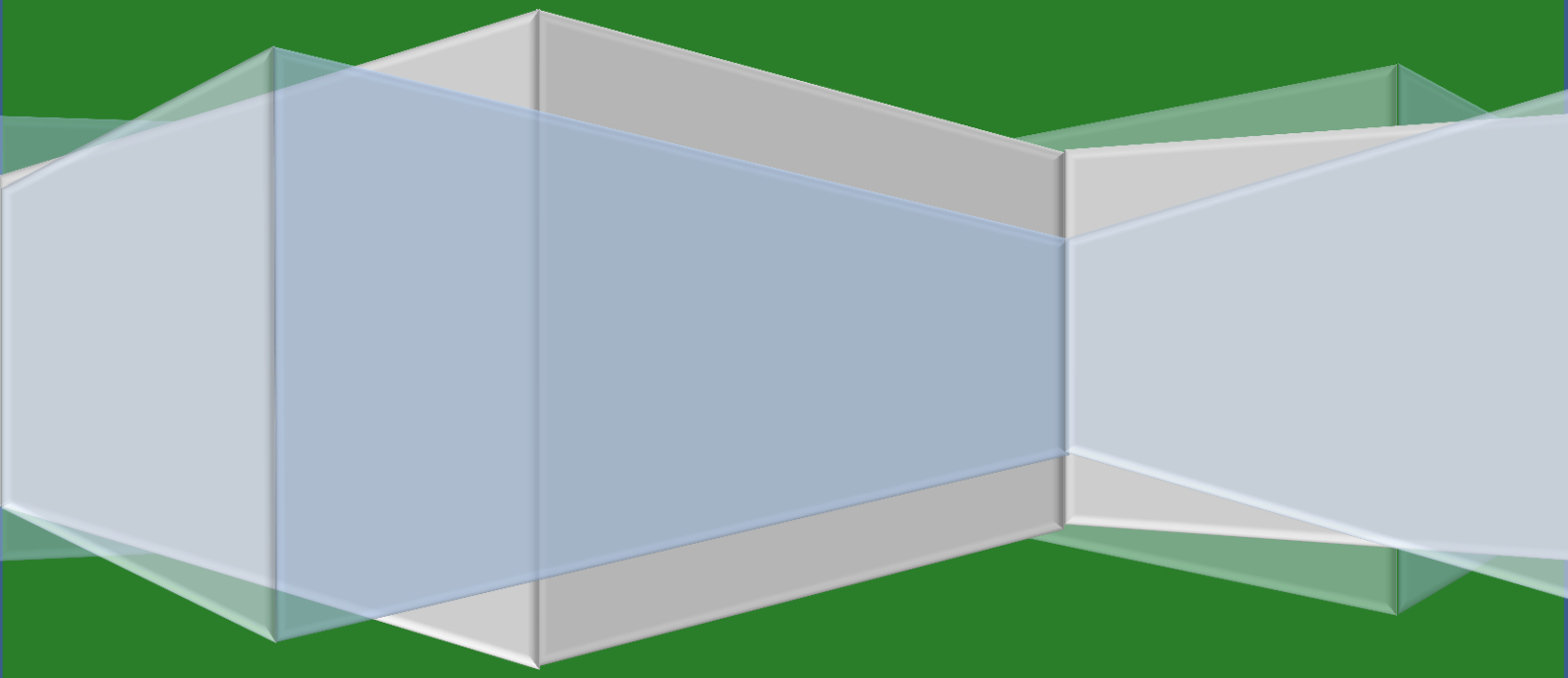
OIC ACCREDITATION CERTIFICATION PROGRAMME FOR OFFICIAL STATISTICS

# ENERGY STATISTICS

## TEXTBOOK



ORGANISATION OF ISLAMIC COOPERATION

STATISTICAL ECONOMIC AND SOCIAL RESEARCH
AND TRAINING CENTRE FOR ISLAMIC COUNTRIES

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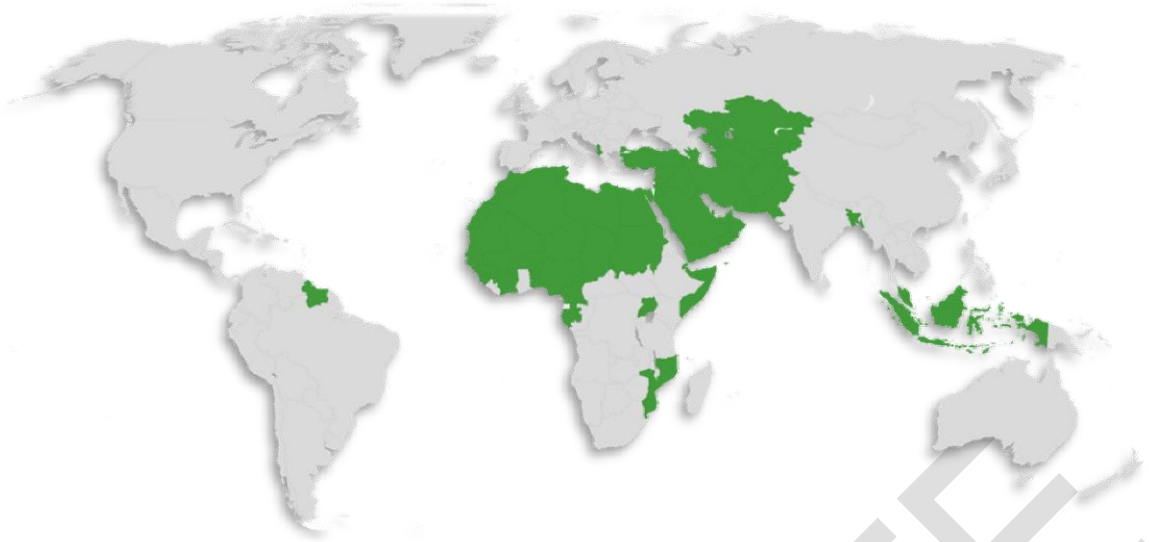

# ENERGY STATISTICS

## TEXTBOOK



{{SIVARAMAKRISHNA. KANTETI}}

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# CONTENTS

# ACRONYMS

| | |
|---|---|
| BBL | barrel |
| BCM | billion cubic metres |
| B/D | barrels per day |
| BTU | British thermal unit |
| CCGT | combined-cycle gas turbine |
| CHP | combined heat and power (plant) |
| CNG | compressed natural gas |
| CO | carbon monoxide |
| CO2 | carbon dioxide |
| COT | coke-oven gas |
| CV | calorific value |
| GCV | gross calorific value |
| GJ | gigajoule, or one joule x 109 (see joule) |
| GJ/t | gigajoule per tonne |
| J | joule |
| kWh | Killo watt/hour, or one watt x one hour x 103 |
| LNG | liquefied natural gas |
| LPG | liquefied petroleum gas; refers to propane, butane and their isomers, which are gases at atmospheric pressure and normal temperature |
| MBtu | million British thermal units |
| MJ/m3 | Mega joule/cubic metre |
| Mm3 | million cubic metres |
