Department for Energy Security & Net Zero

Methodology notes for the energy balance

1. Introduction

The Department for Energy Security and Net Zero (DESNZ) produces energy balances which show the flow of energy from production, transformation and energy industry own use through to final consumption in one common unit of measurement, thousand tonne of oil equivalent (*ktoe*). Energy Balances are generally considered as the best way of presenting the energy flows, and are constructed by Eurostat, the IEA and the UN.

An overall energy balance (referred to as "energy balance" in the rest of the note) is an accounting framework for the compilation and reconciliation of data on all energy entering, exiting and used within the national territory of a given country during a reference period. The energy balance expresses all forms of energy in a common accounting unit, and shows the relationship between the inputs to and the outputs from the energy transformation industries. In the energy balance all energy flows should be accounted for, and the balance is based on the first law of thermodynamics which states that the amount of energy within any closed system is fixed and can be neither increased nor diminished unless energy is brought into or sent out from that system.

Energy balances show the commodity balances in a way that explains fuel conversion and the dependence of supply of one fuel on one another. It presents the energy flow as the primary fuels are processed or used and as the consequent secondary fuels are produced and used.

The presentation of energy statistics expressed in natural units in the form of commodity balances between the supply and use of the energy commodities provides a check on the completeness of the data and a simple means of assembling the main statistics of each commodity so that key data are easily obtained. However, because fuels are mainly bought for their heat-raising properties and can be converted into different fuel products, it is also helpful to present the supply and use data in energy units. The format adopted is termed the energy balance and allows users to see the fuel conversion efficiencies and the relative importance of the different fuel supplies in their contribution to the economy. The energy balance is also the natural starting point for the construction of various indicators of energy consumption (for example consumption per capita or per unit of GDP) and of energy efficiency. The energy balance also acts as a high-level check on the data accuracy as apparent energy gains in conversion processes or large losses indicate data problems.

The energy balance is a multipurpose tool. The main purposes of its compilation include:

(a) To enhance the relevance of energy statistics by providing comprehensive and reconciled information on energy situation on national territory.

(b) To provide comprehensive information on energy supply and demand in national territories in order to understand energy security, the effective functioning of energy markets and other relevant policy goals and to formulate energy policies.

(c) To serve as a quality tool to ensure the consistency and comparability of basic statistics.

(d) To ensure comparability between different years and between different countries.

(e) To establish the basis for estimation of CO2 emissions.

(f) To provide the basis for aggregated indicators (e.g. energy intensity etc).

(g) To compute efficiencies of all the transformation processes occurring in the country (e.g. refining, electricity production by combustion of fuels, etc.).

(h) To allow calculation of relative shares of various products (including renewables versus non-renewables) or sectors to the country total.

(i) To provide an input for forecast modelling.

(j) To provide a common framework for international comparisons.

The scope of an energy balance is determined, amongst other things, by the territory, product and flow boundaries:

(i) Territory boundary – defined by the boundary of the national territory of the compiling country.

(ii) Product boundary – defined by the scope of all energy products shown in the balance columns.

(iii) Flow boundary – defined by the scope of energy flows (uses) shown in the balance rows.

Product and flow boundaries are fixed in the short term. If new sources of energy are discovered and used they should be reflected in the balance.

The scope of energy balance does not include:

- Passive energy such as heat gain of building and solar energy falling on the land to grow crops, etc.
- Energy resources and reserves.
- Extraction of any materials not included in primary energy production.
- Non-energy products not used for energy purposes (e.g. waste and wood are covered in the energy balance only to the extent they are used for energy production and not when used for other purposes).

2. Data collection

Data for the energy balances are based on the individual data collected for commodity balances for coal, petroleum, gas, electricity and renewables, which are detailed in separate methodology notes. Additional data showing the energy content of fuels are required in order to convert the data in the commodity balances into a common unit of measurement, detailed later in this section.

The unit and frequency for commodity data, which are received by the Department are as follows:

Coal (Kilotonnes)

- on a monthly basis from the Coal Authority, International Steel Statistics Bureau (ISSB), HM Revenue & Customs and electricity generators' returns.
- on a quarterly basis: the above and data from major coal companies and the two major distributors.
- on an annual basis: annual returns from the major and smaller coal companies.

