is of the order of 2.5 per cent for anthracite, 3 to 7 per cent for sub-bituminous coals, 10 per cent for lignite, 7 to 9 per cent for liquid fuels and of the order of 10 per cent for natural and other gases. When expressing individual fuel data in terms of common energy units, NCVs should be used for conversion in preference to GCVs.

D. Useful energy

372. One significant omission in the recommended presentation of energy statistics, including those shown in energy balances, is that no indication is shown of the amount of energy which is in practice being utilized to good purpose at the consumption stage. "Useful energy" is the work (usually heat) harnessed for the purpose for which the fuel is consumed, e.g. the heat transmitted to the food-cooking process, the light obtained from an electric

tube or bulb, the work obtained in propelling a motor vehicle. During the process of consumption a significant amount of the energy generated in combustion goes to waste, usually in the form of waste heat.

373. The efficiency of equipment and appliances, i.e. the proportion (expressed as a percentage) of the energy generated in combustion which actually serves the purpose for which combustion takes place, varies considerably between different fuels and for different types of equipment. The degree of variation is illustrated in the following table which shows some approximate average efficiencies of appliances (in percentage):

Open fuelwood fire	10-15
Charcoal stove	20-30
Gas or LPG cooker	37
Kerosene burner	55
Electric cooker	75
Cement kilns	30-40
Blast furnaces	70-75
Coal-fired furnaces/boilers	60
Oil-fired furnaces/boilers	70
Gas-fired furnaces/boilers	70-75
Electric furnaces/boilers	90-95
Diesel engine	35
Jet engine	25
Electric rail haulage	90
Electric lighting (incandescent)	6
Electric lighting (fluorescent)	20

(Note. The above figures are indicative of the variations which apply for different types of appliances using different fuels. Within each type of appliance there will also be a further considerable range, depending on design, construction, size, age, quality of maintenance, mode of operation etc.)

374. When examining or planning the possibilities of future fuel substitution, or monitoring past changes which may have been highlighted in the energy balance, specific attention may have to be drawn to variations in the likely efficiencies with which different fuels are consumed. While there may be little or no difference between the efficiencies of furnaces and boilers fired by different fuels, the same cannot be said for cooking appliances or for different modes of transport. Reference has already been made in chapter XII, section D (f), to the need to account for differences in efficiencies when calculating the quantities of a commercial fuel which would be required to substitute for a non-commercial one.

375. It is not practicable to consider useful energy formally as a final measure of energy consumption within energy balances, though conceptually this would be desirable. Gathering the required detail on final consumption separately for each type of end-use equipment within each consuming establishment would be extremely costly. It should not prevent countries

producing, as occasions demand, illustrative examples of the likely quantities involved in order to assist in monitoring and planning activities.

E. Preparation of energy balance components

376. An example of the energy balance layout recommended by the United Nations for developing countries is shown in annex VIII. Other layouts which adopt similar accounting principles, but which present information in a slightly different format, have been adopted by certain countries and by other international organizations. A description of the different formats in which balances may be presented is given in the publication cited in paragraph 358.

377. In addition to slight differences in format, there are also differences in accounting units and conventions used in some balances. As mentioned above, some countries and organizations use tons of coal equivalent or tons of oil equivalent (tons of coal and oil being equivalent to approximately 29 GJ and 42.5 GJ respectively. (1 gigajoule (GJ) = 1,000 megajoules (MJ).) The use of such units is usually for historical reasons which reflect the importance of the chosen fuel to the country or organization concerned and the use of that accounting unit in policy analysis and planning.

Columns in the balance table

378. The United Nations format for energy balances (see annex VIII) expresses information in terms of terajoules (1,012 joules). The table consists of columns of data for individual, or groups of, fuels; and rows identifying the different categories of production, conversion and utilization. The fuels identified in the columns are:

- Hard coal, lignite and peat
- Briquettes and cokes
- Crude oil and natural gas liquids (condensates)
- Light petroleum products
- Heavy petroleum products
- Other petroleum products
- LPG and other petroleum gases
- Natural gas
- Derived gases
- Electricity
- Primary biomass energy
- Derived (secondary) biomass energy
- Other energy sources
- Total energy

379. This list represents a compromise between a highly aggregated balance, which might show information in six columns (solid fuels, oil and petroleum products, gases, electricity, biomass energy and total energy), and a detailed balance which might present information for different types of coal, individual petroleum products, electricity and a variety of gases and biomass fuels. This latter option could extend for up to 30 columns or more. Though it may be of importance to have such detail it is better that it be confined to commodity tables in order that the energy balance can be accommodated on a double-page spread and be easily read. Each country must judge for itself the level of detail appropriate to its own policy concerns.

380. The grouping of hard coal, lignite and peat in one column requires that original data relating each of these fuels are converted to energy units separately. This may be achieved either by (a) converting each to "standardized" coal units for the presentation of solid fuel information (see chap. V, sect. E (a)), followed by a single conversion to terajoules, or (b) presentation of coal information in original units (tons of bituminous coal, tons of lignite, etc.), and separate conversion to terajoules based on their respective calorific values.

381. Briquettes and cokes are products of conversion of solid fuels, usually with higher calorific values than the products from which they were obtained. They may be consumed for different purposes from those for which primary solid fuels are consumed.

382. The collection, compilation and presentation of statistics on crude oils and NGLs (condensates) have been addressed in chapter VI. Conceptually it is desirable to convert these products from their original units of tons into common energy units (terajoules) separately. In practice, because of the small contribution which NGLs are likely to make compared with that of crude oil, and because of the relatively minor differences in their calorific values (see annex II), it sometimes happens that all primary oil products are converted by one common factor.

383. The groupings of derived petroleum products, into "light", "heavy" and "other" enables a distinction to be made between (light) gasolines and kerosenes, which are mainly used in transport and the domestic sector, and (heavy) diesels and fuel oils used in transport and for a wide variety of industrial processes (including electricity generation). Other petroleum products consist mainly of non-energy products. A full description of the components of "light", "heavy" and "other" products is given in the introduction to Energy Balances and Electricity Profiles 1986. 4/

384. Under "LPG and other petroleum gases" will be included bottled gas (propane and butane) which may be used for a wide variety of industrial, transport and household purposes, as well as those gases derived in the process of oil refining, which may in fact have little or no use outside the plant in which they are produced.

385. The need to exclude other gases (both non-energy gases and LPG) from figures for natural gas has received coverage in chapter VI of this Manual. The aim should be for the description of natural gas in statistical form within the energy balance to be consistently in terms of one product, i.e. in terms of the natural gas finally consumed, whose calorific value falls within a sufficiently small range to make it possible to use a constant conversion factor. If this cannot be achieved, either because upstream data do not clearly distinguish "natural gas" within the overall gas flow, or because some natural gas finally consumed is of a significantly different chemical composition from that consumed elsewhere, particular attention will have to be given to ensuring that correct conversion factors are being separately applied to different rows in the balance table. For example, if the figures showing the production of natural gas in fact includes some production of LPG gases (a) the conversion factor used in the production line should be appropriately greater than that used in other parts of the column relating to natural gas; and (b) the separation of the LPG should be shown either as an "output of

other conversion industries", or as a "net transfer" from "natural gas" to "LPG and other petroleum gases"; and (c) LPG conversion factors will have to be applied to the amount of LPG involved. Apparent discrepancies between production and consumption figures in the figures for natural gas in national energy balances, and which are often treated as "statistical differences", may often be attributed to a failure to identify accurately the natural gas component in a flow containing a mixture of different gases.

386. There has recently been a change in the United Nations convention for presenting electricity in the energy balances relating to developing countries. Up to and including the Energy Balances and Electricity Profiles, 1984, 5/ additional columns appeared which showed in the row for primary production (a) the (notional) conventional fossil fuel required to generate the production of primary electricity (hydro, geothermal etc.) achieved, and (b) the electricity generated in a column headed "Physical energy input". This latter column was once envisaged as containing figures for the kinetic energy input to hydro generation, the captured-heat input to geothermal generation, and the released-heat input to nuclear generation. In practice, this column was used for recording the heat equivalent of the electricity output from primary generation. This has recently altered with effect from the 1986 volume of Energy Balances and Electricity Profiles, 1986 (published in 1988) 4/ with all electricity information now being restricted to one column. What used to appear in the column headed "Physical energy input" of primary electricity, now appears under the single "Electricity" column on the row "Production of primary energy". Reference to the amount of conventional fuel required to generate an equivalent amount of electricity now needs to appear in other national energy tables and in electricity commodity tables. The deletion of this column for electricity has enabled other columns to be included, including an additional one for secondary biomass fuels.

387. This additional column for derived (i.e. secondary) biomass fuels, which is considered of great importance to some developing countries, enables a distinction to be drawn between "Primary biomass" and "Derived biomass" energy. This brings the form of biomass presentation into line with that adopted for coal and coal products. It also provides a more meaningful picture for those countries whose final energy consumption includes a significant proportion of secondary products such as charcoal.

388. It should be noted that the construction of the figures for the biomass columns will essentially be a "bottom-up" exercise: the starting point is the information on final consumption, from which are derived estimates of (a) the primary fuel required to provide the amounts of secondary fuel actually consumed; and (b) total primary fuel production. This is in contrast to the approach adopted for commercial fuels where a "top-down" approach is more likely: for these fuels the information on production and conversion will be at least as accurate as any on final consumption, and may well be of sufficient accuracy to use as a check that estimated components of final consumption are realistic.