| MPP | main (public) power producer |
| MSW | municipal solid waste |
| Mtce | million tonnes of coal equivalent (1 Mtce=0.7 Mtoe) |
| Mtoe | million tonnes of oil equivalent |
| MW | megawatt, or one watt x 106 |
| NCV | net calorific value |
| Nm3 | normal cubic metre |
| NOx | nitrogen oxides |
| PV | photovoltaic |
| tce | tonne of coal equivalent = 0.7 toe |
| TFC | total final consumption |
| TJ | Tera joule, or one joule x $10^{12}$ |
| toe | tonne of oil equivalent |
| TPES | total primary energy supply |

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| | |
|---|---|
| EC | European Commission |
| EEA | European Environment Agency |
| Eurostat | Statistical office of the European Commission |

| | |
|---|---|
| EU | European Union |
| IAEA | International Atomic Energy Agency |
| IEA | International Energy Agency |
| ISO | International Organization for Standardization |
| NEA | Nuclear Energy Agency |
| OECD | Organization for Economic Cooperation and Development |
| UN | United Nations |
| UNCED | United Nations Conference on Environment and Development |
| UNDESA | United Nations Department of Economic and Social Affairs |
| UNECE | United Nations Economic Commission for Europe |
| WHO | World Health Organization |
| GDP | Gross Domestic Product |