Petroleum (Kilotonnes) on a monthly basis from

- Oil companies via Downstream Oil Reporting System (DORS)
- Offshore production via Petroleum Production Reporting System (PPRS)
- HM Revenue & Customs (monthly basis for trade, quarterly basis for road fuel and gas oil demand)

Gas (GWh)

- Monthly via the PPRS (in tonnes for gas terminals and cubic metres for fields)
- National Grid and pipeline operators
- Monthly and annual survey of gas suppliers (domestic/commercial/industrial) (in gigawatt hour)
- Monthly and annual surveys of Major Power Producers (in Therms) for electricity generation
- Monthly survey of liquified natural gas (LNG) terminals (in LNG cubic metres)
- Monthly collection of open source data

Electricity (GWh)

- Annual inquiry to companies covering generating capacity, fuel use, generation, sales and distribution of electricity and licensed suppliers.
- Annually from ISSB and CHPQA administrative data.
- Quarterly for autogenerators or autoproducers.
- Monthly collection of open source data.

Renewables (ktoe)

- Annually (and quarterly for renewable electricity) from Renewable Energy STATisticS database (RESTATS)
- HM Revenue & Customs trade data
- Department for Transport Renewable Fuel Obligation data

Calorific values

- Information on the calorific content of fuels is collected from surveys of the energy suppliers. Data is usually provided on a gross calorific basis, with some firms also supplying data on a net basis. Estimates are made for the moisture content of the fuel to derive net calorific values where these are not supplied.

3. Data Definitions

The most commonly used formats for the presentation of energy data are (a) the commodity balances and (b) the energy balances.

3.1 Commodity balances

These show individual energy commodities, in their source unit, from production to final use. *Fig 1* below illustrates how primary commodities may be used directly and/or transformed into secondary commodities to final use and their contribution to trade and stock changes.

Fig 1 Main commodity flows
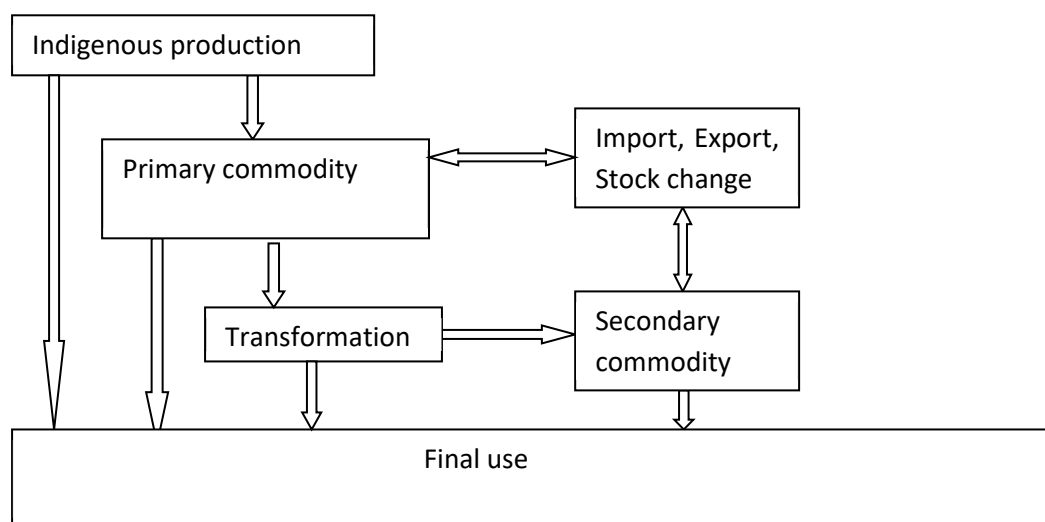
Structure of the commodity balance

The commodity balance comprises a supply section and a demand section. The supply section gives available sources of supply. The demand section is divided into transformation, energy industry use (other than for transformation), energy and non-energy uses by final consumers. Final consumption is the use by sectors of economic activity.

Supply consists of

Production which includes the extraction or capture of primary commodities, primary generation; manufacture of secondary commodities and the quantities used in the extraction or manufacturing process.

Other sources which are production from other sources including recycled products, recovered fuels (slurry or waste coal), electricity from pumped storage plants. Exceptionally, the Other sources row in the commodity balances for ethane, propane and butane is used to receive transfers of these hydrocarbons from gas stabilisation plants at North Sea terminals. In this manner, the supplies of primary ethane, propane and butane from the North Sea are combined with the production of these gases in refineries, so that the disposals may be presented together in the balances.

