What is Oil?

1. General information

Petroleum is a complex mixture of liquid hydrocarbons, chemical compounds containing hydrogen and carbon, occurring naturally in underground reservoirs in sedimentary rock. Coming from the Latin *petra*, meaning rock, and *oleum*, meaning oil, the word “petroleum” is often interchanged with the word “oil”. Broadly defined, it includes both primary (unrefined) and secondary (refined) products.

Crude oil is the most important oil from which petroleum products are manufactured but several other feedstock oils are also used to make oil products. There is a wide range of petroleum products manufactured from crude oil. Many are for specific purposes, for example motor gasoline or lubricants; others are for general heat-raising needs, such as gas oil or fuel oil.

The names of the petroleum products are those generally used in Western Europe and North America. They are commonly used in international trade but are not always identical to those employed in local markets. In addition to these oils, there are others which are “unfinished” oils and will be processed further in refineries or elsewhere.

Oil supply and use in industrialised economies are complex and involve both energy use and non-energy use. As a result, the indications of use given below can only be guides to general practice and not rigid rules. Annex 1 provides full explanations of the processes and activities mentioned within the questionnaire.

Oil is the largest traded commodity worldwide, either through crude oil or through refined products. As a consequence, it is essential to collect data as complete, accurate and timely as possible on all oil flows and products. Although oil supply continues to grow in absolute terms, its share in global total energy supply has been decreasing, from over 45% in 1973 to around 35% in recent years.

2. Specific information related to the joint questionnaire

The Oil Questionnaire covers oils processed in refineries and the petroleum products made from them. All sources of supply and the uses of the oils are to be included as well as their calorific values.

Crude oil is not the only feedstock to a refinery. Other primary or secondary oils can be used as feedstock: NGL, refinery feedstocks, additives and oxygenates and other hydrocarbons such as shale oil or synthetic crude oil from tar sands (see Table 4.1).

A whole range of petroleum products are derived from crude oil, varying from light products such as liquefied petroleum gas (LPG) and motor gasoline to heavier ones such as fuel oil.
Crude oil
Natural gas liquids
Other hydrocarbons
Additives/blending components
Refinery feedstocks
Refinery gas
Transport diesel
Ethane
Heating and other gasoil
Liquefied petroleum gases
Res. fuel: low-sulphur content
Naphtha
Res. fuel: high-sulphur content
Aviation gasoline
White spirit + SBP
Gasoline type jet fuel
Lubricants
Unleaded gasoline
Bitumen
Leaded gasoline
Paraffin waxes
Kerosene type jet fuel
Petroleum coke
Other kerosene
Other products

A full description of these primary and secondary oil products and their specifications are given in Annex 2. These specifications are important, because there are different oil product names in use for certain products in the world, for example “stove-oil” and “mazout”; their specifications should be obtained from suppliers so that the oils can be reported using the product names in the Oil Questionnaire.

**Essential**

*Petroleum is a complex mixture of liquid hydrocarbons occurring naturally in underground reservoirs.*
2 What Units are Used to Express Oil?

General information

Liquid fuels can be measured by their mass or volume. Within each of these measurements, several units are used in the oil industry:

- The most widely used unit of mass (weight) to measure oil is the metric ton (or tonne). For instance, tankers in the oil industry are often described on the basis of their capacity in tonnes, where an ultra large crude carrier (ULCC) is defined as being able to carry over 320 000 tonnes.

- The original unit for most liquid and gaseous fuels is volume. Liquids can be measured by the litre, the barrel, or the cubic metre. A common example of the use of volume as the unit of measurement is in the price of oil, quoted in dollars per barrel.

As liquid fuels can be measured by their mass or their volume, it is essential to be able to convert one into the other. In order to make this conversion, the specific gravity or density of the liquid is needed.

Because crude oil contains a wide range of hydrocarbons from the lightest to the heaviest, the characteristics, including the density, of individual crude oils vary greatly. Similarly, the density of the different petroleum products varies substantially between the products.

The density can be used to classify petroleum products from light to heavy, where for example LPG is considered light at 520 kg/m$^3$ while fuel oil is a heavy product at over 900 kg/m$^3$.

Please note: many countries and organisations use the tonne of oil equivalent (toe) when publishing energy balances. The toe unit which is based on calorific properties is used to compare oil with other energy forms and should not be confused with the mass measurement in tonnes.

Specific information related to the joint questionnaire

The units employed in the questionnaire are thousand metric tons. When other units of mass are used, data are to be converted to metric tons using conversion factors as found in Annex 3.

For volume to mass conversion, specific densities (see Section 3) should be used for both crude oil and petroleum products, including gases (for example refinery gas); however, in cases where these are not available, please use the average factor shown in Annex 3. Figures should be whole numbers without decimal places.

Essential

Oil data are reported in thousand metric tons in the questionnaire. Figures should be whole numbers without decimal places.
How to Make the Conversion from Volume to Mass?

General information

The oil industry in different parts of the world uses different units of measurement. For example, in Europe the metric ton is commonly accepted as the unit of measurement, while in the United States, the volume unit barrel is the unit of choice. In Japan, volume is also used for measuring oil supply and demand; however, the standard unit is the cubic metre.

As so many different units, both volume and mass, are used in the world, it is essential to be able to convert them into a common unit for purposes of comparison. The oil industry internationally uses mainly barrels (bbl) as its reference unit. For certain flows such as production and demand, it is barrels per day (b/d) which is commonly used.

As mentioned above, to convert from mass into volume or vice versa, the specific gravity or density of the oil must be known. Without going into too much technical detail, a few terms need to be explained in order to understand oil conversion factors.

Density is defined as mass per unit volume, i.e. tonne/barrel. The specific gravity is the relative weight per unit volume (or density) of a given substance compared to that of water. The density of water is 1g/cm³. Motor gasoline, for example, has a lower density as it is much lighter for the same volume. The specific gravity of motor gasoline is therefore smaller than 1. Since volume changes with changes in temperature, data on specific gravity are reported with a reference to a specific temperature (for petroleum, the reference is usually 15 degrees Celsius). Moreover, specific gravity is often quoted as a percentage, e.g. a specific gravity of 0.89 is shown as 89.

The term API gravity (a standard adopted by the American Petroleum Institute) is commonly used to express the specific gravity of petroleum.

Nota bene: API gravity is defined as: ( 141.5 / 60° specific gravity at 60° F ) – 131.5.

The result is an arbitrary scale for measuring gravity, expressed in degrees API, where the lighter a compound is, the higher its degree of API gravity. For example, what are considered light crudes are generally greater than 38 degrees API, while those with less than 22 degrees API are labelled as heavy crude oils.