Source: Energy statistics manual 2004, IEA publication

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i. UN publication (2008): International Standard Industrial Classification of all Economic Activities, Rev 4
ii. International Recommendations for Energy statistics ( IRES), draft version, pdf file
iii. Energy statistics definitions, units of measure and conversion factors, series F no 44,UNSDpublication
iv. SESRIC: BASEIND data base
v. IEA/OECD/Eurostat 2004, Energy statistics manual, Paris, France International Energy Agency
vi. Energy indicators for sustainable Development Guidelines and methodologies , Vienna, IEA 2005
vii. Energy Statistics – A manual for developing countries, Studies in Methods, Series F no 56 a UNSD publication

viii. Energy statistics 2014, Central Statistical office, MOSPI, Government of India

ix. 2012 Energy balances Series W No 21, UNSD publication

x. 2012 Energy Statistics Year Book Series J no 56, a UNSD publication

xi. Monthly Bulletin of Statistics, Series Q no 514, Oct 2015, a UNSD publication

xii. UNSD Annual Questionnaire on Energy Statistics

While appreciating all the help received from the people and organizations listed above, I still feel responsible for any errors remaining in the text book. Kindly write to me back if you find any errors like misspelled words, numerical errors, incorrect statements, comprehension errors, typesetting problems or any other qualifying errors.

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# UNIT 1

# Energy, related terms, energy product statistics in OIC countries

## 1.1. Energy products, definitions and important concepts

*Learning Objectives*

1. To understand the definition of energy and Electricity
2. To learn about some of the energy products
3. To know about some of fundamental concepts in Energy Statistics

Statisticians entrusted with the task of collecting and compiling of Energy statisticians should have a working knowledge of the terms involved in energy generation and conversion processes, various fuels, their physical characteristics, specific energy terms and their definitions, units of measurement of energy products, conversion factors for various energy products. Keeping this in view, this unit is started with giving some important terms involved, their definitions, and practices are recorded below.

### Energy

The term energy refers to work derived from combustion of fuels like coal, crude oil, natural gas etc. Energy commodities are fuels and electricity. A fuel is a substance containing the carbon and hydrogen. When burned, it gives heat and power. The carbon and hydrogen that were in the fuel, mix with oxygen in the process of combustion and releases/provides heat. The heat is further transformed to steam energy/mechanical energy/ electrical energy[2].

### Fuels

The sources of energy that occur naturally such as coal, crude oil, natural gas and fuel wood are known as primary fuels and those that are derived from them like coal gas, coke, petroleum products, electricity are secondary fuels. Both these primary and secondary fuels could be converted into electricity[9].

### Types of fuels

These fuels are divided into three kinds (i) solid fuels (ii) liquid fuels (iii) gaseous fuels. Examples of solid fuels are hard coal, lignite, hard coal coke, lignite coke, hard coal briquette, lignite briquette and asphaltite etc.

Liquid fuels are (i) crude petroleum,(ii) liquefied petroleum ( liquefied propane or butane or a mixtures of both), (iii) motor gasoline (mixture of benzene and toluene), (iv) Naphtha (light or medium oils distilled between $30^0$C and $210^0$C, (v) kerosene (mixtures of hydro carbons distilled in the range of $145^0$C and $300^0$C, (vi) Gasoline type jet fuels distilled between the tempratures$100^0$C and $250^0$C, in fact these are a blended mixture of kerosene and naphtha at certain vapour pressure, (vii)Gas oil/diesel oil , (viii) fuel oil (ix) lubricants and (x) petroleum coke etc.

The gaseous fuels are natural gas, coke oven gas and biogases (arising from the anaerobic fermentation of biomass and the gasification of solid biomass including the biomass wastes.

## Biofuels and Fossil fuels

Biofuel is a fuel extracted from organic matter whose energy has been obtained through a process of carbon fixation. Carbon fixation is the conversion of in-organic carbon (such as Carbon Dioxide in the atmosphere) into organic carbon. Plants manufacture food using sunlight (solar energy) in a process called photosynthesis, which converts this solar energy into chemical energy. Biomass which is mainly composed of dead plant matter and animal waste has a large amount of this embodied energy. Biofuel is made up of hydrocarbons containing the embodied energy of the organic matter and can be used as a fuel source.