389. The column headed "Other energy sources" is primarily designed to cover the energy harnessed from steam and hot water which may have been obtained from, for example, (a) geothermal sources, (b) public supply thermal power plants designed to produce a combination of electrical energy and heat, and (c) other plants designed to produce heat in a usable form (e.g. by the

burning of municipal waste). The incidence of the use of "heat" as an energy product in its own right is still quite low. It is likely to increase as opportunities are identified to obtain this form of energy in circumstances which do not add to national primary energy requirements.

390. Because there is, as yet, no common widespread form of obtaining heat - either in its primary (geothermal) form, or as an otherwise wasted secondary product - there is little standardization in the way it is captured, generated or harnessed. Some of the processes involving capturing waste heat are only concerned with a small part of the available energy that would otherwise be wasted in its entirety. More work needs to be done on the commercial viability of different techniques for harnessing, transmitting and consuming heat, and more experience obtained on their application in different countries, before firm guidelines can be produced for the world-wide statistical treatment of this form of energy.

391. This is not to say that countries should ignore any heat which contributes to their overall supply of energy. For the time being, in the absence of generally agreed methods for inclusion in energy commodity tables and balances, they will need to ensure that it is given as appropriate coverage as possible in such tables. The information should be designed to reflect the methods by which it is derived and consumed and the energy contribution (in terajoules) which it is estimated to contribute. Of particular relevance in "heat" commodity tables is the saving in commercial fuels which is obtained from the use of heat.

Rows in the balance table

392. Rows 1 to 5 of the United Nations format for presenting energy balances show the components which, taken together (in row 6), comprise the total energy requirements of the country, for use, broadly speaking, either in the provision of secondary fuels, or for final energy consumption, or for consumption for non-energy uses.

393. The (positive) components which together provide for these energy requirements are domestic production of primary energy and imports (rows 1 and 2). From these have to be deducted the quantities going for export and deliveries for marine bunkers and international aviation, none of which contribute to domestic energy needs (rows 3 and 4). An adjustment for stock changes (row 5) is necessary to remove the effects of any over- or under-supply to which rows 1 to 4 on their own would give rise to. In the balance table, production and imports appear with positive signs, exports and marine/aviation bunkers with negative signs, and stock change either with a positive sign if there is a stock reduction (which adds to supply), or a negative one if stocks have increased (taking products out of supply).

394. The second section of the energy balance (rows 7 to 16) covers the use of primary energy products in energy conversion industries, and the derivation of secondary fuels. This is followed by five further lines (rows 17 to 21) which cover a variety of further measures which are necessary before "balance" can be achieved.

395. Rows 8 and 9 concern briquetting plants and coke ovens respectively. In each case an input of coal (with a negative sign - as for all inputs into conversion) in the "Hard coal, lignite and peat" column will have a corresponding, but smaller, output (with a positive sign) in the "Briquettes and cokes" column. The difference between these two figures represents the energy lost in the conversion process. This loss appears in the total column.

396. Rows 10 and 11 cover the conversion of coal or oil products to derived gases at gasworks and blast furnaces respectively. Negative entries under "Hard coal, lignite and peat", or the appropriate petroleum column (if oil products are being utilized), will be accompanied by positive entries in the "Derived gases" column.

397. Row 12 covers oil refineries. Under "Crude petroleum and NGL" will be the inputs to refineries (negative) with corresponding outputs (positive) in the columns for "Light petroleum products", "Heavy petroleum products", "Other petroleum products", and "LPG and other petroleum gases".

398. The difference between the absolute values of the inputs of crude oil and NGL and the outputs of products (ignoring positive and negative signs) will represent the loss of energy in the refining process. This loss will appear in the total column. The aggregated output expressed as a percentage of the inputs (again ignoring signs) will show the overall efficiency of national refinery processing.

399. Row 13 caters specifically for the separation of petroleum products, recorded in the appropriate products columns, from the treatment of NGLs or condensates. The former, as outputs, appear with positive signs, the latter with a negative sign, in the "Crude oil and NGL" column.

400. Row 14 concerns the production of secondary electricity. The inputs of the different fuels used for electricity generation will appear (with negative signs) in the columns covering these fuels. The combined electricity output will be recorded (positive sign) in the "Electricity" column. This figure covers only secondary electricity generated, it does not include any of the primary electricity generated (row 1) or imported electricity (row 2).

401. The inputs for, and the outputs of, self-generated electricity, as well as those relating to public supply electricity, should be included in row 14. It is incorrect (but not unusual) for only public supply electricity to be covered in this row, and for the inputs of fuels for self-generation to be included elsewhere in the balance as part of industrial final consumption (with no record of the amount of electricity generated and consumed). This error can lead to serious misrepresentation of national consumption patterns and the purposes for which different fuels are required, and lead to less effective planning decisions being taken.

402. Provision is made in row 15, covering heating plants, for the input of fuels (negative sign) burned specifically for the production of heat, the output of which would appear with a positive sign in the column headed "Other energy sources". Where heat is harnessed as a by-product of another conversion process, the output recorded under "Other energy sources" would be recorded on one of the earlier lines (e.g. if produced as a by-product of electricity generation, it would appear in row 14).

403. In the generation of electricity from natural gas by the combined cycle process (a process currently of considerable attraction to planners), some is generated from turbines driven directly by combustion of the gas, and some generated from steam obtained by utilizing the waste heat in the first process. For simplicity the balance does not distinguish between these two processes, recording only the natural gas input (negative sign) and total electricity generated (positive sign) within the figures in row 14. No coverage of this usage of heat is recorded in row 15 or under "Other energy sources".

404. Other conversion industries included in row 16 might include the production of petroleum products from (associated) gas if they have not been separately recorded at the production stage. Alternatively it might be considered more appropriate to record them as transfers (row 17) from natural gas (recorded with a negative sign in the natural gas column) to one of the petroleum product columns (the same quantity recorded with positive sign). Under either of these conditions care has to be taken on the conversion factors which should apply to the original figures. Row 17 will also include the blending of natural gas in the derived gas stream (or vice versa). In all cases a "transfer out" carries a negative sign, and is matched with a "transfer in" figure of identical value but with a positive sign.

405. Transfers of crude oil between oil companies should cancel each other out ("transfers out" being equal to "transfers in"). Figures supplied by all oil companies operating in a country sometimes fail to achieve such balance, in which case the discrepancy may appear as a "Net transfer" (positive or negative) or as a "Statistical difference" (see para. 411 below). Such discrepancies should be investigated.

406. Row 18 is put in to record the consumption of energy within the energy sector - the energy requirements for producing and distributing energy, which cannot correctly be categorized as final energy consumption. The energy which should be recorded on this line is not only consumption of the product being produced or otherwise worked on (natural gas at gas wells, petroleum products at refineries, electricity at power stations etc.), but also the "cross-product" consumption (e.g. electricity consumption at refineries, petroleum products at coal mines etc.) if this can be obtained. All such consumption, or "removal from general supply", is recorded in the balance with a negative sign.

407. It is recognized that in the absence of a comprehensive reporting system from all energy producers, it is likely that data relating to energy industries' "cross-product" consumption may be sparse. It is also unlikely that filling this gap in information will be of top priority. It should however appear in the plans for future improvements to annual statistical coverage wherever it is not already being recorded.

408. Row 19, "Losses in transmission and distribution", is often only specifically recorded in the "Electricity" column (for which see chap. IX, sect. D, above). However losses also occur in the storage and distribution of other products - gas through leakage, petroleum products through evaporation and spillage, coal by pulverization. In order to record such losses good measures of "before" (amounts available for further supply) and "after" (amounts supplied) need to be available. Where they are available the

appropriate entry in row 19 (negative sign) should be incorporated. Where they are not available these amounts are likely to be subsumed in row 21 under "Statistical differences" (see below). Filling these gaps in the information available is more likely to occur as a consequence of better measurements of availability and supply than as a result of requesting further specific data in returns from energy industries.

409. It can be argued that the quantity of energy product consumption for non-energy uses should be deducted from the overall energy available for final consumption (after allowing for the losses in conversion processes, in transmission and distribution, and the needs of the energy industries themselves). This would assume that the figures to be arrived at for final consumption relate only to energy products for energy use. Alternatively it can be argued that the total consumption of energy products is of greater relevance than their consumption for energy purposes, and that the figures for final consumption should represent all final uses to which these products are put. In the latter approach the consumption of energy products for non-energy purposes, and the consumption of non-energy products derived from conventional fuels, should be treated as a memorandum item within other measures of final consumption. The United Nations methodology favours the former approach, identifying consumption for non-energy purposes in row 22, and treating these amounts as something to be deducted from the energy that would otherwise be available for final (energy use) consumption.

410. Rows 1 to 20, derived from a wide variety of statistical sources, may logically be used to derive the quantities of different fuels that have been finally consumed for energy purposes. This is on the basis that such final consumption must be equal to:

-	<u>Production</u>
+	Imports
-	Exports
-	Bunkers
+/-	Stock changes
-	Inputs to conversion industries
+	Outputs of conversion industries
+/-	Net transfers
-	Consumption by the energy sector
-	Losses in transmission and distribution
-	Consumption for non-energy use.

411. In practice, measures of final "downstream" consumption will not be obtained from the same sources of data as some of the earlier "upstream" figures; they may not relate to exactly the same time periods, and for these and other reasons the above equation is likely to be found not to balance completely. Line 21, "Statistical differences", shows the extent to which balance is not being achieved. If in the above calculation fuel consumption derived from rows 1 to 20 is found to exceed measured final consumption, the balancing item (the statistical difference) appears with a positive sign, indicating that this is the amount which needs to be added to recorded final consumption for the balance to be achieved. If actual measured final consumption is the greater of the two measures then the balancing item will appear with a negative sign.