Imports (+) and Exports (-) which relate to UK trade in energy commodities. Exported commodities are produced in the United Kingdom and imported commodities are for use within the United Kingdom (although some may be re-exported before or after transformation). The figures exclude commodities either exported from or imported into HM Revenue and Customs bonded areas or warehouses. These areas, although part of the United Kingdom, are regarded as being outside of the normal United Kingdom's customs boundary, and so goods entering into or leaving them are not counted as part of the statistics on trade used in the balances. Similarly, commodities that only pass through the United Kingdom on their way to a final destination in another country are also excluded. However, for gas these transit flows are included because it is difficult to identify this quantity separately, without detailed knowledge of the contract information covering the trade. This therefore means that for gas, there is some overstatement in the level of imports and exports, however the net flows can be treated as correct. In the commodity balances, exports are shown as negative.

Marine bunkers which are deliveries of fuels (usually fuel oil or gas oil) to ships of any flag (including the United Kingdom) for their voyage consumption to other countries. Marine bunkers are treated like exports.

Stock changes which show additions to (as -ve) and withdrawals from stocks (as +ve) held by producers and transformation industries and which corresponds to withdrawals from and additions to supply, respectively.

Transfers which relate to quantities transferred from one commodity balance to another. For example, for reclassification purposes, the name of the commodity may change through a change in use, to show quantities returned to supply from consumers which may be by-products of the use of commodities as raw materials rather than fuels.

A quantity transferred from a balance is shown with a negative sign to represent a withdrawal from supply and with a positive sign in the receiving commodity balance to indicate an addition to its supply.

Total supply is the sum of production, other sources, imports (+), exports (-), stock change, marine bunkers and transfers.

Total demand represents the disposals and/or consumption of a commodity.
Demand is the sum of the transformation (see explanation below), energy industry use, losses and final consumption by the industry sectors including non-energy use.

Statistical difference is the excess of supply over demand. A negative figure indicates demand exceeds supply. Statistical differences arise when figures are gathered from a variety of independent sources and reflect differences in timing, definition of coverage of the activity or in commodity definition. Differences also arise for methodological reasons in the measurement of the flow of the commodity, for example, if there are differences between the volumes recorded by the gas producing companies and the gas transporting companies. A non-zero statistical difference is normal and, provided that it is not too large, is preferable to a statistical difference of zero as this suggests that a data provider has probably adjusted the balance of account.

The [IEA energy statistics manual](#) contains the following guidance on statistical differences. National statisticians should pursue large statistical differences in order to establish which data are wrong or incomplete. Unfortunately, it will not be always possible to correct the data and, in this case, the statistical difference should not be changed but left to illustrate the size of the problem. Deciding whether a statistical difference should be pursued with the reporting enterprise(s) is a matter of judgement. The percentage difference which one might consider acceptable will depend upon the magnitude of the supply of the commodity. For major supplies, like natural gas or electricity, efforts should be made to keep the statistical differences below one per cent. On the other hand, for a minor commodity like tars and oils from coke ovens, a 10% error can be tolerated.

Transformation which covers those activities that transform the original primary (and sometimes secondary) commodity into a form which is better suited for specific uses. Most of the transformation activities correspond to particular energy industries whose main business is to manufacture the product associated with them. Certain activities involve transformation to make products that are only partly used for energy needs (e.g. coke and oven coke) or are by-products of other manufacturing processes (e.g. coke oven and blast furnace gases). However, since these products and by-products are used, at least in part, for their energy content they are therefore included in the balance system. The production of the secondary commodities is shown in the production row (see above) in the corresponding commodity balance.

Electricity generation which represents the quantities of fuels burned for the generation of electricity. The activity is divided into two parts, covering the Major Power Producers (MPPs) such as those generating electricity for sale, as their main business activity, and autogenerators such as those generating electricity for their own needs but who may also sell surplus quantities. Where a generator uses combined heat and power plant, the figures in the commodity balance include only the part of the fuel used which correspond to the electricity generated.

For autogenerators', figures for quantities of fuel used for electricity generation appear under the appropriate fuel headings in the transformation section heading for autogenerators, whilst the electricity generated appears in the electricity production column. The final consumption figures for energy commodities consumed by the industry branches include all use of electricity, but exclude fuels combusted by the industry branches to generate the electricity.

Heat generation which are the quantities of fuel burned to generate heat that is sold under the provision of a contract to a third party. It includes heat that is generated and sold by combined heat and power plants and by community heating schemes (also known as district heating).

Petroleum refineries which convert crude oil, natural gas liquids (NGL) and other oils needed by refineries for the manufacture of finished petroleum products.

Coke manufacture and blast furnaces which represents quantities of coal for coke ovens and all fuels used within blast furnaces. The consumption of fuels for heating coke ovens and the blast air for blast furnaces are shown under Energy industry use (see below).

Patent fuel manufacture which represents coals and other solid fuels used for the manufacture of solid patent fuels.

Other which consists of any minor transformation activities not specified elsewhere.