Specific gravity and API gravity move in opposite directions. API gravity moves in the same direction as energy content per tonne, i.e. the higher the API gravity, the higher the energy content per tonne, whereas specific gravity moves in the same direction as energy content per unit volume.

Specific information

The Oil Questionnaire requires oil data to be reported in metric tons. It is therefore often necessary for national statisticians to convert volumetric data into metric tons. National statisticians should, to the extent possible, obtain information from the reporting enterprises on how quantities of crude oil and petroleum products have to be converted from volume to metric tons. This is particularly important for some
of the oil products in gaseous form (e.g. refinery gas, ethane, LPG) which have to be expressed in mass terms.

Density and gross calorific values of selected petroleum products can be found in Annex 3.

The following table offers an example of converting volume (in this case given in barrels per day) to mass (in metric tons) for two different months (January and February).

**Table 4.2 • Conversion from Volume to Mass – An Example**

<table>
<thead>
<tr>
<th>Imports</th>
<th>Reported data in barrels per day (volume)</th>
<th>Number of days/month</th>
<th>Density mass/volume (average)</th>
<th>Volume/mass conversion factor</th>
<th>Converted data in metric tons (mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil gasoline</td>
<td>1020</td>
<td>31</td>
<td>0.13569</td>
<td>1/0.13569=7.37</td>
<td>(1020x31)/7.37=4290</td>
</tr>
<tr>
<td>Motor gasoline</td>
<td>546</td>
<td>28</td>
<td>0.11806</td>
<td>1/0.11806=8.47</td>
<td>(546x28)/8.47=1805</td>
</tr>
</tbody>
</table>

**Essential**

*In the questionnaire please convert liquid fuels from volume to mass by using appropriate conversion factors based on actual density.*

4 Oil Flows

General information

The flow of oil from production to final consumption is complex owing to the variety of elements in the chain. The diagram below provides a simplified view of this flow, covering supply of inputs to the refinery, supply of finished products to the end-user, and the petrochemical flows which interact in the process. These main links in the supply chain will be further discussed below.

**Figure 4.1 • Simplified Flow Chart for Oil**
Production of primary and secondary products, trade, stocks, energy sector, transformation, and final consumption are the main elements to be known in order to have a comprehensive view of the flow of oil in a country.

**Specific information related to the joint questionnaire**

The *Oil Questionnaire* consists of six tables. The nature of each table is as follows:

- **Table 1:** Supply of Crude Oil, NGL, Refinery Feedstock, Additives and Other Hydrocarbons
- **Table 2A:** Supply of Finished Products
- **Table 2B:** Deliveries to the Petrochemical Sector
- **Table 3:** Gross Deliveries by Sector
- **Table 4:** Imports by (country of) Origin
- **Table 5:** Exports by (country of) Destination
- **Table 6:** Inputs to Autoproducer Electricity and Heat Generation

It is essential that the figures reported in each table are correctly totalled and that the totals in the different tables are consistent with each other where a logical relationship exists. These table relationships are illustrated in the following diagram:

**Figure 4.2  Table Relations within the Oil Questionnaire**
The following totals have to be consistent between the various tables:

- **Products Transferred** as Refinery Feedstocks in Table 1 should correspond to total **Products Transferred** in Table 2A. The total of **Direct Use** in Table 1 should correspond to the total of **Primary Product Receipts** in Table 2A.

- **Imports by Origin** in Table 4 should be summed, and the sum should be reported under **Total Imports** in Table 1 and Table 2A.

- **Exports by Destination** in Table 5 should be summed, and the sum should be reported under **Total Exports** in Table 1 and Table 2A.

- **Total Gross Inland Deliveries** in Table 2B should correspond to **Gross Inland Deliveries (observed)** in Table 2A. **Backflows from Petrochemical Sector to Refineries** in Table 2B should correspond to **Backflows from Petrochemical Industry** in Table 1.

- **Gross Inland Deliveries** in Table 3 should correspond to **Gross Inland Deliveries (observed)** in Table 2A.

All of the oil entering the refinery should be balanced by total gross production of manufactured products plus any declared losses. So the following check applies:

\[ \text{Refinery Intake Observed (Table 1)} = \text{Gross Refinery Output (Table 2A)} + \text{Refinery Losses (Table 1)} \]

In addition, within the oil processes and activities, there are reclassifications of oil products in which the name of the product changes. For example, a quantity of oil imported as “gas oil” may be used as a “feedstock” and reported under each of the names in different tables of the questionnaire.

The corresponding checks on the consistency of the amounts reported are described below. Specific issues affecting reporting and definitions of flows are also described.

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**Essential**

Please remember the interrelationships between the tables in the questionnaire. Key totals should be consistent

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**Oil Supply**

The oil supply chain is fairly complex, as several types of feedstock are inputs to refineries, and the resulting output is a wide variety of products with many uses. Moreover, the petrochemical industry is a specific case where oil products are used as feedstocks and oil by-products are returned for further processing. The following paragraphs will first describe these three portions of the supply chain, namely: supply of crude oil, supply of finished products, and flows of the petrochemical industry. Information on trade and stocks common to the supply of crude oil and finished products follows the explanations of the petrochemical industry.
Supply of crude oil, NGL, refinery feedstocks, additives and other hydrocarbons

General information

A flow chart of the various feedstocks from production to refinery input is shown in the diagram below. This flow chart is voluntarily simplified in order to give an overall view of the supply chain for crude oil, NGL, refinery feedstocks and other inputs.

Figure 4.3 • Supply of Crude Oil, NGL, Refinery Feedstocks, Additives and Other Hydrocarbons

A number of the flows illustrated above require further explanation:

Indigenous Production: Before describing the production process of crude oil, it is necessary to mention that oil production has two meanings, depending on whether referring to primary or secondary products. For primary products, Indigenous Production of crude oil, natural gas liquids and condensates refers to the process of extracting these oils from the earth. In the case of secondary products, Refinery Output refers to the production of finished products at a refinery or blending plant (see section below on Supply of finished products).

Crude oil can be produced from different locations, onshore or offshore fields or from different types of wells, in association with natural gas or not. Any gas extracted from associated oil wells may be flared, vented, reinjected or form part of natural gas production (see Chapter 3 on Natural Gas).

When crude oil is produced from the well, it is a mixture of oil, water, sediment and dissolved gases (methane, ethane, propane, butane and pentanes). In the first instance, all gases are separated from the oil/water mixture. The gases are extracted because of their higher value and readily marketable state, such as propane and butane which are liquefied petroleum gases (LPG). In a later stage, the sediment and other unwanted substances are removed in treatment plants.
The gases are separated in a wellhead separation plant from onshore wells; from offshore wells, this happens through a separator on the platform. The methane will form the constituent of natural gas, while the other constituents form the natural gas liquids (NGL). Natural gas liquids, however, can also be produced in conjunction with natural gas.