Biofuel refers to solid, liquid, or gaseous fuel consisting of or derived from biomass which are recently living organisms or their metabolic byproducts such as manure from cows and buffaloes. There are various plants and plants derived materials used in biofuel production such as sugar cane crops, wood and its byproducts, waste materials including agriculture, household, industry, and forestry are some examples.

As said earlier, the biofuels include fuel wood/ round wood, wood chips, wood wastes, pelleted wood. The wet wood has got more moisture content than the dry wood and thus gives less amount of heat. Generally, the moisture content and heating values for these biofuels are specified by the suppliers. There are liquid bio fuels and gaseous bio fuels also. Bioethanol and biodiesel are some examples of liquid biofuel. Bio gas produced from fermentation of cow or buffalo dung is an example of the gaseous biofuel.

The production of biofuels can be varied from small scale to large scale with a high degree of heterogeneity in their production methods. Biofuels are mostly produced in developing countries and mostly by households for their own use[2]. Biofuel is a renewable form of energy because it is obtained from organic matter that can be re-created in short time frame.

Fossil fuels too are organic hydrocarbons formed from the remains of plants and animals but take long time to form under certain conditions like high pressures and temperature under the deep layers of the earth. Fossil fuels are coal, oil, and natural gas etc[2].

## Fuel characteristics

Fuel characteristics are also to be noted for better understanding of the grades, differential prices. For example the important energy product like the coal contains fixed carbon content, volatile matter content, moisture content, ash content and sulphur content in it. Depending on the levels of moisture content and volatile content involved in the coal, it is ranked. Higher ranked coals do contain more heat and energy content and thus are priced more[1].

Coal gives primary coal products like coking coal, bituminous coal, lignite coal, and peat and derived fuels like (i) coke- oven coke, (ii) gas coke, (iii) coke oven gas, (iv) blast furnace gas, and (v) gasworks gas etc.

The fuel resource occurring within a specified area of the borehole point are named as reserves. There are three types of reserves of these fuels (proved reserves, indicated reserves and inferred reserves). Proved reserves are those resources falling within an area of 200m radius from a borehole point. The resources occurring in the area falling between radii of 200m to 1Km from the borehole pint are known as indicated reserves. The inferred reserves are those reserves falling between the radii of 1Km to 2 Km from the borehole point[3].

Petroleum products are not entirely used for fuel purposes but also used as raw materials in non-fuel purposes. Examples are (i) spirit is used as a solvent in paints and varnishes, lubricants used for machinery and automobile engines, natural gas and LPG are used for fertiliser industry and petrochemical industry to generate varieties of products which are not for generation of energy, bitumen for tapping the roads in

construction, paraffin waxes for candle manufacturing, polishes, petroleum coke is for manufacturing electrodes, graphite and chemical production etc.

## Electricity and types of electricity produced

Electricity is a form of energy resulting from the existence of charged particles (such as electrons or protons), either statically as an accumulation of charge or dynamically as a current. It is used for providing power to buildings, electrical appliances and automobiles etc. It is produced in various ways. Electricity produced is mainly of two types. When heat is used to produce the electricity it is known as thermal electricity and when heat is not used to produce the electricity, then it is known as non-thermal electricity. Example of non-thermal electricity are electricity produced from wind, hydro, tidal waves. The photovoltaic cells transforms the sunrays to electricity directly and is known as non-thermal electricity. However the solar panels convert the solar radiation to heat and the heat is used for heating water etc. From geothermal reservoirs, nuclear fission reactors and solar panels heat emerges first and this heat is further transformed to other energies. The electricity generated with these plants are known as the thermal electricity.

In hydroelectric plants, the potential energy of water while moving down from a higher to lower level converts itself to kinetic energy and to mechanical energy and to electricity. Similarly the kinetic energy in water flows in the rivers or in tidal waves converts to mechanical energy and to electrical energy in these hydroelectricity plants. The kinetic energy in the wind moving from a higher pressure area to lower pressure area creates mechanical energy in wind plants. The sun rays if harnessed properly through solar panels give heat energy, the hot rocks give heat energy. The heat and electricity produced through these systems are treated as primary energy because of use of natural resources in them and are also known as renewable energy. By convention, the heat produced due to the controlled nuclear fusion is also known as primary energy.