Energy industry use is consumption by both extraction and transformation industries to support the transformation process (but not for transformation itself). Typical examples are the consumption of electricity in power plants (e.g. for lighting, compressors and cooling systems) and the use of extracted gases on oil and gas platforms for compressors, pumps and other uses. The headings in this section are identical to those used in the transformation section with the exception of *Pumped storage* which reports on the electricity used to pump water to the reservoir.

Losses which cover the intrinsic losses that occur during the transmission and distribution of electricity and gas (including manufactured gases). Other metering and accounting differences for gas and electricity are within the statistical difference, as are undeclared losses in other commodities.

Final consumption which covers both final energy consumption (by different consuming sectors) and the use of energy commodities for non-energy purposes. Final consumption occurs when the commodity is used and the energy concerned disappears from the account. Any fuel used for electricity generation by final consumers is identified and reported separately within the transformation sector. When an enterprise generates electricity, the figure for final consumption of the industrial sector to which the enterprise belongs includes its use of the electricity it generates itself as well as supplies of electricity it purchases from others, but does not include the fuel used to generate that electricity. The classification of consumers according to their main business follows, as far as practicable, the *Standard Industrial Classification (SIC 2007),* see section 3.3 below.

Within **Industry** two sub-sectors Iron and steel and Chemicals require special mention as they both undertake activities that fall across the transformation, final consumption and non-energy classifications used for the balances.

The iron and steel industry is a heavy energy user for transformation and final consumption activities. Figures shown under final consumption for this industry sub-sector reflect the amounts that remain after quantities used for transformation and energy sector own use have been subtracted from the industry's total energy requirements. Use of fuels for transformation by the industry may be identified within the transformation sector of the commodity balances. The amounts of coal used for coke manufacture by the iron and steel industry are shown in the transformation section of the coal balance and include the amount of coal used for coke manufacture by the companies outside of the iron and steel industry such as solid fuel manufacturers. The corresponding production of coke and coke oven gas may be found in the commodity balances for these products. The use of coke in blast furnaces is shown in the commodity balance for coke, and the gases produced from blast furnaces and the associated basic oxygen steel furnaces are shown in the production row of the commodity balance for blast furnace gas. Fuels used for electricity generation by the industry are included in the figures for electricity generation by autogenerators and are not distinguishable as being used by the iron and steel sector

in the balances. Fuels used to support coke manufacture and blast furnace gas production are included in the quantities shown under energy industry use. These gases and other fuels do not enter coke ovens or blast furnaces but are used to heat the ovens and the blast air supplied to furnaces.

The petro-chemical industry uses hydrocarbon fuels (mostly oil products and gases) as feedstock for the manufacture of its products. Distinguishing the energy use of delivered fuels from their non-energy use is complicated by the absence of detailed information.

Transport which represents quantities used strictly for transport purposes. However, the figures recorded against road transport usually include some fuel that is actually consumed in some "off-road" activities. Similarly, figures for railway fuels include some amounts of burning oil not used directly for transport purposes. The Transport sector use of electricity includes all electricity used in industries classified to SIC 2007 Groups 49 to 51. Fuels supplied to cargo and passenger ships undertaking international voyages are reported as marine bunkers (see previous explanations). Supplies to fishing vessels are included under "agriculture".

Other sectors - all of the consumers except *domestic* in this category follows the *SIC 2007* classification, for example public administration, commercial, agriculture and miscellaneous. The consistency of the classification across different commodities cannot be guaranteed because the figures reported are dependent on what the data suppliers can provide.

Non energy use of fuels may be divided into two types. They may be used directly according to their physical properties (e.g. lubricants or bitumen used for road surfaces) or by the petro-chemical industry as raw materials for the manufacture of goods such as plastics. In their use by the petrochemical industry, relatively little combustion of the fuels takes place and the carbon and/or hydrogen they contain are largely transferred into the finished product. However, in some cases heat from the manufacturing process or from combustion of by-products may be used. Data for this energy use are rarely available. Depending on the feedstock, non energy use consumption is either estimated or taken to be the deliveries to the chemicals sector.

3.2 Energy balance

The energy balance shows the content of the commodity balances translated into a standard energy unit. In the UK tonnes of oil equivalent (toe) are used. Alternatives such as joules, therms or GWh could be used. The balance shows, for all fuels together the flows from production to final use, including the movements between fuel categories, for example gas produced, may be transformed into electricity and then consumed by the domestic sector.

Structure of the energy balance

The energy balance presents an overall view of the energy supplies for the United Kingdom; the relative importance of each energy commodity; dependence on imports; the contribution of our own fossil and renewable resources and the interdependence of commodities on one another.