Crude oil is very diverse; its characteristics can vary widely. Economically, the most important characteristics are its specific gravity and the sulphur content, as these will be instrumental in determining the price of the crude oil.

To complete the supply balance, other inputs such as additives, oxygenates and other hydrocarbons also need to be included in the production data. Additives and oxygenates are those substances (usually non-hydrocarbon compounds) which are added to fuels to improve their properties, e.g. oxygenates increase the amount of oxygen in motor gasoline.

In the Other Hydrocarbons category are included the production of products such as emulsified oils (e.g. orimulsion) and synthetic crude oil from tar sands. This product category also covers shale oil, liquids produced from the coal liquefaction process, hydrogen and other such products.

Refinery Intake is the total amount of oil (including additives, oxygenates and other hydrocarbons) to have entered the refinery process. Refinery throughput refers to this intake and the corresponding output of refined products, described below as refinery gross output in the section Supply of finished products. The difference between this intake and output is the losses that occur in the refining process, such as evaporation during distillation.

**Specific information related to the joint questionnaire**

*Indigenous Production* in Table 1 of the questionnaire should include only marketable production of crude oil, NGL, and other hydrocarbons.
There are a number of other categories contributing to production in the supply of products to the refinery which are outlined below. For explanations on trade and stock levels and changes, please consult the appropriate sections which follow.

From Other Sources: These are oils whose production has been covered in other fuel balances. For example, the conversion of natural gas into methanol to be used as a gasoline component, the production of oil from liquefaction of coal or shale oil production from oil shale. Inputs of these oils should be reported as from Other Sources if the production of the primary energy form is already covered in other fuel balances, e.g. synthetic oil from coal liquefaction: the production of coal is covered in the Coal Questionnaire, the inputs into the coal liquefaction plant are in the Transformation Sector of the Coal Questionnaire (Table 1), while the synthetic oil resulting from this process is reported as from Other Sources of Other Hydrocarbons in the Oil Questionnaire.

Backflows from Petrochemical Industry are oils returned to the refinery from processes in the petrochemical industry. They are by-products of processing feedstock oil supplied to the petrochemical enterprises by the refinery. The refinery may use the backflows as fuel or include them in finished products. Total Backflows from Petrochemical Industry reported in Table 1 should be identical to backflows reported in Table 2B.

Products Transferred are oils which are reclassified under another name. There is a corresponding row in Table 2A in which the amounts to be transferred are reported. The need for reclassification arises when semi-finished products are imported for use as feedstock in the refinery and therefore appear in the import data shown in Table 2A. The amounts to be used as feedstock are shown as negative quantities in the Products Transferred row in Table 2A and the total of all products transferred is then reported as a positive quantity in the Refinery Feedstocks column of Table 1.

Refinery Losses are mass differences which appear between the total oil throughput of the refinery (reported as Refinery Intake Observed in Table 1) and the total gross production of finished products (reported in Table 2A). The losses arise through genuine oil losses and the conversion of refinery statistics used within the refineries to mass units.

Direct Use is amounts which do not enter the refinery but enter consumption directly. The “direct use” of crude oil and/or NGL outside refineries must also be reported in Table 2A so that their subsequent disposal can be accounted for. In this case, any figures entered under Direct Use for crude oil and NGL should be equal to those shown in Table 2A, Primary Product Receipts.

The formula for Refinery Intake (Calculated) is the sum of production, inputs from other sources, backflows, transfers (as individually mentioned above), and amounts of imports and stock change, after deducting exports and direct use.

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**Essential**

*Indigenous production concerns marketable production within national boundaries, including offshore production.*

*Refinery intake is the total amount of oil to have entered the refinery process.*
Supply of finished products

General information

A simplified flow chart of the supply chain from the refinery to the end-user is shown below.

Figure 4.5 - Supply of Finished Products

Crude oil as it comes out of the ground is a raw material with limited use. Although it can be used as a burning fuel, the real potential of crude oil is reached when it is refined into a range of products, which will be useful for specific purposes to the final consumer (e.g. gasoline for transportation). The objective of refining is to add value to the raw material, as the total of the refined products should be more valuable than the feedstock.

There are many refinery processes used to transform crude oil. The first basic phase, however, in the refinery process is distillation. Crude oil is heated and fed into a fractionating column at atmospheric pressure, resulting in a separation of the crude oil into 4-6 broad cuts. Beyond the atmospheric distillation unit are more complex units, in which each stream is redistilled to provide a better yield and more precise cut of the final products. For more detailed information, please consult Annex 1, Section 2.

Specific information related to the joint questionnaire

Refinery Output is reported in Table 2A. There are a number of other categories contributing to production in the supply of finished products. These are outlined below.

Primary Products Receipts is the row which brings into Table 2A the crude oil and NGL reported as Direct Use on Table 1 so that the disposal can be shown. NGL
Essential

Refinery output should be reported as gross, including any fuels used by the refinery in support of its operations.
Petrochemical flows

General information

While petroleum products main uses are for their energetic properties, there are a number of non-energy uses of petroleum, most notably in the petrochemical industry. Petrochemicals are chemicals derived from petroleum, and used as the basic chemical building blocks for a variety of commercial products. Dating back to the early 1920s, the petrochemical industry today is very diverse, supplying the raw materials for the manufacturing of plastics, synthetic fibres and rubbers, fertilisers, pesticides, detergents and solvents. Industries as diverse as textile, food, pharmaceutical, automobile, and paint manufacturing use petrochemicals. Petrochemical feedstocks are created from a number of petroleum products, mainly naphtha, LPG and ethane.

The petrochemical industry, however, is not only a large consumer of petroleum products, it is also a producer of petroleum products, as it extracts the necessary components for production of petrochemicals and then returns the by-products to the refineries or to the market.

The flow chart below illustrates the flow scheme between refineries and petrochemical plants.

Figure 4.6  Deliveries to the Petrochemical Sector

Specific information related to the joint questionnaire

Petrochemical flows are reported in Table 2B. The details of these flows are outlined below.

Gross Deliveries should represent the total quantity of each oil product delivered to the petrochemical companies for feedstock use. It should not be a “net” flow, that is, any oils returned to the refinery from the petrochemical companies should not be subtracted from the deliveries. The feedstock may also cover some or all of the fuel requirements of the industrial process using the feedstock. However, it should not include oils which are used as general purpose fuels unrelated to the process.
Energy Use in the Petrochemical Sector should be the amount of the delivered feedstock oils used as fuel during their processing. The fuels are some of the by-product gases obtained from the feedstock oils during processing. The fuel use information must come through the petrochemical companies that may be able to provide it through the refineries if there is joint refining and petrochemical processing on the site.