The quantity of heat available, the quantity of heat being harnessed and the quantity of heat being utilised are different in these systems. Here comes the importance of energy conversion systems, efficient heat harnessing technologies. Generally, the nuclear fission reactors work at 30 to 33% efficiencies. The hydro, wind, tide, wave, ocean and solar photovoltaic systems work at 100% efficiency in converting the input energy to

output energy product –electricity. The least efficiency plants are geothermal heat plants, they work at 10% efficiency to convert the heat energy to electricity[9].

### Imports

Energy imports generally comprise of all the fuels or other energy products entering the national territory as a result of purchases made by the residents, at least partly for domestic use, in the country. When the products crosses the national boundary then they are treated as imports irrespective of customs' clearances. Goods (in transit) transported through the country and destined to other countries are not to be included. But reimports (which are domestic goods exported and admitted back) are to be included. Care should be taken while recording the data on the imports of energy products. Details on the origin of the country from where the goods are imported, quantity, value, product specification of the fuel following the energy product classification (SIEC), the name of the company/stockist etc who is importing the product, his licence particulars etc should be recorded. The bunkering of the fuel outside the national boundary, by the national merchant ships or civil aircraft engaged in international travel are excluded from imports. These bunkered fuels should be classified as 'international marine or aviation bunkers'[3].

### Exports

Similarly for exports, care should be taken while recording the details of the energy products which are exported. Energy exports comprise of all energy products leaving the national territory as sales made by the residents of the country. When the commodity crosses the national boundary irrespective of customs clearances, they are treated as exports. Goods (in transit) transported through the country and destined to other countries are not to be included in exports. But re exports (goods exported in the same state as previous imported) are included in the exports. Details of the destination country from to where the goods are exported, details of the importer for each energy product, quantity, value, product specification as per the energy product classification (SIEC) should be recorded. The bunkering of the fuel outside the national boundary, into the foreign national merchant ships or civil aircraft engaged in international travel are excluded from exports. These bunkered fuels should be classified as 'international marine or aviation bunkers' irrespective of the nation the ships or the aircraft belong to[3].

### Stocks of fuels:

The stocks serve to maintain operations smoothly. These supplies are maintained by three types of stockists namely (i) fuel suppliers or (ii) power generators or (iii) by consumers. The fuel suppliers (include both the producers and importers) maintain the stocks for meeting the imbalances in their fuel orders (demand and supply position) at different time points. The power generators maintain stock to cover the fluctuations in deliveries of fuels to them and continuous demand of the power generation plants. The consumers (bulk and large scale type) maintain the stocks to balance the fluctuations in fuel deliveries and their consumptions. Stocks of fuel suppliers and power generators are always to be taken into consideration while compiling the energy statistics. But the stocks of consumers are to be included only when the consumption statistics are compiled through the 'surveys of consumers'. Opening stock at the beginning of the year, closing stock at the end of the year or accounting period are recorded. The change in these stocks (opening – closing stock) gives the stock increase or decrease. The increase in stock (closing stock is more than the opening stock) is known as stock build and decrease in stock is known as stock draw. This estimate of change in stock level is used in the compilation of energy balances[3].

International Marine and Aviation Bunkers : These are quantities of fuels delivered to merchant (including passenger) ships, civil aircrafts of any nationality, for consumption during international voyages flights transporting goods or passengers. International voyages/flights take place when the ports of departure and arrival are in different national territories. Fuels delivered for consumption by ships/ flights during domestic navigation or domestic aviation, or for domestic fishing or domestic military flights are not included here. For the purposes of energy statistics, International Marine/Aviation Bunkers are not included in exports[10].

## Energy efficiency

Energy efficiency is "using less energy to provide same services". This can be viewed as (i) reducing the amount of energy required to provide same amount of products and services and there by reduction in energy costs (ii) efficient way of conversion of input form of energy in to an output form of energy through a conversion machine[2]. There is a slight difference in energy efficiency and energy conservation. Switching off the light when not required is energy conservation while replacing the existing incandescent lamp by a LED bulb or fluorescent lamp is termed energy efficiency[2].

The energy efficiency could be obtained by using efficient technologies, and efficient appliances and switching over to higher use of energy appliances working on renewable energy resources. There are three important areas where energy efficiency measures could mandatorily be implemented: (i) in building construction and maintenance, (ii) transport sector, (iii) and industrial sectors (in plants and industrial processes).