412. It warrants mention again that what is described here as "final consumption" is, for coal and petroleum products, more accurately described as "deliveries for final consumption". The additional measures required to obtain absolute final consumption would be those of changes in stocks among final distributors and consumers, which are impracticable to obtain regularly, accurately or comprehensively. Thus, a fuel such as gasoline is deemed to have been consumed when it leaves the last supplier who makes regular statistical returns to Government; no allowance is made of the stock changes at filling-stations (or other middlemen) or in the tanks of vehicle users.

413. Of the remaining rows in the United Nations balance, row 22 shows final consumption for energy use in aggregate, followed by breakdowns for consumption "By industry and construction" (rows 23 to 26), "By transport" (rows 27 to 31), and "By households and other consumers" (rows 32 to 35). The totals for Industry and construction, Transport, and Households and other (rows 23, 27 and 32 respectively) may, unfortunately but unavoidably, contain slightly different definitions from those conventionally used. Each fuel industry usually has its own classification and coverage of market sectors to match its tariff or other price categories, and unfortunately these rarely match the national standard industrial classification (if there is one).

414. There may also be inconsistencies in the application of these sectoral definitions even among the suppliers of data in respect of one fuel. The actual levels they show for consumption therefore have to be treated with some caution, though the trends they highlight for changes over time should be less open to doubt. The definitions used should be explained in accompanying notes to the energy balance and to other tables to which they are relevant.

415. Further difficulties and discrepancies may exist in obtaining measurements for the breakdowns recommended for "Industry and construction" (Iron and steel industry, Chemical industry, and Other Industry, separately), for "Transport" (Road, Rail, Air and internal and Coastal Waterways), and for "Household and other" (Households, Agriculture and Other). The resolution of such difficulties and discrepancies, the introduction of stricter conformity with conventional definitions, and the expansion of subsectoral breakdowns generally, are all matters which should in the end be addressed on a country-specific basis. Guidance on the approaches to be adopted for different fuels, and the tables which one should be aiming to produce (and on which these components of the energy balance would draw) have been covered extensively in chapters V to XII. The extent to which national energy statistics are achieving (or failing to achieve) consistency in subsectoral breakdowns should also be indicated in the notes accompanying the relevant statistical tables.

416. Finally it should be emphasized again that the main purpose for which a country would find it valuable to compile energy balances and other statistical tables is to assist that country in the planning and monitoring of the energy issues with which it is directly concerned. Although there is some degree of commonality in the types of problems which countries have to face, these have to be handled with widely different infrastructures, and with different ordering of priorities. It would therefore be wrong to think that countries should all adopt, even where they are able to do so, a prescribed list of detailed recommendations concerning energy statistics. Allowance has to be made for the need for a flexible approach, in order that countries may concentrate on the issues which are most important to them.

417. What has been put forward in the various chapters of this Manual should be seen therefore as no more than a framework from which countries may be able to identify the most serious gaps in their energy information systems, and how the more important of these might cost-beneficially be filled. It is hoped that, in addition, it may help in the identification of levels of detail, comprehensiveness and conformity with which information may realistically be expected to be provided, and from which energy administrations might expect to obtain benefit in developing energy policies.

XIV. THE USE OF MICROCOMPUTERS IN ENERGY STATISTICS

A. General

418. A very considerable amount of activity has been undertaken during the past two decades in developing software for the purposes of modelling the energy system and the interrelationships between it and the national economy as a whole. Initially this work was carried out on mainframe computers (the only kind available at the time), but during the past 10 years or so an increasing amount of attention has been given to the use of microcomputers for these and related purposes. These types of development all call for clean and comprehensive sets of energy data being available for a run of years. Such data-sets serve as one of the main inputs to larger databases which often need to be supported by other sets of data covering other variables (e.g. industrial output, GDP, consumer expenditure etc.), to which the energy variables may be expected to relate. The aims of the software developed in this context are to establish relationships between different energy variables, or between energy and non-energy variables, and to project the effects of these relationships, whether constant or changing, into the future.

419. Software of this type requires good energy data to be available for all identified parameters for a number of years, or, when not available, for realistic estimates (and trends in estimates) to be fed in. It does not offer assistance in the compilation of the original data that are required. Attention has been concentrated until now only on what to do with the information once assembled, and not on the assembly of the data itself. As a result, some of the mechanistic processes to which information is now being subjected, and the interpretations being put on the results obtained, cannot always be fully justified because of unrecognized deficiencies in the underlying data. Computer software itself can only go a limited way towards checking the accuracy of the energy data assembled, by using arithmetical and consistency checks when occasion permits. Such validation checks should not be dismissed as useless (see below), but they are unlikely to detect relatively small errors in the data being supplied originally by the energy industries; neither will they be able to identify if there are consistent omissions of whole blocks of data, or if data are being systematically misrecorded.

420. This Manual has been primarily concerned with the assembly of data of sufficient quality and comprehensiveness to be used with confidence for planning and for making projections. As already noted, the requirements of model-builders will be for information which has been obtained consistently for a number of years and from which they are able to identify the underlying trends that have been established.

421. The first question which then needs to be put is how intensively a computer is likely to be used in the compilation of a country's energy statistics. Those countries producing only annual information which a central collection point has obtained in already-aggregated form, e.g. all oil data from an oil company or ministry, all electricity data from one national electricity company (or from the ministry responsible for electricity etc.), may only re-present the same data in a different context and different format. But these data in electronic form could then be readily incorporated

into more comprehensive databases with wider possibilities for analysis. There may be, in the future if not currently, extensive computer usage for the derivation and compilation of individual fuel data within other ministries or agencies, though this may not always be achievable on consistent lines. Moreover, since data are increasingly stored and transmitted electronically, computers are becoming the institutional memories of many organizations.

422. If there is one office (energy ministry or central statistical office) responsible for compiling all fuel and energy statistics from data supplied directly from the energy (and other) industries, it is quite likely that intensive use will be made of computers for the assembly of statistics because of the volume of work involved and the advantage of speedy processing. This is particularly true if the aim is to expand the amount of detail and increase the frequency of information provided.

423. If computers can be made available for statistical compilation, and the size of the task is deemed to warrant such investment, the first and key decision is whether to start with the assembly of annual data, and to develop this in due course to provide computer-assembled information more frequently; or to build up information from the smallest data building blocks (and therefore of the highest frequency) to produce annual, or any other frequency, tables. Though the latter is conceptually more attractive it will involve more resources (and more time) for its development and execution. In any country where only annual statistics achieve anything approaching comprehensiveness (either because of the range of topics they cover, or because of their level of detail) the former approach may be preferred.

424. Once the decision has been taken to compile and produce energy tables on microcomputers, the selection of appropriate software will need to place equal emphasis on its abilities for database assembly and on its statistical powers. Data will come from a number of sources (electricity companies, oil distributors, coal mines etc.) which may include some level of aggregation (perhaps for power stations in total or by area, as well as individually), and an early decision has to be taken whether the start-point for data input should be the individual unit or the aggregate (or sub-aggregate). This will clearly affect both the computer storage capacity required and the time to be taken for data input. A small country with only two or three power stations may be able to decide readily on individual station input to the database, whereas one with hundreds of stations may opt for aggregates only, particularly if these are already being included in the returns made by companies. If a large country were to opt for individual station input, and equivalent detail for other fuel inputs, there would be a high requirement for computing power (both hardware and software). In the case of such countries, at some point data may have to be transferred to a minicomputer or to a mainframe computer, owing to the volume of information for treatment.

425. If data are being supplied more frequently than annually, one important determinant of the computer power required is whether there is consistency in the time period covered by all such data. Data for different fuels, or from different companies, may relate to slightly different time periods (e.g. some "monthly" data may in fact relate to four weeks, five weeks, or to a calendar month). A decision is needed on whether all data should be adjusted to a common period or whether it is acceptable in its "raw" form. If adjustments of this sort are made, then an aggregate of adjusted data for 12 successive

months may well not be consistent with an annual figure separately obtained, and further computerized "corrections" will have to be incorporated.

426. Adjustments are likely to have to be catered for also, to allow for amendments to data some time after they have originally been submitted. Again, this calls for decisions on whether the amendments that will be necessary to ensure that annual data are consistent with more frequent data should be handled manually or accommodated within the software used for processing. Allowance also has to be made for the fact that more frequent data may well be less comprehensive (e.g. it may not include details about the sectoral split of final use of energy, and may say nothing about self-generated electricity) than that produced with annual frequency.

427. It will therefore be seen that in designing a system for compiling energy statistics on a microcomputer the following aspects have to be addressed:

(a) The number of sources of data supply;

(b) The frequency with which data are to be compiled;

(c) The incidence of data provided only annually, and therefore to be excluded from more frequent analyses;

(d) Inconsistencies in the frequencies with which data will be provided from different sources;

(e) The scope for revisions to data after they have initially been supplied;

(f) The number of variables covered;

(g) The extent (if any) of subnational information to be included in the output;

(h) The extent of free-standing information compiled elsewhere and requiring to be transcribed to the database (e.g. estimates of non-commercial fuel consumption derived from surveys).

428. In the case of quarterly or monthly data, if information is required on a seasonally corrected basis, one would probably be catering for both corrected and uncorrected main series to be held on computer file. The seasonal correction process might not be available within the database software being utilized, and therefore might have to be carried out as a separate process from other data assembly. This particular problem can sometimes be avoided by including in published time-series comparisons with the same period a year ago. This kind of comparison can be further improved by publishing three-month moving sums or averages, in order to achieve some smoothing effect.