Backflows from Petrochemical Sector are oils returned to the refinery from processes in the petrochemical industry. They are by-products of processing feedstock oil supplied to the petrochemical enterprises by the refinery. The refinery may use the backflows as fuel or include them in finished products.

**Essential**

Gross deliveries to the petrochemical sector are oil products used as raw material in the manufacture of petrochemicals.

Products returning to the refinery for further processing or blending should be reported as backflows.

**Imports and exports**

**General information**

One of the basic economic realities of oil is that it is often found in areas far removed from the consuming markets. Two-thirds of the reserves of crude oil are either in the Middle East or in Russia, while almost 90% of the oil is consumed in other areas.

This is why oil needs to be shipped from producing zones to consuming regions. As oil is a liquid and compact form of energy, transportation is made relatively easy. Oil can be transported in tankers, pipelines, railways and trucks, and a vast transportation network exists between producing and consuming regions.

The information required on origins and destinations of the imported and exported oil is of prime importance. Indeed it is important for a country to know from which export country it is dependent for its oil supplies, as in case of an export supply crisis, it can determine how much is imported from that particular country. Similarly, although slightly less important, it is useful to know what the destinations are of the oil exports, so that in case of disruption it is known which export countries will be affected.

**Specific information related to the joint questionnaire**

The trade figures are reported in several tables of the questionnaire. The total import and export numbers are reported as totals in the supply balance tables; the disaggregated data by origin and destination are requested in other tables.

The sum of all imports from all origins must equal imports reported for each product in the supply tables. Similarly, the sum of all exports by destination must equal exports reported for each product in the supply tables.
Precise definitions of the geographical scope of national territories of certain countries covered by the annual Oil Questionnaire are given in the questionnaire’s reporting instructions, under Geographical Definitions.

Amounts are considered as imported or exported when they have crossed the national boundaries of the country, whether customs clearance has taken place or not.

Quantities of crude oil and products imported or exported under processing agreements (i.e. refining on account) should be included. Re-exports of oil imported for processing within bonded areas (or free-trade zones) should be included as an export of product to the final destination.

Any gas liquids (e.g. LPG) extracted during the regasification of imported liquefied natural gas should be included as imports in this questionnaire. Petroleum products imported or exported directly by the petrochemical industry should be included.

Import origins or export destinations not listed individually on the trade tables are to be reported under the appropriate Other category (Other Africa, Other Far East, etc.) as shown in Annex 1 of the annual Oil Questionnaire. Where no origin or destination can be reported, the category Not Elsewhere Specified should be used.

Statistical differences may arise if imports and exports are available only on a total basis (from customs or refinery surveys) while the geographical breakdown is based on a different source of information. In this case, report the differences in the Not Elsewhere Specified category.

Crude oil and NGL should be reported as coming from the country of ultimate origin; refinery feedstocks and finished products should be reported as coming from the country of last consignment. In both cases it is the country where the oil is produced which is the reported origin. For primary oils, i.e. crude oil and NGL, it is the country where it was indigenously produced; for secondary oils, it is the country in which they were refined or processed.

Data are to be reported in thousand metric tons. All values should be rounded to zero decimal places and negative values are not allowed.

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### Essential

**Crude oil and NGL should be reported as coming from the country of ultimate origin.**

**Refinery feedstocks and finished products should be reported as coming from the country of last consignment.**

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### Stock levels and changes

#### General information

Oil stocks are a critical element of information in an oil balance. The majority of oil stocks are essential to keep the global supply system operating. Stocks allow for the balance between supply and demand; stocks are drawn to help meet demand...
when supply falls short, while a stock build offers an outlet for oil products to flow when supply exceeds demand. Not to include stock data in the oil balance leads to a lack of transparency in the market. The trend in stocks is important for many oil analysts when making an evaluation of the oil market situation.

Stocks are a leading indicator of prices: the level of oil stocks often determines the price, e.g. when oil stocks are low it means that there may be a shortage or a need for replenishing, which indicates that prices might be rising. On the other hand, if the industry is amply supplied with the right oil, there may be a price reduction expected. This is why it is important to have information on the situation of oil stocks in the world.

Information on product stocks can be as important as crude oil stocks. For example, crude oil stocks give an indication of the availability of crude to refineries in each country, and therefore are evidence on how well the refineries might provide the domestic market. On the other hand, information on low gasoline stocks before the driving season, or low heating oil stocks before the winter can be a warning signal to refineries, oil companies and governments that not only prices could rise, but shortages might possibly occur – e.g. heating oil problems experienced in autumn 2000.

Data on oil stocks are of particular importance for strategic decisions made by governments or larger oil companies. Aggregate and timely stock information is needed in order to look at longer-term planning so as to ensure adequate supplies to meet demand. Governments require extensive stock information so that they can react appropriately when oil supply disruptions occur (both nationally and internationally). Oil stocks are a critical element of information in an oil balance.

**Primary stocks** are held by the various companies supplying the markets: ranging from producers, refiners to importers. They are held in refinery tanks, bulk terminals, pipeline tankage, barges and coastal tankers (if they stay in the same country), tankers in port (if they are to be discharged at port) and in inland ship bunkers. Additionally, stocks held for strategic purposes by governments (e.g. US Strategic Petroleum Reserve) or by stockholding organisations (e.g. EBV in Germany) are included in the primary stock category.

**Secondary stocks** are stocks in small bulk plants (marketing facilities below a certain capacity, e.g. 50 000 barrels in the United States, which receive their products by rail or truck) and retail establishments.

**Tertiary stocks** are stocks held by end-consumers; these can be power plants, industrial entities or consumers in the residential/commercial sector.

**Specific information related to the joint questionnaire**

Please note that when referring to stock data, the terms primary and secondary may be used in a slightly different context than when talking about primary and secondary products as mentioned above in Section 1 What is Oil?

The annual Oil Questionnaire collects data for primary stocks on national territory. Secondary and tertiary stocks, as well as stocks held in oil pipelines, are not included. Pipeline amounts are not included as the amounts are not available for use, i.e. the pipeline cannot function without its contents which are available only when the pipeline is emptied.
Oil stocks and stock changes are to be reported in the supply balance tables. Opening Stock level is the amount of primary stocks on national territory measured on the first day of the year being reported (1st January, unless a fiscal year is used). Closing Stock is the amount of primary stocks on national territory measured on the last day of the year being reported (31st December, unless a fiscal year is used). The Stock Change is calculated as the opening stock level minus the closing stock level. Thus, a stock build is shown as a negative number, and a stock draw as a positive number.

**Essential**

Stock changes should reflect the difference between opening stock level and closing stock level for primary stocks held on national territory.

## Oil Consumption

Petroleum products are consumed in many areas. They are easily recognised in the gasoline used to fuel cars and the heating oil used to warm homes. Less obvious are the uses of petroleum-based components of plastics, medicines, food items, and a host of other products.