Following are the uses of energy efficiency measures

1) Reducing the amount of energy used in terms of units and enables to decision makers to reallocate the energy to other demanding and useful sectors for their consumption.
2) Reducing the energy costs for producing the same services or products (heat, light, illumination, and cooling effects etc)
3) Helps in reduction of greenhouse gas emissions in the country
4) Reducing the dependence on imports and ensuring energy security
5) Contributes in slowing down the depletion of energy resources.

## Energy intensity

Energy intensity is an important indicator that measures the energy efficiency of a nation's economy. This indicator is compiled as the ratio between the gross domestic consumption of energy and the gross domestic product (GDP) for the reference period, usually a year[2]. High energy intensities indicate a high price or cost of converting energy into GDP. Low energy intensity indicates a lower price or cost of converting energy into GDP. The energy consumption is generally measured in kilogram of oil equivalent and GDP is measured in thousand domestic currencies or US dollars, the energy intensity ratio is measured in kgoe per thousand domestic currency/US dollar.

### 1.2 Energy Product Statistics in some of the OIC Member countries.

*Learning Objectives*

1. To study the energy production and consumption in top 10 ranking OIC member countries
2. To understand the relative position of the top ten OIC member countries in production of Crude oil, Natural gas and Electricity

The table 1 gives the first ten ranked OIC member countries in the energy production out of the 39 OIC countries for which data is available in the period 2006 to 2011. The

unit of measurement is thousand metric tons of oil equivalent. All along the period, Saudi Arabia produced highest amount of energy. In 2011, its production share is 17.84% of the total energy produced in the OIC countries, It was followed by Indonesia and Iran with the shares 11.7% and 10.49% respectively. These three countries together produced more than 40% of the electricity in 2011. The first five ranked countries namely Saudi Arabia, Indonesia, Iran, Nigeria and Qatar have contributed more than 54% of the total energy production in the OIC countries[7].

The table 2 gives the energy consumption in the first ten ranked OIC member countries out of the 46 OIC countries for which data is available[7] in the period 2008 to 2011. The unit of measurement is thousand metric tons of oil equivalent. The first five ranked countries namely Iran, Indonesia, Saudi Arabia, Nigeria and Turkey have together consumed more than 50.1% of the total energy consumption in the OIC countries. Iran was the topmost consumer in the year 2011 and it accounted for 12.67% of the total OIC energy consumption. It was followed by Indonesia and Saudi Arabia with the shares 12.47% and 11.17% respectively. These three countries together alone consumed more than 36% of the total consumed. However, when per capita consumption out of these ten countries are looked at, the UAE stood at the top position with 7.568 kg of oil equivalent kgoe and then followed by Saudi Arabia with 6.498kgoe and Kazakstan with 4.716 kgoe respectively.

The table 3 gives the first ten ranked OIC member countries in the production of crude oil out of the 23 OIC countries for which data is available in the period 2009 to 2014. The unit of measurement is thousand barrels per day. All along the period, Saudi Arabia produced highest amount of crude oil[7]. In 2014, its production share is 30.51% of the total crude oil produced in the OIC countries, It was followed by Iran and Iraq with the shares 9.79% and 9.77% respectively. These three countries together produced more than 50% of the crude oil in 2014 in the OIC countries. The first five ranked countries namely Saudi Arabia, Iran, Iraq, Kuwait and UAE have contributed more than 67.85% of the total crude production in the OIC countries.

The table 4 gives the first ten ranked OIC member countries in the production of Electricity out of the 39 OIC countries for which data is available in the period 2005 to 2011. The unit of measurement is billion kilowatt hours. Among the top ten countries Saudi Arabia was the top producer of electricity in the year 2011 and accounted for

11.92% of the total OIC production of electricity. It was followed closely by Iran and Turkey with the shares 11.42 and 11.41% respectively. These three countries together produced around 35% of the total electricity in the OIC countries in the year 2011. The first five ranked countries namely Saudi Arabia, Iran, Turkey, Indonesia and Egypt have together contributed more than 50.91% of the total electricity production[7].