429. Temperature-corrected data may be desirable for some purposes. This would require the use of more powerful software (with some statistical capability), but the resulting corrected series might also be accommodated on the database file. On the other hand more sophisticated temperature correction, either requiring daily data adjustment, or which had to be applied to a number of subnational series for individual fuels (using methodology

along the lines of that described in chap. XII, sect. I), is unlikely to be accommodated within an overall data assembly package. One would almost certainly be seeking to input "clean" temperature-corrected data alongside, or instead of, the original series. (Temperature correction may, however, not be regarded as a priority requirement.)

430. Software packages designed for energy planning and related purposes call for information along the lines set out in chapter XII of this Manual. Essentially they provide a prescription of the categories of data they need to be input, and in some packages there may be little scope for variation in this, whatever the size of the country, its energy sector structure or its policy concerns. Some software may not be able to cope with data that fall outside this prescription, even though such data may be of relevance in the particular circumstances prevailing in a given country. (It is only by adopting such an approach that packages can be designed for general applications across many countries.)

431. The type of software required by any particular country has to have the appropriate capacity to handle and assemble the range and detail of data available in the country and of relevance to it when addressing its particular policy concerns; that software may or may not have specialist statistical facilities; but it must be able to produce a variety of outputs in accordance with the country's needs. Whether this can be met by an off-the-shelf spreadsheet/database package, such as D-BASE (Version 3, 4 or 4+), or whether tailor-made software would be necessary can only be determined in the context of the circumstances prevailing in that country.

432. Any consideration of the possibility of using micro-computers for energy data management should include an examination of the software (and hardware) used or envisaged by the energy planners and policy analysts in the country concerned, whether those planners and analysts are located inside or outside the ministry or agency in question. Those planners and analysts will require a great deal of data (as has already been pointed out) not only on energy flows and stocks but also on energy procuring, processing, transformation, storage, distribution and end-use equipment, and on more general economic and social factors such as the level and structure of GNP, agricultural and industrial output, population, prices, taxes and so on. It is important that the energy data inputs to modelling and other analyses should be so defined as to be directly "importable" from the appropriate parts of the energy database. Correspondingly, the structure and content of that database should be so defined as to facilitate the direct export of data for inputting to the appropriate parts of the energy models and other analytical tools.

433. At the same time, however, the definitions and accounting conventions used for all energy stocks and flows should in principle be those used in constructing the energy accounts and balances, and it follows that the planners should if possible be persuaded to agree to follow this practice (if they do not already do so). The output reports of the planners and modellers can then readily include overview tables in the form of "top down" or "bottom up" energy balances (see below). All too often, institutional competitiveness leads to a quite unnecessary number of variants of a simple basic statistic, to overlapping and misuse of scarce and costly resources within Government and its agencies, and - not least - to an increased reporting burden and a longer reporting delay at the level of the energy industries from whom the statistical data must ultimately come.

434. In assessing the suitability of available software (and whether special, custom-tailored software may be necessary), the factors described below should be borne in mind.

B. Data entry

435. Original data records often use a small unit of measurement such as the kilowatt-hour, barrel or cubic foot (or metre). This may be perfectly proper if the reporting entity is the power station or the oil/gas field, but this can easily generate very large numbers consisting of 9, 10, 11 and even 12 digits when all reports are aggregated across an industry. As has been pointed out, such large numbers are almost impossible to take in visually when presented in a table and are quite unnecessary in the tables or text of a report. Published tables should never contain more than four or five digits in total and should not generally display more than two places of decimals. If more than three integers are displayed, the first three should be separated from the rest by a comma. When, exceptionally, six or more integers are shown in a table, commas should always be used to separate groups of three. The question then arises of how many digits from an original record should be entered in a file of an energy database.

436. If, as in principle it should be, a single energy database is to be the source of statistical data for all official purposes, then the number of digits entered into the data files should be the number of digits required for the purpose - whatever it may be - that really requires the greatest number of digits. Thus if kilowatt hours really are required for some administrative purpose, then kilowatt hours should be entered into the database, whatever the number of digits; but for most purposes no more than five or six digits should ever be displayed on the monitor screen. If however, kilowatt hours are requested in a reporting form for the convenience of the reporting entity (e.g. the power station), but if only megawatt hours are required for the most precision-demanding Government purpose, and if the quantities concerned amount to more than six digits when expressed in kilowatt hours, then the numbers entered into the database need only be defined in such a unit as will give six digits (namely, MWh +3 decimal places, i.e. one more than is required in any output figure). Where larger numbers of digits have to be input to the database because of the greater precision-demanding nature of a limited number of demands on the database for data, the chosen software should be capable of displaying on screen only the more restricted number of digits appropriate for all other purposes.

437. It is sometimes argued that the full number of digits in the original record should always be entered into the database, as this makes it easier to check that an entry has been made correctly. In support of such a practice it is said that the capacity of modern micros is such that the additional storage space needed is quite negligible. As against this, the meticulous entry of large numbers of figures each consisting of six or more digits is likely to lead to operator fatigue, lowered morale, and an increased likelihood of entry errors through the reversal of digits or even the omission of a digit.

C. Data validation

438. Data validation can take a number of forms: the most obvious and straightforward is checking that the sum of available supplies equals the sum of recorded uses. Such a balance structure should of course, whenever possible, be incorporated in the design of routine questionnaires in which data are reported to the Government and its agencies. It should be borne in mind, however, that such a simple balance may sometimes depend on one of the elements itself being a residual calculated from the other elements. "Stock-change" is sometimes calculated in this way in returns for "stockable" products. In such a case the arithmetical balance does not constitute a sufficient check on the validity of any of the constituent elements, and some kind of complementary check is necessary.

439. Software can include one or more of a number of complementary checks such as the following:

Does the current figure differ by more than x units from (or y% of) the corresponding figure in the previous report?

Does the current figure bear the same percentage relationship as previously to a closely related figure in the same return (e.g. refinery fuel and crude throughput)?

Does the current figure bear the same relationship as previously to a group of different but related figures (e.g. electricity output and the sum of all fuel inputs to generation)?

Does the percentage change from the previous figure correspond with the percentage change, calculated for the same time interval, in a closely related statistic (e.g. fuel use in industry and industrial output) within a margin of z percentage points?

440. An alternative to the incorporation of validation checks in the software itself is for the software to provide for graphical plots on screen that will immediately show unusual kinks or lack of expected correlations.

D. Transition tables

441. It is highly unlikely that the terminology used by each energy industry to denote the various flows from production to consumption will be the same, or that the terminology of any will correspond fully with that used in constructing an energy commodity account (ECA). Production of coal may be gross or net of screenings; production of oil and gas may be gross or net of contaminants and vented, flared or injected gas; generation may be gross or net of the output from pumped storage. Data sometimes need to be combined from different original sources. Further, the conventions used in putting together an ECA are often not the same as those used by the energy industries themselves (e.g. the treatment of autogenerated electricity). This selection, reclassification, adjustment, rearrangement and combination of data can be carried out either outside or inside the software program for the energy database, but it is clearly an advantage if the program itself is capable of providing for the transformation of the raw data from the original data source

to the form required by the basic ECA. There is however much to be said for this operation being carried out on-screen using previously designed transformation tables, rather than that these operations should be executed invisibly as an integral part of the program itself.

E. Conversion factors

442. The energy database will consist of files - or possibly spreadsheets in the case of data drawn from balance-type original returns - that record all data initially in original units (barrels, tons, cubic feet or metres, kilowatt hours) - or, more likely, in such units multiplied by 1,000 raised to an appropriate power. It should also be so designed as to be able to generate at least the two basic "core account" spreadsheets, namely energy commodity accounts (ECA) and overall energy balances (OEB). The ECA consists of an array of columns, one for each of a specified series of energy commodities (counting electricity as a "commodity" for this purpose), and having a common set of standardized side headings for the rows. Since the figures in each column are expressed in the appropriate multiple of the original unit, there will be no "Total" column. The OEB will show all the corresponding quantities expressed in a chosen common unit (TCE (tons of coal equivalent), TOE (tons of oil equivalent), TJ (terajoules)) and will have a "Total" column. The question arises of what conversion factors to use when deriving the OEB from the ECA.

443. The obvious answer is to use factors that correspond to the actual heat values of the particular qualities of each energy source used in the country concerned (and used for the specification of the coal or oil chosen by that country when defining one TCE or one TOE). However, countries will almost certainly also be interested in comparing their own energy situation and outlook with that of similar countries, countries supplying their import needs and/or countries to which they sell their exports. Countries are also likely to want to understand and assess the picture of their energy supply and use level and structure as shown in the publications of the major international agencies.

444. From this it follows that a single set of conversion factors will not be sufficient. The software should be capable of generating OEBs using national or alternative international conversion factors (because the international agencies do not all use the same factors for all energy sources). It is also desirable that the software should be so designed that switching from one set of conversion factors to another does not result in a long delay before the newly calculated OEB is displayed on screen.

F. Accounting conventions and OEB structure

445. It is not only the conversion factors that differ between countries and the international agencies, and also between the agencies themselves: some accounting conventions differ too, particularly in the case of primary electricity. Some balances show production of such electricity in terms of its output energy value; others show it in terms of its notional fossil fuel input equivalent. Some balances show both values and have two "Electricity" and "Total" columns in consequence. Yet other balances show production and

consumption of all electricity in terms of its fossil fuel input equivalent as a supplementary set of statistics or as components of a second "Total" column. Countries will need to consider whether they wish their database software to be capable of generating alternative OEBs with additional columns that can include one or more of these variants.