Oil consumption occurs in the following main sectors:

- In the transformation sector.
- By the energy industries in the energy sector.
- In the transportation and distribution of oil (although limited).

*Figure 4.7* Oil Consumption by Sector
In the various sectors and branches of final consumption (industry, residential, etc.), including both energy and non-energy uses of oil.

A short description of these sectors is given in the next paragraphs, highlighting the impact of the specificity of the end-use sector on statistics. For general information, refer to Chapter 1, Fundamentals, Section 8.

Consumption of oil in the transformation sector

General information

The quantities of oil used in the process of transformation of oil to another energy form should be reported in the transformation sector. This largely consists of oil products burnt in order to produce electricity or heat, but covers all instances of oil products being converted into another form of energy. Examples of this include oil products used in coke ovens, blast furnaces, oil used to produce gas in a gasification plant, or as binding materials in producing patent fuels.

The use of oil products in the generation of electricity has been in steady decline since the 1970s. Representing almost 25% in 1973, inputs of oil for electricity generation have declined at a rate of 2.4% per annum since, and currently account for less than 8% of world electricity generation.

Specific information related to the joint questionnaire

Electricity and Heat Generation: Electricity and heat plants are divided according to their main business purpose (public or autoproducer) and the types of energy they produce (electricity, heat, or both).

Total amounts of oils delivered to power plants for electricity generation only should be included in the Transformation Sector. Quantities shown as used at stations containing combined heat and power (CHP) units should represent only the fuel used for electricity generation and for generating heat for sale. Fuel reported as delivered to autoproducer heat-only plants should be the amount used to produce heat for sale. The quantities of fuel consumed by the autoproducer plants for the production of heat which is not sold will remain in the figures for the final consumption of fuels by relevant sector of economic activity. Please refer to Chapter 2 on Electricity and Heat for further information.

Blast Furnaces: Report only the oils which are injected into the blast furnaces. Use of oils elsewhere on the iron and steel site or for the heating of air for blast furnaces will be reported as final consumption or energy sector use. See notes on blast furnaces in Annex 1.

Petrochemical Industry: See above section on Petrochemical flows. From the energy statistician’s viewpoint, the petrochemical conversion of feedstock input into “backflows” returned to refineries is a fuel conversion process. The inputs to the process should therefore be reported in the transformation sector. The contribution of the different feedstock types to the backflows cannot be known with any certainty.
and so a simple model approach is adopted to estimate the transformation input quantities.

To keep the total fuel use figures correct and avoid double counting, the quantities reported in the transformation sector must be subtracted from the final consumption by the chemical and petrochemical industry reported later in the questionnaire.

**Essential**

In the transformation sector, only report oil and oil products transformed into other forms of energy.

Consumption of oil in the energy sector

**General information**

Besides being used in the transformation sector as detailed above, oil products can be used by the energy industry to support energy production. This is, for example, oil used in a coal mine in support of the extraction and preparation of coal within the coal-mining industry. This is consumption of oil used for heating, operating a generator, pump or compressor by the energy sector to support the extraction or transformation activity.

**Specific information related to the joint questionnaire**

Report in the Energy Sector the quantities of oils consumed within the fuel and energy enterprises in the sense that they disappear from the account rather than appear after transformation as another energy commodity. The commodities are used to support the various activities within the fuel extraction, conversion or energy production plant, but they do not enter into the transformation process.

Note that quantities of oil transformed into another energy form should be reported under the Transformation Sector. Care should be taken to distinguish between oils used for heat-raising in the activity and those used for transport. Transport fuels should be reported in the Transport Sector. Thus, oil consumed in support of the operation of oil and gas pipelines should be reported in the Transport Sector.

In the case of blast furnaces, report only the quantity of oil (if any) used to heat blast air. Oils injected into the blast furnace should be reported as transformation use.

**Essential**

In the energy sector, only report oil used by the energy industries to support the extraction or transformation activity.
Oil transport and distribution losses

General information

The transportation and distribution of petroleum products often involve multiple episodes of handling and storage. There are four main means for transporting petroleum as it moves from the wellhead to the refinery and on to the final consumer: by sea, pipeline, railway and roadway. Storage facilities along the transportation route facilitate the movement of the products. These are often found between the different means of transportation, such as at ports where tankers are offloaded and products continue via pipeline.

In the course of this transportation, there are a number of ways in which some amounts of oil can be lost from the supply stream. The most spectacular example of this is when a tanker spills at sea, such as in 1989 when nearly 250,000 barrels of crude oil were spilled off the coast of Alaska. Pipeline leakage, train car derailments and tanker truck accidents are also possible sources of losses along the transportation and distribution chain.

Specific information related to the joint questionnaire

The category Distribution Losses (Table 3) should include all losses which occur during transportation and distribution, including pipeline losses.

If no distribution losses have been reported, check with the reporting entity whether reported losses have not been included with the statistical difference. If independent measures exist to determine the transportation and distribution losses, then these amounts should be reported in the appropriate category and not included with the statistical difference.

Losses are to be reported in thousand tonnes, values reported are positive numbers.

Essential

All quantities of oil products lost during transportation and distribution should be reported in distribution losses.

Final consumption

General information

Final consumption is all energy used by final consumers in the transport, industry, and other sectors (residential, commerce, public services and agriculture). It excludes all oil used for transformation and/or own use of the energy-producing industries.

While oil's share in world total energy supply has been decreasing over the last 30 years, world oil consumption has nevertheless grown during this period. This growth has come almost entirely from the transport sector’s energy demand, as alternatives to oil for use in transportation have proven difficult to develop.
Currently at 57%, transport accounts for the largest portion of total world final consumption of oil. This is an increase on 1973 levels, where the transport sector consumed over 42% of the world total. Industry and “other sectors” have both fallen from their 1973 level of just over 26% and 25% respectively, to roughly 20% and 17% at present.

Data are collected for energy and non-energy (feedstock) use of oil in the sectors and branches of final consumption. The most important use as feedstock is in the chemical and petrochemical industry.

**Specific information related to the joint questionnaire**

**Transport Sector**

The figures reported here should relate to use in the transport activity itself and not to consumption by the transport company for non-transport purposes. Similarly fuels consumed for transportation in industries or other sectors should be considered consumption in the transport sector and not for the industrial or other sector activity.

**Aviation**: Figures for quantities of aviation fuels delivered to aircraft should be divided between domestic and international flights. Domestic flight fuel use should include quantities used for military aircraft. International flights are defined in a manner similar to the definition of international sea voyages. Any flight for which the next landing is in a foreign airport is an international flight. All other flights are domestic.

**Road Transport**: Report quantities used by any type of vehicle for transportation on public roads. Off-road use should be excluded.