The table 5 gives the energy production of the natural gas world marketed in the first ten ranked OIC member countries out of the 25 OIC countries for which data is available in the period 2008 to 2014. The unit of measurement is Million standard cubic metres. The first five ranked countries namely Iran, Qatar, Saudi Arabia, Algeria and Indonesia have together contributed more than 53.98% of the total gas production. Iran was the topmost producer of the natural in the year 2014 and it accounted for 17.69% of the total OIC production of natural gas[7]. It was followed by Qatar and Saudi Arabia with the shares 14.47% and 8.51% respectively.

## UNIT 2

## Core data items for compilation of Energy statistics and source agencies involved

### 2.1 Important items for compilation of energy statistics

*Learning Objectives*

1. To understand various types of energy and sets of energy statistics
2. To know about the coverage of energy statistics for each set

There are mainly five energy types, namely (i) Electricity (ii) Coal, (iii) Oil (iv) Natural gas and (v) Renewable energy. Statisticians should collect the data on these five energy types. Broadly data on the production, consumption, imports and exports, stocks and energy balances of each energy product along with the related price statistics are to be collected, The energy statistics include the data on installed capacity of plants/ refineries, operating and efficiency factors of the installed systems, reserves, production, imports, exports, stocks, consumption, and price of each energy product. The statistics are to be collected and compiled on monthly, quarterly and annual basis for specified regions and for the total economy. They also comprise the sectoral analyses of the produced and consumed energy sources. Energy indicators also need to be compiled and the trends in them over a given period should be used as tool to monitor the effectiveness of energy programmes implemented for the sustained social development in the nation and to assess the alternative programmes[13].

Thus the coverage of energy statistics broadly includes (i) Electricity generation and transmission, (ii) Electricity distributions and consumption statistics, (iii) Solid fuel statistics, (iv) petroleum products statistics, (v) natural gas and liquefied petroleum gas statistics, (vi) Liquid biofuel statistics related to bioethanol and biodiesel statistics, (vii) Price statistics of all energy products supplied to each consumer groups (viii) energy balance sheets for each product and (ix) energy consumption statistics by economic activity industry and the (x) energy indicators.

Group wise items

Important items, within each group, on which comprehensive data is required, are detailed below.

Electricity statistics : Installed capacity of the power plants, projected production and actual production, consumption of fuels ( oil, and by type of solid fuels), heat generated

in CHP, electricity generated in CHP, Energy transmission facilities available by type, distribution facilities available, number of power distribution / transformation stations with their design specifications, region wise length of distribution lines, transmission loss of electricity, list of final end consumers, list of bulk consumers, quantity (units) of energy supplied to users by type of consumer groups and amount charged for the energy supplied, prices charged for the energy for each consumer group etc[13].

From the nuclear reactors, data on their installed capacity, design details (whether fission type or fusion type, cooling mechanisms involved), inputs being utilised by type, stock of inputs, quantity of electricity generated, plant efficiencies, supply of electricity to customers groups by type, prices charged etc. need to be collected. This information is to be collected and made available for preparation of monthly, annual reports and for preparation of energy balances.

Solid fuel statistics: Production of hard coal by type of coal (hard coal, lignite, hard coal coke, lignite coke, hard coal briquettes, lignite briquette, and asphalted), despatches of coal by type, stocks at pit heads by type, exports of coal by type, imports of coal by type, prices charged per unit of coal by type. This information is required to be collected and made available for preparation of monthly, annual reports and for compilation of energy balances.

Crude oil and petroleum products: Information on petroleum search operations, reserves by type, production of petroleum products by type, stocks by type of product, quantity supplied to market / bulk customers, list of refineries and their installed capacities, amount charged, prices charged by type and by customer group, imports and exports by type of liquid fuel, quantity and value of fuel used for own consumption in the refineries, value of inputs utilised in the products ( oils and other additives), the list of ratios of existing crude reserves to their production, etc. This information is to be collected in the scope of market business and made available for preparation of monthly, annual reports and for preparation of energy balances[13].

Natural gas , LPG gas: Natural gas , LPG gas and other gaseous energy products : Information on natural gas search operations, reserves by type of gas specification, production, ratios of existing natural gas reserves to their production, stocks by type, quantity supplied to market, list of bulk customers, list of refineries, quantity supplied

and amount charged to the customers, prices charged to the end customer and by bulk customer groups, imports and exports by type of fuel, quantity and value of gaseous fuel for own consumption in the industry, value of inputs ( gases, oils and other additives), authorities involved in generation and distribution and market regulations, licenses issued to distributors by type etc. This information is to be collected in the scope of market business and made available for preparation of monthly, annual reports and for preparation of energy balances[13].