The energy balance is constructed from the commodity balances and is normally presented by arranging the data in columns by fuel type. Heat sold is also included and treated as a fuel.

An energy balance contains three main blocks of rows as follows:

Top block - flows representing energy entering and leaving the national territory as well as stock change to provide information on supply of energy on the national territory during the reference period.

Middle block - flows showing how energy is transformed, transferred, used by energy industries and lost in distribution and transmission.

Bottom block - flows reflecting final energy consumption and non-energy use of energy products.

A separate row is reserved for the statistical difference (defined as the difference between primary supply and primary demand).

The main sections of the energy balance are described as follows, drawing out some of the differences of treatment compared with the commodity balances.

Primary supply: Within the energy balance, production covers extraction of primary fuels and the generation of primary electricity (hydro, nuclear, solar and wind). The production of secondary fuels (refined petroleum products such as petrol) and secondary electricity (that generated from coal fired power stations) are shown in the transformation section and not in the indigenous production row at the top of the balance. For fossil fuels, indigenous production represents the marketable quantity extracted from the reserves. Indigenous production of primary electricity comprises hydro-electricity, wind, solar and nuclear energy. The energy value for hydro-electricity is taken to be the energy content of the electricity produced from the hydro power plant and not the energy available in the water driving the turbines. A similar approach is adopted for electricity from wind and solar generators where the electricity is regarded as the primary energy form because there are currently no other uses of the energy resource "upstream" of the generation. For nuclear, an estimate of the heat content of the steam from the reactor is used as a measure of production output.

The other elements of the supply part of the balance are identical to those in the commodity balances, imports, exports, marine bunkers and stock change. Exports and international marine bunkers are normally shown with negative signs, to indicate that they are taken away from the production figure before determining a measure of primary supply.

A stock build carries a negative sign to denote withdrawal from supply whilst a stock draw carryies a positive sign showing addition to supply. Primary supply expresses the national requirement for primary energy commodities from all sources and foreign supplies of secondary commodities. It is an indicator of the use of indigenous resources and external energy supplies. Both the amount and mixture of fuels in final consumption of energy commodities in the United Kingdom will differ from the primary supply. The "mix" of commodities in final consumption will be much more dependent on the manufacture of secondary commodities, in particular electricity. Primary supply

is the combination of the indigenous production, trade, marine bunkers and stock changes (taking their signs into account).

Transformation which plays a key role in moving primary electricity from its own column in the balance into the electricity column, so that it can be combined with electricity from fossil fuelled power stations and the total disposals shown.

Indigenous production of primary electricity comprises of nuclear electricity, hydro electricity and electricity from solar and wind generation. Nuclear electricity is obtained by passing steam from nuclear reactors through conventional steam turbine sets. The heat in the steam is considered by international standards to be the primary energy available and its value is calculated from the electricity generated using the average thermal efficiency of nuclear stations in the United Kingdom, see DUKES table 5.10.C.

The electrical energy from hydro, solar and wind is transferred from the *Primary electricity* column to the *Electricity* column using the *transfers* row because electricity is the form of primary energy and no transformation takes place. However, because the form of the nuclear energy is the steam from the nuclear reactors, the energy it contains is shown entering electricity generation and the corresponding electricity produced is included with all electricity generation in the figure, in the same row, under the *Electricity* column.

Quantities of fuels entering the transformation activities (fuels into electricity generation and heat generation, crude oil into petroleum product manufacture (refineries), or coal into coke ovens) are shown with a negative sign to represent the input and the resulting production is shown as a positive number. For electricity generated by Major Power Producers, the inputs are shown in the *Major Power Producers* row of the *coal, manufactured fuels, primary oils, petroleum products, gas, renewables* and *primary electricity* columns. The total energy input to electricity generation is the sum of the values in these first seven columns. The *Electricity* column shows total electricity generated from these inputs and the transformation loss is the sum of these two figures, given in the *Total* column. Within the transformation section, the negative figures in the *Total* column represent the losses in the various transformation activities. This is a convenient consequence of the sign convention chosen for the inputs and outputs from transformation. Any positive figures represent a transformation gain and, as such, are an indication of incorrect data.