**Rail**: Include all oils used for diesel-propelled locomotives for freight, passenger traffic and movements of locomotives for rolling stock management.

**Inland Waterways (national navigation)**: Report oil consumption in vessels used in inland waterways and for coastal shipping. Oil fuels used in vessels undertaking international voyages must be reported as *International Marine Bunkers*. Oils consumed by fishing vessels must be reported under *Agriculture, Forestry and Fishing*.

**Industry Sector**

The definitions of the industrial branches shown in the questionnaire in terms of the economic activities they contain are given by reference to ISIC rev. 3 and NACE rev. 1. The definitions are given in the notes accompanying each of the annual questionnaires. The industry sector includes the construction branch but not the energy industries.

The figures reported in the *Industry Sector* for the consumption of fuels by enterprises should exclude quantities used to generate electricity and heat for sale and for transport on public roads (see the above section on *Consumption of oil in the transformation sector* and the paragraphs above on *Transport Sector*).

Quantities should include fuels used for all non-energy purposes but the non-energy quantities must also be reported in Table 3 so that they are identified separately.
Other Sectors

The branches of Other Sectors (Commerce and Public Services, Residential and Agriculture) are common to the annual questionnaires, and are detailed in Section 8 of Chapter 1: Fundamentals - Final Energy Consumption.

Non-energy Use

A number of fuels may be used for non-energy purposes, as raw materials in the different sectors. These are products which are neither consumed as a fuel nor transformed into another fuel. For further information, please refer to Section 8 of Chapter 1, Fundamentals - Non-energy Uses of Fuels.

Essential

Final consumption is all energy delivered to final consumers and does not include transformation or uses in the energy-producing industries.

Additional requirements for the Joint Questionnaire on Oil

Inputs to autoproduction

General information

With the growing importance of the environmental debate, it has become essential to identify total consumption of fuels in each respective industry and consuming sector, so that for each sector appropriate measures can be developed to conserve energy and reduce greenhouse gas emissions.

For general information and definitions for autoproduction, please refer to Chapter 2, Electricity & Heat, Section 1.

Specific information related to the joint questionnaire

Inputs to autoproducer electricity and heat production are reported on Table 6.

This table provides information on the fuel use by autoproducers of electricity and heat for sale according to their principal economic activity. The table is separated into three parts corresponding to three recognised types of generating plant: Electricity-only, CHP, and Heat-only. The data are used for tracking fuel inputs and electricity and heat outputs by autoproducers as part of the United Nations efforts to understand CO₂ emissions.

In the case of CHP plants, reporting separate figures for the amounts of fuel used for the production of electricity and heat requires a method of dividing the total fuel use between the two energy outputs. The division is required even if no heat
is sold because the fuel use for electricity production must be reported in the Transformation Sector. The method proposed is described in Annex 1, Section 1 of the Manual and should be followed carefully.

Please note that the totals reported in this table should equal the respective totals reported in the Transformation Sector (Table 3). Also note that a similar table is included with the Electricity and Heat Questionnaire. To avoid inconsistent reporting, please contact the person responsible for the completion of the electricity questionnaire in your country.

**Essential**

*Report oil used by autoproducers as input for electricity and heat (sold) production in the respective sectors.*
Annex 3
Units and Conversion Equivalents

1 Introduction
The most common units employed to express quantities of fuels and energy are those relating to volume, mass and energy. The actual units employed vary according to country and local conditions and reflect historical practice in the country, sometimes adapted to changing fuel supply conditions.

This annex will first describe the various units in use and their interrelationships. It will then provide reference ranges for calorific values of fuels in common use.

2 Units and their Interrelationships
The internationally recognised units which cover almost all of the measurements of fuel and energy quantities are the cubic metre, tonne (metric ton) and joule. They are derived from the metre, kilogramme and second included in the Système International d’Unités (SI) and serve as an international basis for science, technology and commerce. These are the SI units. However, over many years other units have been used and the sections below will list their relationships where they are well defined.

3 Decimal System Prefixes
The following table gives the most common multiple and sub-multiple prefixes used in energy statistics. Note that the prefixes should be used exactly as given. In particular, prefixes in lower case should never be written as upper case. For example, a figure expressing x kilowatts should be written as x kW, never x KW.

Table A3.1 • Most Common Multiple and Sub-multiple Prefixes

<table>
<thead>
<tr>
<th>Multiple</th>
<th>Sub-multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^1$</td>
<td>deci (d)</td>
</tr>
<tr>
<td>$10^2$</td>
<td>centi (c)</td>
</tr>
<tr>
<td>$10^3$</td>
<td>milli (m)</td>
</tr>
<tr>
<td>$10^6$</td>
<td>micro (µ)</td>
</tr>
<tr>
<td>$10^9$</td>
<td>nano (n)</td>
</tr>
<tr>
<td>$10^{12}$</td>
<td>pico (p)</td>
</tr>
<tr>
<td>$10^{15}$</td>
<td>femto (f)</td>
</tr>
<tr>
<td>$10^{18}$</td>
<td>atto (a)</td>
</tr>
</tbody>
</table>
Conversion Equivalents

Please note that a user-friendly electric unit converter for Volume, Mass and Energy is provided on the IEA web site at www.iea.org. When on the site, click on Statistics then click on Unit Converter and follow the instructions.

Units of volume

The unit of length underlies the unit of volume (metre, centimetre, etc.).

The gallon and litre were originally standards of liquid measure but are now formally defined in terms of the cubic metre.

The stere and cord are used exclusively for fuelwood measurement and represent 1 cubic metre and 128 cubic feet of stacked fuelwood, respectively. The actual volume of solid wood in each of the units is, therefore, ill-defined as the density of stacking and shape of the pieces of wood used can vary considerably.

Table A3.2 • Conversion Equivalents between Units of Volume

<table>
<thead>
<tr>
<th>From:</th>
<th>To:</th>
<th>gal U.S.</th>
<th>gal U.K.</th>
<th>bbl</th>
<th>ft³</th>
<th>l</th>
<th>m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. gallon (gal)</td>
<td>U.S. gallon (gal)</td>
<td>1</td>
<td>0.8327</td>
<td>0.02381</td>
<td>0.1337</td>
<td>3.785</td>
<td>0.0038</td>
</tr>
<tr>
<td>U.K. gallon (gal)</td>
<td>U.K. gallon (gal)</td>
<td>1.201</td>
<td>1</td>
<td>0.02859</td>
<td>0.1605</td>
<td>4.546</td>
<td>0.0045</td>
</tr>
<tr>
<td>Barrel (bbl)</td>
<td>Barrel (bbl)</td>
<td>42.0</td>
<td>34.97</td>
<td>1</td>
<td>5.615</td>
<td>159.0</td>
<td>0.159</td>
</tr>
<tr>
<td>Cubic foot (ft³)</td>
<td>Cubic foot (ft³)</td>
<td>7.48</td>
<td>6.229</td>
<td>0.1781</td>
<td>1</td>
<td>28.3</td>
<td>0.0283</td>
</tr>
<tr>
<td>Litre (l)</td>
<td>Litre (l)</td>
<td>0.2642</td>
<td>0.220</td>
<td>0.0063</td>
<td>0.0353</td>
<td>1</td>
<td>0.001</td>
</tr>
<tr>
<td>Cubic metre (m³)</td>
<td>Cubic metre (m³)</td>
<td>264.2</td>
<td>220.0</td>
<td>6.289</td>
<td>35.3147</td>
<td>1000.0</td>
<td>1</td>
</tr>
</tbody>
</table>