446. There are other structural options that countries may wish to consider too, if some of these would enable the OEB to reflect more closely their particular policy concerns. A country might want to embody in the OEB (and not just in the transition tables mentioned above) lines for production not used (e.g. coal screened, gas flared or injected), or to include lines for stock levels as well as for the stock change, or to include bunkers as a category of "Consumption" rather than as a (negative) component of "Supply", or to subdivide the "Transformation" sub-matrix into separate matrices for "Transformation inputs" and "Transformation outputs". If any such variants from the recommended standard international matrix structure are desired, then the country wanting this will also need to be able to generate the standard matrix as well, and it follows that computer software will be needed that can generate the desired variant(s) in addition to the standard OEB matrix.

447. Before considering other possible matrices that might complement the basic OEB, a point worth underlining is that any matrix should always be accompanied by suitably worded explanatory notes setting out the exact meaning of the signs used in the rows for "Stock-change" and "Statistical difference". A new reader of a table would expect a plus (+) sign to denote a stock raise and a minus (-) sign to denote a stock fall. In a standard OEB, which shows energy flows into and out of the account, a stock rise is a diminution of the available supply and is consequently denoted by a minus sign, and conversely a stock fall is an increase in the available supply and is consequently denoted by a plus sign. A note to the "Stock-change" row of the OEB should therefore state:

Stock rise, - ; Stock fall, +.

Correspondingly, a note to the "Statistical difference" row should state:

Supply exceeds consumption, - ; Consumption exceeds supply, +.

For completeness, the "Transformation" section of the OEB should be accompanied by a note which states:

Input, - ; Output, +.

All these explanatory footnotes should of course be embodied in the micro-software used for the database.

448. Naturally, database software should be flexible enough for it to be easy to introduce additional columns for further energy sources such as non-commercial, traditional energy (e.g. fuelwood, charcoal ...) and novel renewable sources (e.g. biogas, solar, wind ...).

449. There is one other desirable reporting feature that any energy database software should incorporate, and that is the ability to generate not only as complete a set of ECAs and OEBs as a country's energy data can support, but also at least one lower-order set of matrices reflecting one or more degrees of aggregation of energy sources and/or transactions. Thus, for example, the fully detailed matrices would distinguish separately each petroleum product of significance to the country while an aggregated matrix would perhaps have a single column for all petroleum products. An intermediate degree of aggregation might show separately light, medium and heavy petroleum products. It is highly desirable that at least an aggregated OEB should be able to fit on to a single A3 page (and similarly for the corresponding ECA); and if possible (and, if necessary, in an even more highly aggregated form) on to a single page of A4 without the need for reprographic reduction.

450. Given the importance of consistency and coordination between the statistical work and the analytical and modelling work of Government and its agencies, both within and between departments and agencies, yet another feature of any energy-oriented software used for energy data management should be sufficient flexibility for speedily restructuring an OEB matrix to meet the presentational requirements of the modellers. It is of the nature of energy projection work that future energy needs are commonly assessed on the basis of the projected level of demand for final energy (i.e. for energy in the form in which it is delivered to final energy consumers) by each end-use sector (agriculture, industry, transport, commerce, other services and households). Then, by making assumptions about the future size, structure, technical characteristics and supply pattern of the energy transformation sector, a country's estimated future requirements for indigenous or imported primary energy are arrived at.

451. The presentation of the results of such a projection exercise should include an energy balance so designed as to illustrate the logic of the assessment. This can be achieved by a simple inversion of the standard OEB so as to show first the sub-matrix of "Final consumption", then the sub-matrix for "Transformation" and below that the sub-matrix for "Primary supplies". A highly simplified example of such an inverted matrix is shown in the accompanying table. It will be noted that "Exports" have been treated as a component of (projected) demand, and that the transformation sign convention has been reversed: in this projection matrix, an output from transformation now appears with a negative sign, and an input to transformation now appears with a positive sign.

Simplified projection balance
(In megajoules)

	Crude	Petroleum products	Gas	Electricity	Total
Industry	0	1 000	100	500	1 600
Transport	0	1 500	0	200	1 700
Commerce	0	400	50	300	750
Other domestic	0	100	10	250	360
Exports	500	500	0	0	1 000
Final	500	3 500	160	1 250	5 410
Power stations	0	3 750	0	-1 250	2 500
Refineries	8 000	-7 250	0	0	750
Requirements	8 500	0	160	0	8 660
Primary production	8 400	0	160	0	8 560
Imports	100	0	0	0	100

452. There are two other variants on the standard OEB structure that some countries might wish to consider - and which they might therefore expect energy database software to be capable of generating (on the assumption that the further data needs of the expanded matrices can be adequately met). The first is to extend the matrix "upstream" by providing rows for (a) reserves (appropriately defined) of each fossil fuel, (b) new discoveries during the accounting year, and (c) depletion during the year. This last row would correspond to "Gross production" which, after deducting screenings and otherwise unused material, would give (net) production for the ECA and OEB.

453. The second variant would extend the matrix "downstream" by providing two new sub-matrices. One would show average coefficients of efficiency of final-use appliances and equipment within each final-use sector, and the other would show the derived estimates of useful energy consumed by each final-use sector. In principle such information would be invaluable for the making of energy projections and for analysing the scope for substitution between energy sources for particular final uses. Such an extended OEB would require a fairly detailed analysis of the purposes for which each energy source is used within a detailed breakdown of each sector of final energy use, together with

a detailed survey of appliance and equipment use and efficiencies. Acquisition of estimates of these types would be costly but might be undertaken by some countries once (say) every five years. If a country envisages the possibility of such a development in the future then it would be one more factor to bear in mind when assessing the capabilities of different software packages.

G. Derived time-series tables

454. The ECA and OEB will be generated by the software from the data in the individual data files of the database (or possibly from existing spreadsheets in the case of data from original returns that themselves were structured as spreadsheets). Besides being able to generate the ECA and OEB, and the numerous time-series tables listed in chapter XII, the software should be able to generate time-series tables expressed in the common unit used in the OEB and representing vertical or horizontal "slices" through the three-dimensional "block" of data constituted by an assembly of OEBs covering a number of years. A vertical slice would generate a time-series for a selected commodity (e.g. fuel oil) showing separately all the elements of the supply-and-use account; a horizontal slice would generate a time-series for a selected flow (e.g. imports) showing separately all the different energy sources.

H. Energy balances and input/output

455. If the energy planners in a given country use, or envisage using, an input/output type of model for the economy as a whole, then the energy statisticians are likely to be interested in seeking consistency between the transaction values appearing in the energy commodity or energy industry cells of the Leontiev matrix for the economy and the corresponding energy quantities appearing in the ECA for the year concerned. The link between the two is energy average prices, suitably defined, plus distribution margins and taxes (or subsidies). In addition, there are conceptual differences between some of the flows in an ECA (and OEB) on the one hand, and in a Leontiev matrix on the other.

456. Firstly, "final" consumption has a different meaning in the two contexts: in national accounts and input/output, "final" relates only to consumption by government, households, exports (and bunkers supplied to non-nationals) and stock-building. In energy accounts, "final" means all sectors outside the energy sector. Secondly, in national accounts "households" are defined more narrowly, and bunkers acquired abroad - which are completely ignored in energy accounting - are treated as rather analogous to imports. These points are mentioned to draw attention to another set of reasons for wanting, probably, a much greater degree of flexibility in energy database software than might be sufficient for the construction of energy accounts and balances and the various time-series tables that may be generated from them (and from the basic files needed for their construction).

I. Flow diagrams

457. It is possible for some software to generate monochrome or multicoloured flow diagrams, showing for each energy source an arrow whose width is proportional to the size of the flow at each stage from production or import, through transformation to final consumption. If the data are available, such a diagram can be extended to show, with the same proportionate arrows, the quantities of useful energy absorbed by each type of end-use (heat, light and motive power). This is just one more software capability whose presence in a package some countries might think desirable for the future.

458. The following paragraphs review briefly four of the internationally sponsored database packages that have been specially developed for use on micros in developing countries.

J. Some particular software packages

(a) ENERPLAN

459. ENERPLAN was commissioned by the Department of Technical Cooperation for Development and has been designed to be easy to use even on low-cost microcomputers. Its main characteristics are that it embodies a database module that covers both energy and macroeconomic data and, besides being able to generate United Nations-type standard OEBs, associated time-series and supporting graphics, it includes software for regression analysis of relationships between energy and economic data and for model-building based on regression or other relationships between selected variables. The OEBs can be presented in terms of any one of a wide choice of common units (TCE, TOE, BOE (barrels of oil equivalent), Btu, Tcal or TJ), all presumably defined on the basis of net calorific values (NCV), though this is not stated in the "User's Manual". Conversion factors from original units into each of these presentation units, and the operation of conversion, are embodied in the package. Although the OEBs are generated from the database files, they can be saved on diskette. There is a special module for storing data on traditional sources of energy. The capacity of the energy database amounts to 44 commercial energy sources and 4 traditional sources, 35 energy transactions (production, imports, transformation, final consumption etc.) and 60 records for each data flow (which are intended to cover 60 years but could apparently cover 5 years of monthly data - though individual records of this frequency would only be designated by serial numbers). The macroeconomic database can cover up to 500 different variables, with 60 records for each.