In the energy balance, the columns containing the input commodities for electricity generation, heat generation and oil refining are separate from the columns for the outputs. However, for the transformation activities involving solid fuels this is only partly the case. Coal used for the manufacture of coke is shown in the coke manufacture row of the transformation section in the coal column, but the related coke and coke oven gas production are shown combined in the *Manufactured fuels* column. Similarly, the input of coke to blast furnaces and the resulting production of blast furnace gas are not identifiable and have been combined in the *Manufactured fuels* column in the blast furnace row. As a result, only the net loss from blast furnace transformation activity appears in the column. The share of each commodity or commodity group in primary supply can be calculated from the table. This table also shows the demand for primary as well as foreign supplies. Shares of primary supplies

may be taken from the *Primary supply* row of the balance. Shares of fuels in final consumption may be calculated from the final consumption row.

Energy industry use and final consumption in which the figures for final consumption and energy industry use follow, in general, the principles and definitions described under commodity.

3.3 Standard Industrial Classification (SIC)

Producers and consumers in the energy balance are defined as per the SIC 2007 codes in *Table1* below. Details of the components that make up these codes can be found in the main volume on the Office for National Statistics website.

Table 1: SIC 2007 classifications

Fuel producers	05-07, 09, 19, 24.46, 35
Final consumers:	
Industrial	
Unclassified	*See explanation below.*
Iron and steel	24, (*excluding* 24.4, 24.53, 24.54)
Non-ferrous metals	24.4, (*excluding* 24.46), 24.53, 24.54
Mineral products	08, 23
Chemicals	20-21
Mechanical engineering and metal products	25, 28
Electrical and instrument engineering	26-27
Vehicles	29-30
Food, beverages & tobacco	10-12
Textiles, clothing, leather, & footwear	13-15
Paper, printing & publishing	17-18
Other industries	16, 22, 31-33, 36-39
Construction	41-43
Transport	49-51 (part*)
Other final users	
Domestic	Not covered by SIC 2007
Public administration	84-88
Commercial	45-47, 49-51 (part*), 52-53, 55-56, 58-66, 68-75, 77-82
Agriculture	01-03
Miscellaneous	90-99

* Note – transport sector includes only energy used for motion/traction purposes. Other energy used by transport companies is classified to the commercial sector.

An 'unclassified' category is added in the industry sector for those occasions where the data suppliers have been unable to allocate an amount to a category and where the Department has been unable to allocate data from other sources. In this case, the category is considered as 'unclassified', enabling the reader to decide whether to accept a residual, pro-rate, or otherwise adjust the figures. The 'miscellaneous' category also contains some unallocated figures for the services sector. As of the publication of 2010 data, the Department changed to SIC 2007, in line with ONS guidance.

Calorific values

Calorific value or heating value of a fuel expresses the heat obtained from one unit of the fuel. They are necessary for the compilation of overall energy balances, to convert from the original units in which the fuels are measured 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). Even though calorific values are often considered in the context of the preparation of energy balances, they have wider application in the preparation of any tables designed to show energy in an aggregated form or in the preparation of interfuel comparative analyses.

Calorific values are obtained by measurements in a laboratory specializing in fuel quality determination. They should preferably be in terms of joules (or any of its multiples) per original unit, for example gigajoule/ton (GJ/t) or gigajoule/cubic metre (GJ/m^3). Major fuel producers (mining companies, refineries, etc.) measure the calorific value and other qualities of the fuels they produce and supply these to the Department. A calorific value is a conversion factor, in the sense that it can be used to convert mass or volume quantities into energy content.

There are two main issues as regards calorific values: the first one refers to whether they are measured gross or net of the heat necessary to evaporate the water formed during combustion and the water previously present in the fuel in the form of moisture; and the second one is related to the quality of the energy product, as the calorific value of, say, a ton of hard coal may vary greatly by geographic and geological location. These two issues are discussed in detail in the next two sections.

Gross and net calorific/heating values

The expression of original units of energy sources in terms of a common unit may be made on two bases as the energy stored in fuels may be measured in two stages.

The gross calorific value (GCV), or high heat value, measures the total (maximum) amount of heat that is produced by combustion. However, part of this heat will be locked up in the latent heat of evaporation of any water present in the fuel before combustion (moisture) or generated in the combustion process. This matter comes from the combination of hydrogen present in the fuel with the oxidant oxygen (O_2) present in the air to form H_2O. This combination itself releases heat, but this heat is partly used in the evaporation of the generated water.

The net calorific value (NCV), or low heat value, excludes this latent heat. NCV is that amount of heat which is actually available from the combustion process in practice for capture and use. The higher the moisture of a fuel or its hydrogen content, the greater is the difference between GCV and NCV. For some fuels with very little or no hydrogen content (e.g. some types of coke, blast furnace gas), this difference is negligible. In terms of magnitude, the difference between gross and net calorific values of commercial energy sources (coal, oil, products, and gas) is less than 10 per cent while that of wood is usually more than 10 per cent. Figures for the main energy commodities are available in [DUKES tables A.1 and A.2](). The applied technology to burn a fuel can also play a role in determining the NCV of the fuel, depending for example on how much of the latent heat it can recover from the exhaust gases.