Units of mass

The SI unit of mass is the kilogramme (kg); the tonne (metric ton), equal to 1000 kilogrammes, is widely used as the smallest unit in energy statistics. For most countries, the national commodity balances will use the kilotonne (1000 tonnes) as the unit for presentation of commodities expressed in mass terms.
Energy units

The SI unit of energy is the joule (J). Many other units for energy are in use for the practical expression of energy quantities partly for historical reasons and partly because the small size of the joule demands the use of unfamiliar (for non-scientists) decimal prefixes. As a result, the international organisations have used units for energy of a size appropriate for expressing national fuel supplies and related to the commodities in use. Historically the ton of coal equivalent was used but, with the ascendance of oil, this has been largely replaced by the tonne of oil equivalent (toe) defined as 41.868 gigajoules. Many national balances use this unit but the terajoule is increasingly used in accordance with the recommendations by the International Standards Organization (ISO).

There are several definitions of the calorie in use. The conversion equivalent between the calorie and the joule given here is the International Steam Table (IT) value which is defined to be 4.1868 joules. Similarly, the internationally agreed value for the British thermal unit (Btu) is now 1 055.06 joules. The Btu is the basis for the quad (10^15 Btu) and the therm (10^5 Btu).

Table A3.3 • Conversion Equivalents between Units of Mass

<table>
<thead>
<tr>
<th>From:</th>
<th>To:</th>
<th>kg</th>
<th>t</th>
<th>lt</th>
<th>st</th>
<th>lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilogramme (kg)</td>
<td>1</td>
<td>0.001</td>
<td>9.84 x 10^{-4}</td>
<td>1.102 x 10^{-3}</td>
<td>2.2046</td>
<td></td>
</tr>
<tr>
<td>Tonne (t)</td>
<td>1000</td>
<td>1</td>
<td>0.984</td>
<td>1.1023</td>
<td>2204.6</td>
<td></td>
</tr>
<tr>
<td>Long ton (lt)</td>
<td>1016</td>
<td>1.016</td>
<td>1</td>
<td>1.120</td>
<td>2240.0</td>
<td></td>
</tr>
<tr>
<td>Short ton (st)</td>
<td>907.2</td>
<td>0.9072</td>
<td>0.893</td>
<td>1</td>
<td>2000.0</td>
<td></td>
</tr>
<tr>
<td>Pound (lb)</td>
<td>0.454</td>
<td>4.54 x 10^{-4}</td>
<td>4.46 x 10^{-4}</td>
<td>5.0 x 10^{-4}</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table A3.4 • Conversion Equivalents between Units of Energy

<table>
<thead>
<tr>
<th>From:</th>
<th>To:</th>
<th>TJ</th>
<th>Gcal</th>
<th>Mtoe</th>
<th>MBtu</th>
<th>GWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terajoule (TJ)</td>
<td>1</td>
<td>238.8</td>
<td>2.388 x 10^{-5}</td>
<td>947.8</td>
<td>0.2778</td>
<td></td>
</tr>
<tr>
<td>Gigacalorie</td>
<td>4.1868 x 10^{-3}</td>
<td>1</td>
<td>10^{-7}</td>
<td>3.968</td>
<td>1.163 x 10^{-3}</td>
<td></td>
</tr>
<tr>
<td>Mtoe*</td>
<td>4.186 x 10^4</td>
<td>10^7</td>
<td>1</td>
<td>3.968 x 10^7</td>
<td>11630</td>
<td></td>
</tr>
<tr>
<td>Million Btu</td>
<td>1.0551 x 10^{-3}</td>
<td>0.252</td>
<td>2.52 x 10^{-8}</td>
<td>1</td>
<td>2.931 x 10^{-4}</td>
<td></td>
</tr>
<tr>
<td>Gigawatt-hour</td>
<td>3.6</td>
<td>860</td>
<td>8.6 x 10^{-5}</td>
<td>3412</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*Million tonnes of oil equivalent.
5 Typical Calorific Values

Coals

Table A3.5 • Range of Calorific Values by Hard Coal Type

<table>
<thead>
<tr>
<th>Hard coals</th>
<th>GCV (as used) MJ/kg</th>
<th>NCV (as used) MJ/kg</th>
<th>Carbon content (as used) kg/t</th>
<th>Moisture content (as used) %</th>
<th>Carbon content (dmmf)* kg/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite</td>
<td>29.65 - 30.35</td>
<td>28.95 - 30.35</td>
<td>778 - 782</td>
<td>10 - 12</td>
<td>920 - 980</td>
</tr>
<tr>
<td>Coking coals</td>
<td>27.80 - 30.80</td>
<td>26.60 - 29.80</td>
<td>674 - 771</td>
<td>7 - 9</td>
<td>845 - 920</td>
</tr>
<tr>
<td>Other bituminous</td>
<td>23.85 - 26.75</td>
<td>22.60 - 25.50</td>
<td>590 - 657</td>
<td>13 - 18</td>
<td>810 - 845</td>
</tr>
</tbody>
</table>

Cokes

Table A3.6 • Calorific Values by Coke Type

<table>
<thead>
<tr>
<th>Coke type</th>
<th>GCV (as used) MJ/kg</th>
<th>NCV (as used) MJ/kg</th>
<th>Carbon content (as used) kg/t</th>
<th>Moisture content % (as used)</th>
<th>Carbon content kg/t (dmmf)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallurgical coke</td>
<td>27.90</td>
<td>27.45</td>
<td>820</td>
<td>8 - 12</td>
<td>965 - 970</td>
</tr>
<tr>
<td>Gas coke</td>
<td>28.35</td>
<td>27.91</td>
<td>853</td>
<td>1 - 2</td>
<td>856</td>
</tr>
<tr>
<td>Low-temperature coke</td>
<td>26.30</td>
<td>25.40</td>
<td>710</td>
<td>15</td>
<td>900</td>
</tr>
<tr>
<td>Petroleum coke (green)</td>
<td>30.5 - 35.8</td>
<td>30.0 - 35.3</td>
<td>875</td>
<td>1 - 2</td>
<td>890</td>
</tr>
</tbody>
</table>