460. Generation of the OEB is preceded by validation checks on the basic data, followed by aggregation into predetermined subgroups (e.g. "Light petroleum products"), so that the resulting OEB distinguishes only 12 separate energy sources, of which one covers traditional fuels compared with the original 44 commercial energy sources and 4 traditional sources. The embodied conversion factors appear to be fixed, and the defined colorific values for the TOE (45.4 GJ) is more than 6 per cent higher than that used by the Statistical Office (42.6 GJ). The defined value for the TCE is the same as the one used by the Statistical Office (29.3 GJ). The number of transactions in the OEB is the same as that (35) provided for in the database itself. It seems that this software cannot generate a matrix of original-unit ECAs.

461. Other limitations are that the grouping of the initial 44 energy sources to form the restricted set of 12 for the OEB cannot be varied, and the only variation possible among the 35 energy transactions is to redefine the first two components of "Industry" and the first two components of "Households and other" in the final consumption sector. (The third component in each subsector is, by definition, a residual.)

462. Models can be constructed by the user on the basis of discovered regression relationships, macroeconomic identities or other equations relating commercial energy variables to economic variables. In the case of traditional energy, the structure of modelling is different and consists of relating fuel consumption for each of four purposes (cooking, lighting, heating and hot water) to current and projected future rural population, family size and end-use efficiency. On the supply side, fuelwood and charcoal are made dependent on forest stock and gross depletion rates, whilst animal and crop residues are related to crop output and livestock numbers. The results of projections made by means of ENERPLAN modelling can be presented at the report stage in the form of, among other tabulations, OEB matrices.

463. A new release of the software, ENERPLAN III, is currently (1991) being tested. It will no longer require a BASIC language compiler and thus will have greater compatibility with users' hardware. It will also feature a vastly improved OEB capability allowing highly disaggregated matrices. A powerful OEB editor is also included.

(b) ENERBASE

464. The ENERBASE package was also developed by the Department of Technical Cooperation for Development as a tool for the organization of national energy information systems. It uses DBase IV. The module covering energy demand permits storage of data for any number of energy sources at any level of disaggregation available. ENERBASE traces energy supplies upstream to proven reserves of fossil and fissile fuels, without however introducing the refinements of providing for annual depletion and annual new discoveries. On the socio-economic side, it covers very considerable detail on energy costs, prices and taxes; capacity and technical characteristics of energy producing and energy transforming equipment; population and employment; interest rates; terms of trade; GDP; and other such variables.

465. ENERBASE is a database construction and management system only. It does not incorporate any provision for model-building or for projection reporting in the format of an OEB or otherwise.

(c) SIEE

466. The Energy-Economic Information System was developed by the Latin American Energy Organization (OLADE) with the support of the Commission of the European Communities (EC). It consists of modules for data on the supply, demand and prices of energy and uses LOTUS 1-2-3 for the generation of OEBs having the standard OLADE balance structure though expressed in BOE. This structure cannot be altered within the program. The original proposals for SIEE envisaged including data on reserves and resources of fossil and forest energy; solar, wind and water power; animal and vegetable wastes; the stock and technical characteristics of plant and equipment for the production,

preparation, transformation, distribution and consumption of energy (including useful energy); and socio-economic data on population, wages and salaries, GNP, investment, external trade, currency reserves and interest rates.

(d) ENERUTIL

467. This is a program (using DBase IV), developed by the Department of Technical Cooperation for Development and designed for processing the results from detailed sample surveys of households and other final-use sectors. Such surveys would be aimed at estimating the useful energy from each source (each petroleum product, gas, electricity etc.) consumed for each of four types of purpose (heat, motive force, illumination and other). The summary results from such surveys would be used for the construction of a "Useful energy" matrix, which could be added at the bottom of the standard OEB.

Notes

1/ Department of International Economic and Social Affairs, Concepts and Methods in Energy Statistics, with Special Reference to Energy Accounts and Balances: A Technical Report, Studies in Methods, Series F, No. 29 (United Nations publication, Sales No. E.82.XVII.13).

2/ Department of International Economic and Social Affairs, Energy Statistics: Definitions, Units of Measure and Conversion Factors, Studies in Methods, Series F, No. 44 (United Nations publication, Sales No. E.86.XVII.21).

3/ Strictly speaking, these calorific values should be expressed in kilojoules per kilogram (kJ/kg), since the joule (and its multiples) is the standard unit recommended by the United Nations for the measurement of energy: see chap. XIII. However, for the examples in the present chapter, kilocalories are used in order to keep the numbers simpler. One kilocalorie equals 4.186 kilojoules, so that 7,000 kcal/kg = 29,300 kJ/kg.

4/ Energy Balances and Electricity Profiles, 1986 (United Nations publication, Sales No. EF.88.XVII.7).

5/ Ibid., 1984 (United Nations publication, Sales No. E.86.XVII.14).

Annex I

ENERGY: SOME CLASSIFICATIONS

Type	Renewability		Renewable	Non-renewable
Conventional	Commercial		Hydropower (large scale) Geothermal Nuclear (breeder)	Fossil fuels Nuclear (other) a/
	Traditional	Other	Solar (air drying) Hydro- (mills, pumps etc.) Wind (mills, pumps and sails) Animate (animal and human)	
		Biomass	Fuelwood "cropping" from natural forest/charcoal Twigs, leaves, sticks etc. Crop residues (straw, husks etc.) Animal residues (dung, tallow etc.) Industrial residues (wood waste, sawdust etc.)	Fuelwood "mining" Charcoal
Non-conventional	Novel		Plantation and marine crops (for distillation, pyrolysis etc.) Biogas	
		Other	Solar (collectors, photovoltaic) Hydro (mini and micro) Wind (wind motors) Tidal, wave power Ocean thermal gradients Heat pumps	Nuclear (fusion) Petroleum from coal, shale etc. Synthetic natural gas

a/ Other fusion.

Annex II

ENERGY CONVERSION FACTORS FOR DIFFERENT FUELS

(All heat values in net calorific value (NCV))

Solid fuels

	Gigajoules/ton or Megajoules/kilogram	Million Btu per ton	Megacalories/ton or Kilocalories/kilogram
Hard coal	29.31	27.78	7 000
Lignite	11.28	10.70	2 700
Coke	26.38	25.00	6 300

Note. The calorific values of coal and lignite vary greatly by geographical or geological location, and over time. The above factors are based on world-wide average values.

Liquid fuels

	Gigajoules/ton or Megajoules/kilogram	Million Btu per ton	Megacalories/ton or Kilocalories/kilogram
Crude oil (average)	42.62	40.39	10 180
Propane	45.59	43.21	10 890
Butane	44.80	42.46	10 700
LPG (average)	45.55	43.17	10 880
Natural gasoline	44.91	42.56	10 730
Motor gasoline	43.97	41.67	10 500
Aviation gasoline	43.97	41.67	10 500
Jet fuel (gas type)	43.68	41.39	10 430
Jet fuel (kero type)	43.21	40.95	10 320
Kerosene	43.21	40.95	10 320
Gas-diesel oil	42.50	40.28	10 150
Residual fuel oil	41.51	39.34	9 910
Lubricating oil	42.14	39.94	10 070
Bitumen/Asphalt	41.80	39.62	9 980
Petroleum coke	36.40	34.50	8 690
Petroleum wax	43.33	41.07	10 350
White spirit	43.21	40.95	10 320
Naphtha	44.13	41.83	10 540
Ethyl alcohol	27.63	26.19	6 600
Methyl alcohol	20.93	19.84	5 000

Note. 1 ton = 1 metric ton = 1,000 kg

Electricity

1 kilowatt-hour = 3.6 MJ = 3,412 Btu = 860 kcal

1 megawatt-hour = 3.6 GJ = 3.412 million Btu = 860 Mcal

Gaseous fuels

	Megajoules per cubic metre	Thousand Btu per cubic metre	Kilocalories per cubic metre
Natural gas (average)	39.02	36.98	9 320
Coke oven gas	17.59	16.67	4 200
Blast furnace gas	4.00	3.79	960
Refinery gas	46.10	43.70	11 000
Gasworks gas	17.59	16.67	4 200
Biogas	20.00	19.00	4 800
Methane	33.50	31.70	8 000
Ethane	59.50	56.30	14 200
Propane	85.80	81.30	20 500
Isobutane	108.00	102.00	25 800
Butane	111.80	106.00	26 700
Pentane	134.00	127.00	32 000