NCVs are generally more used than GCVs when building balances, since most current technologies are still not able to recover the latent heat, which would thus not be treated as part of a fuel's energy providing capability. However, providing both gross and net calorific values while making clear which one is used in the balance is considered good practice. This allows the monitoring of technological advances in respect to recovering latent heat.

A consultation was undertaken in 2005 to see whether a change to NCV's should be made for the headline statistics. The results of the consultation were not conclusive, and so GCV's remain the basis for the UK's headline data.

How to calculate average calorific values
The calculation of calorific values is not straightforward. There are two levels involved in the calculation of calorific values. The first is the actual measurement of the heating value of an energy product. This is done in laboratories specializing in fuel quality determination. In general, major fuel producers (mining companies, refineries, etc.) do measure the quality of the energy product they produce as this may affect the price and the product specification, etc.

The second level in the calculation of the calorific values pertains more to the compilers of energy statistics as it involves the aggregation of different quality of a fuel. Coal produced at different mines may very well have (and often has) different qualities. The quality of the imported coal may vary according to the origin of the flow. Similarly, the quality of the consumed coal may also differ: the case, for example, of imported steam coal for electricity generation, and home produced lignite for household consumption. Thus in the preparation of energy balances and in the comparison of the energy content of energy products, it is necessary to take into account the different quality of the products themselves. In general, in order to aggregate different qualities of an energy product, it is necessary to calculate the average calorific value.

Since calorific values may change according to the type of flow (e.g. production, imports, exports, consumption by different types of users etc.), countries are encouraged to collect calorific values at least on production, imports and exports.

In line with international best practice, detailed estimates by fuel and by flow are used in the UK to move from commodity balances to energy balances.

4. Methodology

Once compiled and vetted for quality and consistency (see below), commodity data are converted to a common unit for inclusion in the energy balances.

Energy balances are published on both a quarterly basis in Energy Trends and on an annual basis in the Digest of United Kingdom Energy Statistics (DUKES). Both publications are available on the Department's website at Energy Trends and DUKES.

The following section aims to describe the methodology involved in processing the data leading to the energy balance.

Commodity data are collected and compiled from various sources (section 2) and aggregated to provide the quarterly and provisional annual energy balance data.

For coal and petroleum products, conversion from their natural unit into energy units incorporates a calorific (or heating) value, however for all of the other fuel types conversion to Mtoe is performed through simple multiplication by their respective conversion factors. This is because gas and electricity are normally measured in terms of their energy (GWh).

The calorific value or energy density (energy per unit) of a fuel is the quantity of heat produced by its combustion under normal temperature and pressure. Major fuel producers and users, such as mining companies and refineries, measure the calorific value of fuels they produce, and supply these to the Department.

Table 2 below shows the standard conversion factors for energy units.

Table 2. **Conversion factor table**

From:	To (multiply)			
	Thousand tonne of oil equivalent	**Terajoules**	**Gigawatt hours**	**Million therms**
Thousand tonne of oil equivalent	1	41.868	11.63	0.39683
Terajoules (TJ)	0.023885	1	0.27778	0.0094778
Gigawatt hours (GWh)	0.085985	3.6	1	0.034121
Million therms	2.52	105.51	29.307	1

1 Gigajoules (GJ)= 1000 Terajoules (TJ)

Mtoe = Million tonnes of oil equivalent (Mtoe) = 1000 Kilo tonnes of oil equivalent (ktoe)

TWh = Terawatt hour

The examples below illustrate the conversion from data in commodity balances to common energy units.

For steam coal production, we need to multiply the volume of production by the calorific value of this fuel, and then convert to tonnes of oil equivalent.

Domestic consumption of house coal = 362 thousand tonnes. The GCV of house coal was 30.093. Together these are combined to show that consumption was 10,894 GJ. This can then be converted into tonnes of equivalent by multiplying by 0.023885 to give 260 thousand tonnes of oil equivalent.

Manufactured fuel and primary oil

Amount (ktoe)=$\dfrac{\text{Amount (Ktonnes)} \times \text{calorific values}_{\text{fuel type}}\text{ (GJ/tonnes)}}{41.868}$

Petroleum products (Mtoe) = $\dfrac{\text{Petroleum (ktonnes)} \times \text{Calorific values (GJ/tonnes)}}{41.868}$

Natural gas (ktoe) = Natural gas production (Million therms) x 0.00252 or
Natural gas production (GWh) x 0.0.085985

Primary electricity (Mtoe) = Primary electricity (TWh) x 0.085985

Primary electricity consists of electricity output from (i) nuclear and (ii) wind, solar and natural flow hydro.