*dmmf: dry, mineral matter-free.
## Coal-derived gases

### Table A3.7  Typical Calorific Values for Coal-derived Gases

<table>
<thead>
<tr>
<th>Gas type</th>
<th>GCV (as used) MJ/m³</th>
<th>NCV (as used) MJ/m³</th>
<th>NCV (as used) MJ/kg</th>
<th>Carbon content (as used) kg/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke-oven gas</td>
<td>19.01</td>
<td>16.90</td>
<td>37.54</td>
<td>464</td>
</tr>
<tr>
<td>Blast-furnace gas</td>
<td>2.89</td>
<td>2.89</td>
<td>2.24</td>
<td>179</td>
</tr>
</tbody>
</table>

## Petroleum products

### Table A3.8  Typical Calorific Values for Selected Petroleum Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Density kg/m³</th>
<th>Litres per tonne</th>
<th>Gross calorific value (GJ/t)</th>
<th>Net calorific value (GJ/t)(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>366.3</td>
<td>2730</td>
<td>51.90</td>
<td>47.51</td>
</tr>
<tr>
<td>Propane</td>
<td>507.6</td>
<td>1970</td>
<td>50.32</td>
<td>46.33</td>
</tr>
<tr>
<td>Butane</td>
<td>572.7</td>
<td>1746</td>
<td>49.51</td>
<td>45.72</td>
</tr>
<tr>
<td>LPG(2)</td>
<td>522.2</td>
<td>1915</td>
<td>50.08</td>
<td>46.15</td>
</tr>
<tr>
<td>Naphtha</td>
<td>690.6</td>
<td>1448</td>
<td>47.73</td>
<td>45.34</td>
</tr>
<tr>
<td>Aviation gasoline</td>
<td>716.8</td>
<td>1395</td>
<td>47.40</td>
<td>45.03</td>
</tr>
<tr>
<td>Motor gasoline(3)</td>
<td>740.7</td>
<td>1350</td>
<td>47.10</td>
<td>44.75</td>
</tr>
<tr>
<td>Aviation turbine fuel</td>
<td>802.6</td>
<td>1246</td>
<td>46.23</td>
<td>43.92</td>
</tr>
<tr>
<td>Other kerosene</td>
<td>802.6</td>
<td>1246</td>
<td>46.23</td>
<td>43.92</td>
</tr>
<tr>
<td>Gas/diesel oil</td>
<td>843.9</td>
<td>1185</td>
<td>45.66</td>
<td>43.38</td>
</tr>
<tr>
<td>Fuel oil, low-sulphur</td>
<td>925.1</td>
<td>1081</td>
<td>44.40</td>
<td>42.18</td>
</tr>
<tr>
<td>Fuel oil, high-sulphur</td>
<td>963.4</td>
<td>1038</td>
<td>43.76</td>
<td>41.57</td>
</tr>
</tbody>
</table>

(1) For naphtha and heavier oils, the net calorific value is assumed to be 95% of gross.
(2) Assumes a mixture of 70% propane and 30% butane by mass.
(3) An average for motor gasolines with RON between 91 and 95.
Natural gas

The calorific values for methane are 55.52 MJ/kg (gross) (37.652 MJ/m³) and 50.03 MJ/kg (net) (33.939 MJ/m³). However, natural gas as supplied contains gases in addition to methane (usually ethane and propane). As the heavier gases raise the calorific value per cubic metre, the gross calorific values can vary quite widely – between 37.5 and 40.5 MJ/m³.

Table A3.9  Conversion Factors from Mass or Volume to Heat (Gross Calorific Value)

<table>
<thead>
<tr>
<th>To:</th>
<th>LNG</th>
<th>GAS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MJ</td>
<td>Btu</td>
</tr>
<tr>
<td></td>
<td>MT</td>
<td>Btu</td>
</tr>
<tr>
<td></td>
<td>MJ</td>
<td>Btu</td>
</tr>
<tr>
<td></td>
<td>MJ</td>
<td>Btu</td>
</tr>
<tr>
<td></td>
<td>MJ</td>
<td>Btu</td>
</tr>
<tr>
<td>From:</td>
<td>multiply by:</td>
<td></td>
</tr>
<tr>
<td>Cubic metre*</td>
<td>40.00</td>
<td>37912</td>
</tr>
<tr>
<td></td>
<td>42.51</td>
<td>40290</td>
</tr>
<tr>
<td></td>
<td>35.40</td>
<td>33550</td>
</tr>
<tr>
<td></td>
<td>37.83</td>
<td>35855</td>
</tr>
<tr>
<td></td>
<td>39.17</td>
<td>37125</td>
</tr>
<tr>
<td>Kilo-gramme</td>
<td>54.40</td>
<td>51560</td>
</tr>
<tr>
<td></td>
<td>52.62</td>
<td>49870</td>
</tr>
<tr>
<td></td>
<td>45.19</td>
<td>45.19</td>
</tr>
<tr>
<td></td>
<td>42830</td>
<td>54.42</td>
</tr>
<tr>
<td></td>
<td>20.56</td>
<td>47920</td>
</tr>
</tbody>
</table>

* at 15°C.

Table A3.10  Conversion Equivalents between Standard Cubic Metres (Scm) and Normal Cubic Metres (Ncm)

<table>
<thead>
<tr>
<th>To: Standard cm</th>
<th>Normal cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>From:</td>
<td>multiply by:</td>
</tr>
<tr>
<td>Standard cm*</td>
<td>1</td>
</tr>
<tr>
<td>Normal cm**</td>
<td>1.055</td>
</tr>
</tbody>
</table>

*1 Scm measured at 15°C and 760 mm Hg.
**1 Ncm measured at 0°C and 760 mm Hg.
Table A3.11  Conversion Equivalents between LNG and Natural Gas Units

<table>
<thead>
<tr>
<th>From:</th>
<th>To:</th>
<th>Metric ton of LNG</th>
<th>cm of LNG</th>
<th>Standard cm*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric ton of LNG</td>
<td>1</td>
<td>0.948</td>
<td>1360</td>
<td></td>
</tr>
<tr>
<td>Cubic metre (cm) of LNG</td>
<td>0.45</td>
<td>1</td>
<td>615</td>
<td></td>
</tr>
<tr>
<td>Standard cm*</td>
<td>7.35*10^-4</td>
<td>1.626*10^-3</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*1 Scm = 40 MJ.

Table A3.12  Gross versus Net Calorific Value of Natural Gas

1 NCV* = 0.9 GCV**

*NCV = Net Calorific Value.
**GCV = Gross Calorific Value.