Biomass

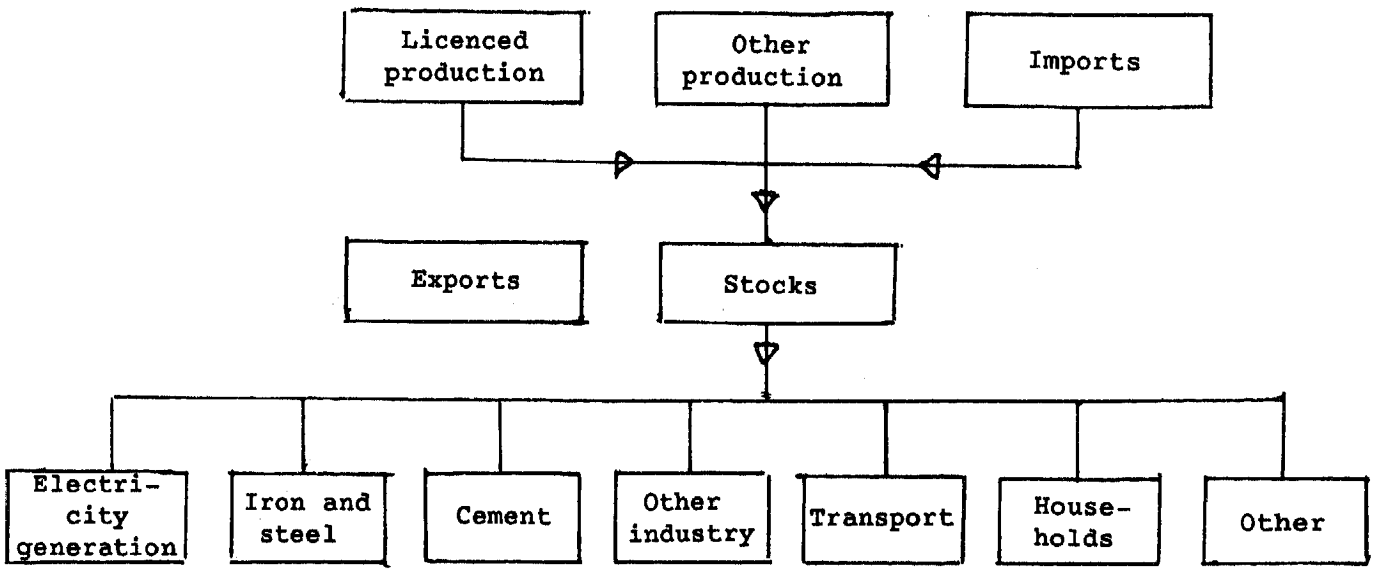
	Moisture (%) Dry basis*	Wet basis*	Megajoules per kilogram	Btu per pound	Kilocalories per kilogram
Green wood	160	62	5.7	2 450	1 360
	100	50	8.2	3 530	1 960
Air-dried wood	60	38	10.8	4 640	2 580
	30	23	13.8	5 930	3 300
	20	17	15.2	6 530	3 620
Oven-dried	10	9	16.8	7 220	4 010
	0	0	18.7	8 040	4 470
Wood charcoal	5	5	30.8	13 240	7 360
Crop residue charcoal	5	5	25.7	11 050	6 140
Animal dung	15	13	13.6	5 850	3 250
Bagasse	30	23	12.6	5 420	3 010
	50	33	8.4	3 610	2 010
Coconut husks	8	8	16.7	7 180	3 990
Coffee husks/cherries	30	23	13.4	5 760	3 200
Oil-palm husk/fibre	55	35	8.0	3 440	1 910
Rice straw/husk	15	13	13.4	5 760	3 200

Source: Department of International Economic and Social Affairs, Studies in Methods, Series F, No. 44, Energy Statistics: Definitions, Units of Measure and Conversion Factors (United Nations publication, Sales No. E.86.XVII.21).

* "Dry basis": moisture expressed as percentage of dry wood weight. "Wet basis": moisture expressed as percentage of wet wood weight.