The current practice for the United Kingdom and the International Energy Agency (IEA) is to use the tonne of oil equivalent (toe) as common unit. One tonne of oil equivalent is defined as 107 kilocalories (41,868 gigajoules). The tonne of oil equivalent is another unit of energy like the gigajoule, kilocalorie or kilowatt hour, rather than a physical quantity. It has been chosen as it is easier to visualise than the other units. Due to the natural variations in heating value of primary fuels such as crude oil, it is rare that one tonne of oil has an energy content equivalent to one tonne of oil equivalent. The energy figures are calculated from the natural units of the commodity balances by multiplying by the factors representing the calorific (heating) values of the fuels. The gross calorific values of fuels are used for the purpose of the energy balance. When the natural unit of the commodity is already an energy unit (electricity in kilowatt hours, for example) the factors are just constants, converting one energy unit to another.

Quality checks
Once a balance has been prepared, a number of checks are done to ensure that the data seem reasonable. Comparisons are made of the growth rates over time of the separate cells within the balance concentrating on the major aggregates.

In general the growth in say production of gas between energy balances for different years, should be similar to that seen by comparing the growth in gas production from the commodity balances.

By combining all fuels together, estimates can now be seen of for example final energy use by the industrial sector. This estimate is compared with the National Accounts estimate of growth over the same time period. If differences in growth rates are noticed, then further investigation is required in order to determine if a problem exists. If for example output from energy intensive industries has declined at a sharp rate, then energy use by industry could well have fallen despite perhaps there being an overall rise in total industrial output.

If problems are identified in producing energy balances, corrections, once identified are applied to either the data in the commodity balances or the calorific values, to ensure that an internally consistent set of data is produced.

Statistical differences
In the energy balance, the statistical difference is calculated as the numerical difference between the total supply of a fuel/energy and the total use of it. It arises from various practical limitations and problems related to the collection of the data which make up supply and demand. The data may be subject to sampling or other

collection errors and/or be taken from different data sources which use different time periods, different spatial coverage, different fuel specifications or different conversions from volume to mass or from mass to energy content in the supply and demand sides of the balance. Large statistical differences are investigated because this indicates that data are inaccurate or incomplete.

In general the supply side is deemed more accurate as often this is easier to measure and normally is derived from fewer data sources.

The statistical difference in the commodity balances can provide an explanation of large statistical difference in the energy balances: if the commodity balances show a small statistical difference, this may indicate that the conversion factors to energy units should be investigated.

In general we expect statistical differences to be below 0.5% for each fuel for each time period. However, on occasion preliminary quarterly data may well be presented with larger values.

Temperature correction

Data in energy balances are not adjusted for temperature effects. However, analysis of temperature corrected data is useful to provide an insight into underlying trends in data series. Temperature corrected figures indicate what consumption might have been if the average temperature had been the same as the average for the years 1991 to 2020. As part of the current method, heating degree days (HDD) are used to adjust for temperature rather than the average temperature in the month. HDD are calculated relative to a base temperature – the outside temperature above which a building needs no heating.

In calculating the HDD, the Department uses 15.5º Celsius as the base temperature. If the outside air temperature on a given day is above this base temperature, no energy for heat would be needed and the heating degree day is zero. However if the outside air temperature is below the base temperature then the heating degree day is temperature difference between the base temperature and the outside temperature. For each particular month, the heating degree days are averaged and compared with its long-term average.

The temperature correction procedure is applied to coal and gas. Consumption of oil, bioenergy and waste, nuclear, hydro, wind, solar and net imports of electricity are not corrected for temperature.

The temperature deviation is calculated using the average daily temperature data provided by the Meteorological Office on a monthly basis and reported in Energy Trends table 7.1.

The average temperature is calculated as the average temperature across daily readings of maximum and minimum temperatures at 17 weather stations in the UK.

Data users

Users of the total energy data vary widely and generally include the Department itself (for example, the economists modelling team in the Department use the data to produce analytical projections); other government departments, including DEFRA, Committee on Climate Change, and the Energy Group in the FCDO; energy companies; consultancy firms; local authorities; researchers; academia and the media. It is also a requirement of the Department that we submit aggregate total energy data on a net calorific value basis to the International Energy Agency (IEA) on an annual basis.