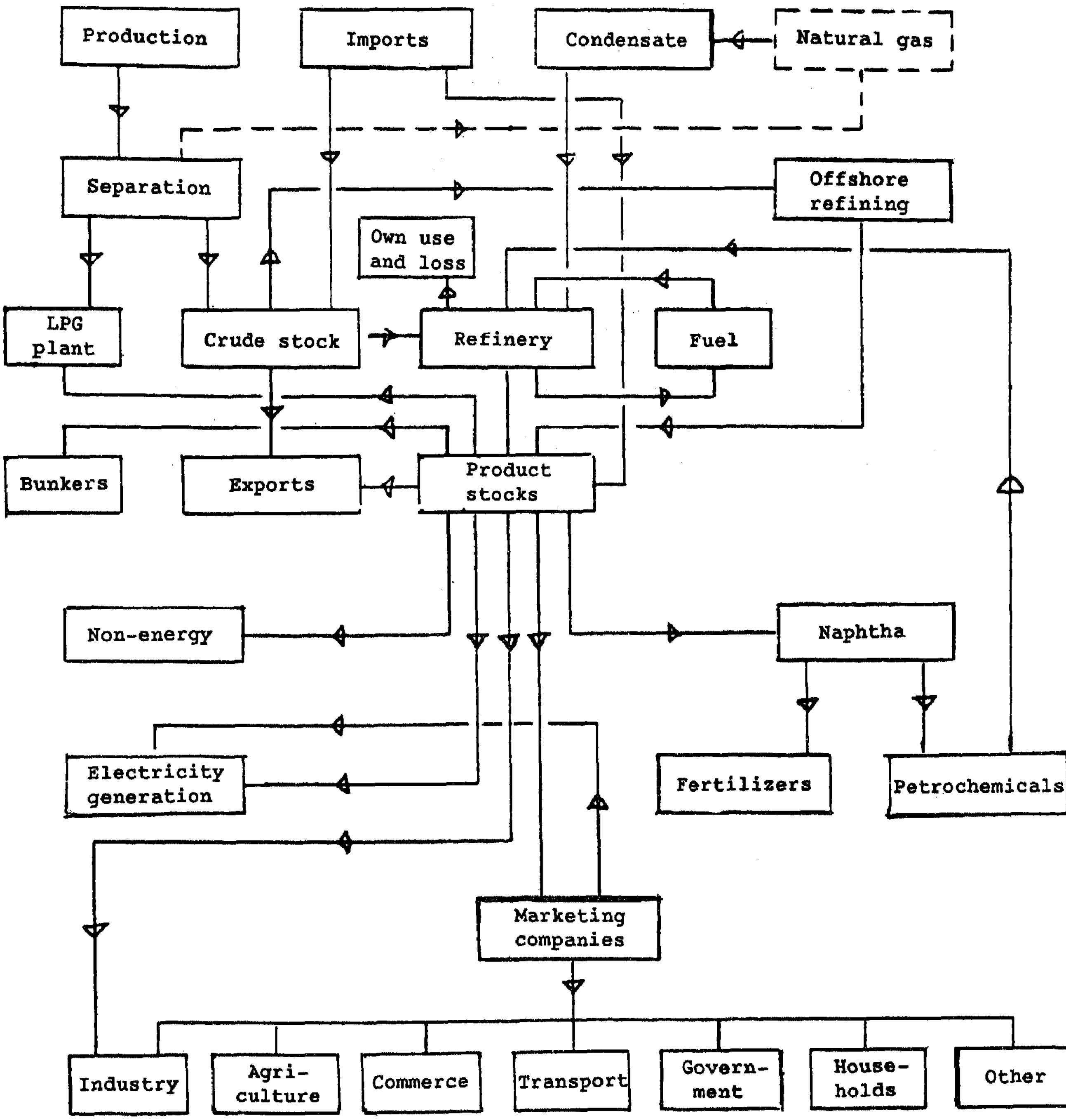
Annex III

COAL: FLOW CHART



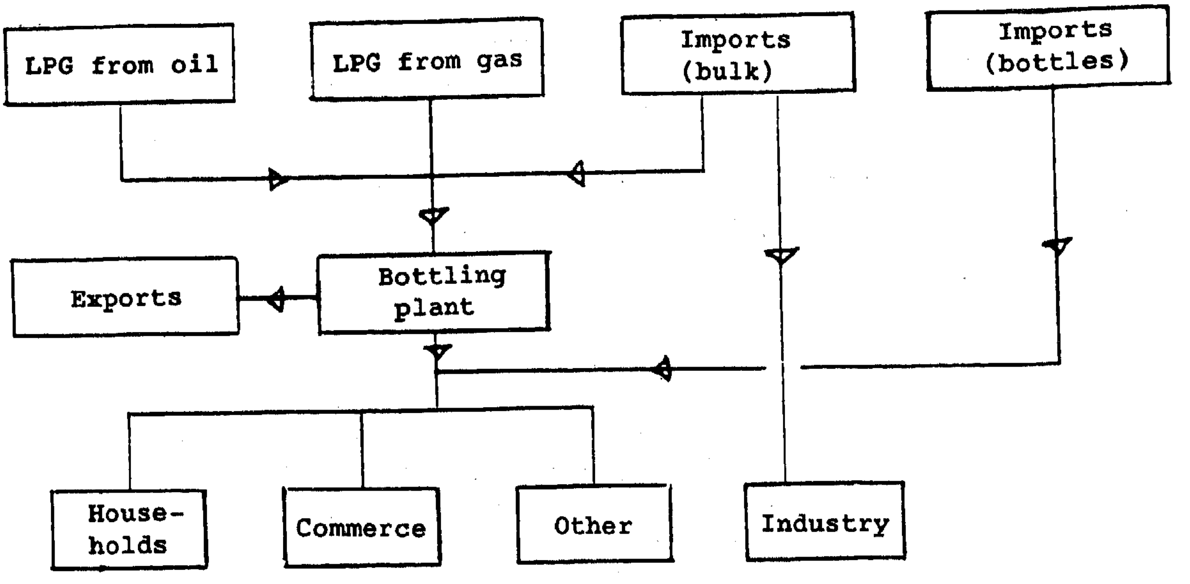
Annex IV

CRUDE OIL AND PETROLEUM PRODUCTS: FLOW CHART



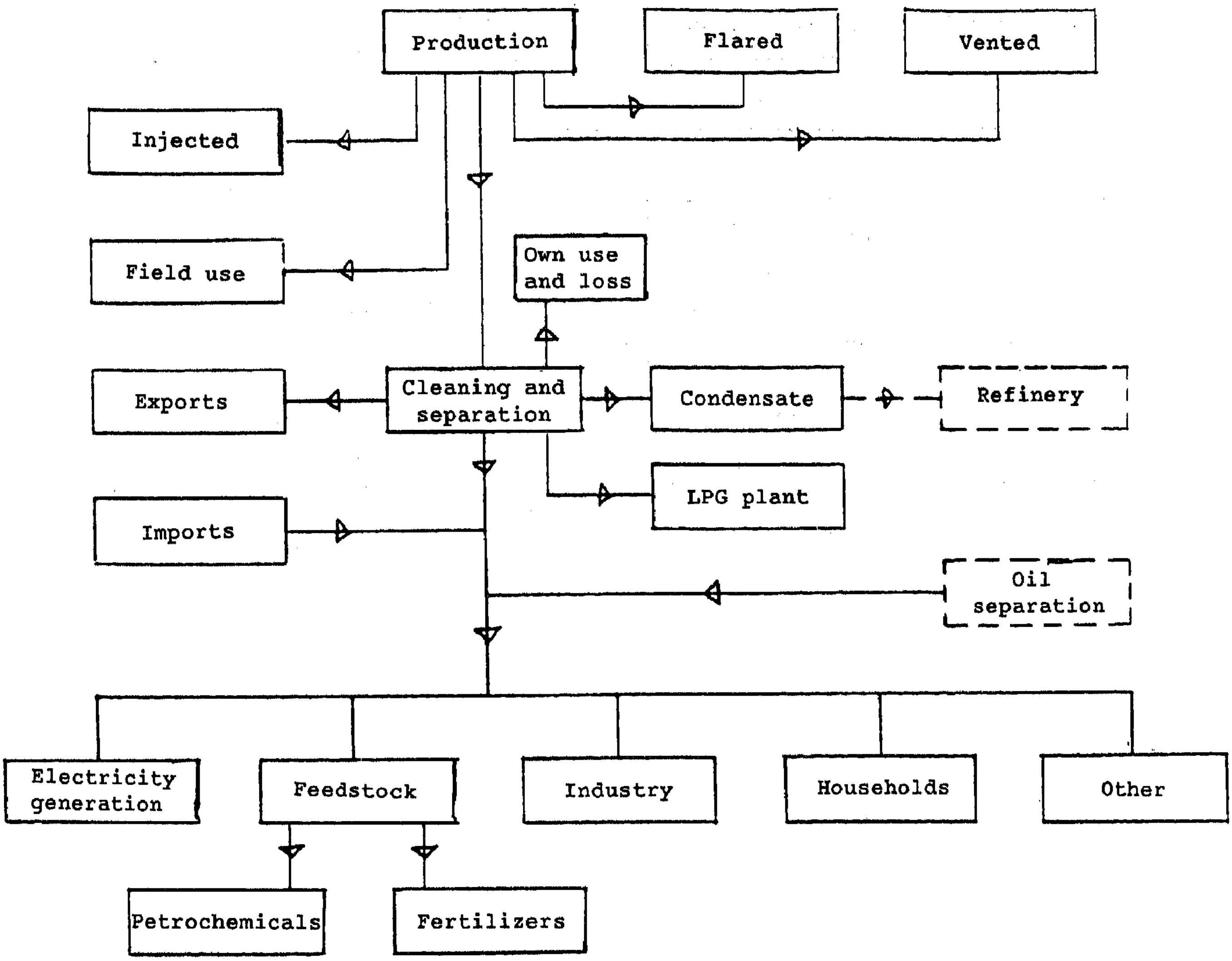
Annex V

LIQUEFIED PETROLEUM GAS (LPG): FLOW CHART



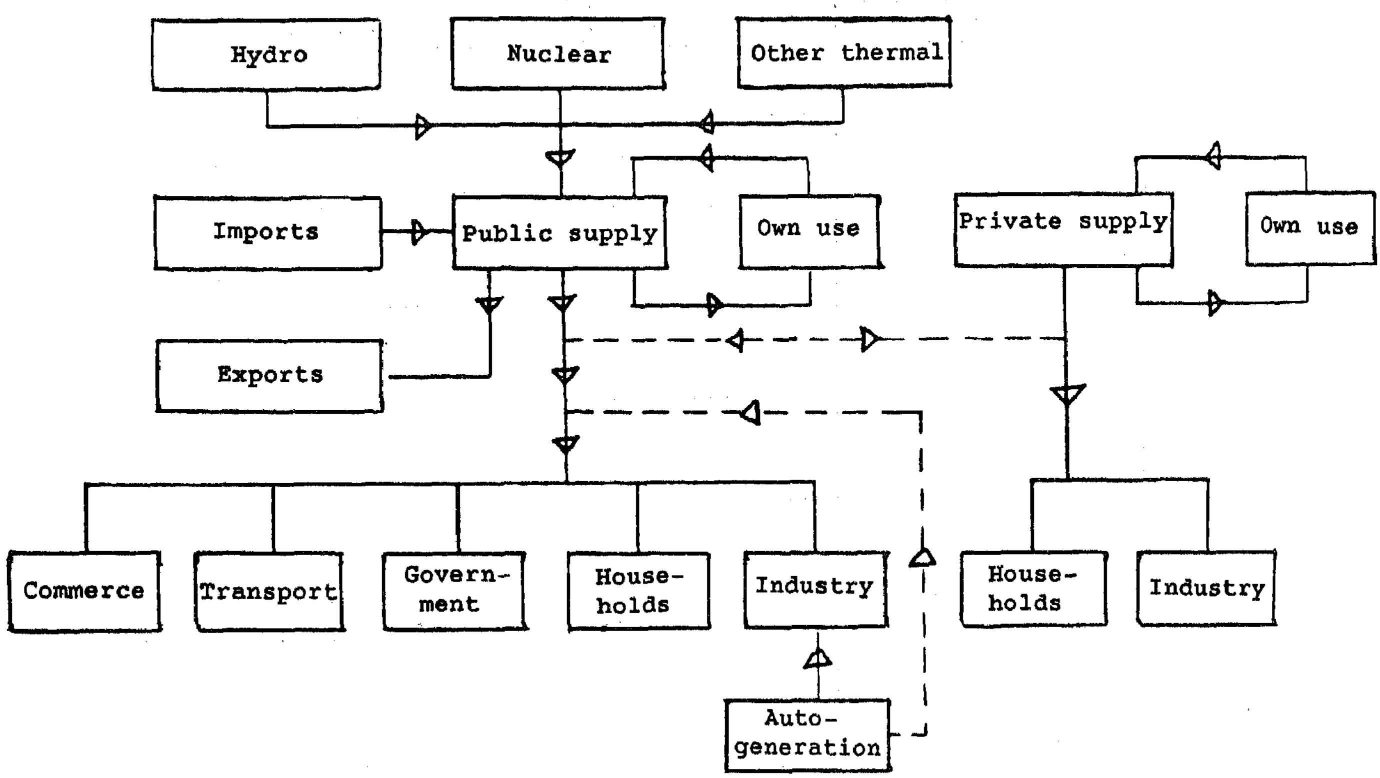
Annex VI

NATURAL GAS: FLOW CHART



Annex VII

ELECTRICITY: FLOW CHART



Annex VIII

ENERGY BALANCE LAYOUT

Unit: terajoules — Unité: terajoules

Energy sources and products Production et utilisation	Hard coal, lignite, peat Houile, lignite, tourbe (1)	Briquettes, cokes Agglomérés, cokes (2)	Crude petroleum and NGL Pétrole brut et GNL (3)	Light petroleum products Produits pétroliers légers (4)	Heavy petroleum products Produits pétroliers lourds (5)	Other petroleum products Autres produits pétroliers (6)	LPG and other petroleum gases GLP et autres gaz de pétrole liquéfié (7)	Natural gas Gaz naturel (8)	Derived gases Autres gaz dérivés (9)	Electricity Electricité (10)	Primary biomass energy Energie de biomasse primaire (11)	Derived biomass energy Energie de biomasse dérivé (12)	Other energy sources Autres sources d'énergie (13)	Total energy Energie totale (14)	Sources et produits d'énergie Production et utilisation
1. Production of primary energy															1. Production d'énergie primaire
2. Imports															2. Importations
3. Exports															3. Exportations
4. Marine/aviation bunkers															4. Soutes
5. Stock change															5. Variations des stocks
6. Total energy requirements															6. Total besoins énergétiques
7. Energy converted															7. Energie convertie
8. Briquetting plants															8. Usines de briquettes
9. Coke ovens and coke plants															9. Fours à coke et cokeries
10. Gasworks															10. Usines de gaz
11. Blast furnaces															11. Hauts fourneaux
12. Petroleum refineries															12. Raffineries de pétrole
13. NGL processing plants															13. Usines de GNL
14. Electric power plants															14. Centrales électriques
15. Heating plants															15. Centrales thermiques
16. Other conversion industries															16. Autres industries transform.
17. Net transfers															17. Transferts net
18. Consumption by energy sector															18. Consom. secteur énergétique
19. Losses in transport and distribution															19. Pertes transportations et distribution
20. Consumption for non-energy uses															20. Utilis. à fins non énergétiques
21. Statistical differences															21. Ecarts statistiques
22. Final consumption															22. Consommation finale
23. By industry and construction															23. Industries et constructions
24. Iron and steel industry															24. Industrie sidérurgique
25. Chemical industry															25. Industries chimique
26. Other industry and construction															26. Autres industries et constructions
27. By transport															27. Transports
28. Road															28. Transports routiers
29. Rail															29. Transports ferroviaires
30. Air															30. Transports aériens
31. Inland and coastal waterways															31. Transports fluviaux cabotage
32. By households and other consumers															32. Ménages et autres consommateurs
33. Households															33. Ménages
34. Agriculture															34. Agriculture
35. Other consumers															35. Autres consommateurs

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