Statistics related to liquid biofuels: monthly production, stocks and consumption, list of customers by type and quantities supplied by type, prices charged by consumer groups, consumption for own use within the producing industries, number and details of organisations involved in generation and distribution of biofuels, imports and exports if any, region wise and at the national economy level. This information is to be collected in the scope of market business and made available for preparation of monthly, annual reports and for preparation of energy balances.

Statistics related to Energy Balance sheets: Data on energy product wise supply by different sources and demand by different uses are to be collected along with the distribution and supply losses. Information on consumption of energy for own use by the generating plants, distribution/ supply of energy to the customers by sector are also to be collected. Further, information on the data source agencies, contact details, frequency of data collection and submission to the compilation authority of energy balances, mode of transmission, units and conversion factors used for each energy product need to be collected for compilation of energy statistics[13],

Other important related energy statistics

List of regulating agencies on environmental pollution, details of CO2 emissions measured by the authorised / environmental regulatory agencies from each of Electricity and heat generation plants are also to be maintained by the statisticians.

In addition to the above, the following data items are also important[12].

a) Separate lists of principal exporters and importer for various fuels like hard coal, crude oil and natural gas

b) Electricity generated from different fuels by type ( only electricity, heat and electricity only) combined heat and power plants) from various types of fuels, namely combustible fuels, nuclear fuels, hydro, wind and solar energy
c) Heat produced from heat only and combined heat and power plants from all type of fuels namely combustible fuels, geothermal , solar thermal, nuclear, chemical heat , heat pumps and electric boilers, and direst of solar thermal and geothermal type of plants

In summary, all the characteristics of each energy related fuel and energy in total are to be collected. If the fuel statistics are reliable and complete, then one can have good and reliable energy statistics[12].

## 2.2 Source agencies for energy statistics

*Learning Objectives*

1. To know about the source agencies involved
2. To understand the current status on source agencies in one of the OIC member country.

As there are wide variety of energy products from fossil fuels to biofuels, and many different physical characteristics are involved, many agencies (ministries, authorities and market regulatory agencies) are involved in collecting, compiling and disseminating the information on the energy products. Some energy statistics are also collected by the market regulatory authorities/ monitoring legal authorities which are entrusted with proper implementation of legal provisions laid down in the acts concerned with the energy products. More specifically, Ministry of Mines, Coal Extraction and Distribution Authorities or Coal Controller Authorities for the coal product, Power Generating and Transmission Authorities, Electricity Distribution Authorities for Electricity and Heat, General Directorate of Petroleum Affairs or designated Central Petroleum or Oil and Gas agencies for petroleum and natural gas products, Marketing Regulatory Authorities on Petroleum Products especially the LPG and LNG regulatory authorities. Renewable Energy Ministries or Market Regulatory Authorities for renewable energy products like biofuels: ethanol, biodiesel, and biogas, collect statistics on energy products about the production, generation, consumption etc. Similarly, big Consumer Organisations collect the data and disseminate the data at regular intervals.

Further, most of the above said agencies are also involved in monitoring the earlier policy decisions, studying the impact of current energy programs being implemented and alternative cases for sustained social development, especially on production, despatches, imports and exports, energy generation, distribution and consumption, thus they give sufficient importance for comprehensive data collection and dissemination practices.

The real practice varies from country to country. They collect the data through periodical reports from all enterprises dealing with the energy products, and disseminate the data at regular intervals (monthly, quarterly and annually)[13].

The box given below presents the current status regarding the source agencies for each type of the Energy statistics in Turkey, one of the OIC member countries[13].

| Type of statistics | Organisation involved, frequency of collection, method of collection etc |
|---|---|
| Electricity generation and transmission statistics | Administrative records of Electricity Generation Co, its mobile centrals or its subsidiaries, Other generation companies (build - operate or build- operate- transfer, or independent license holders)<br>Turkish electricity distribution company, Turkish electricity trading and contracting inc. Monthly, annually collected through surveys and administrative records, at national level, Electricity production, transmission statistics are issued in a printed book annually by Turkey Electricity Distribution company. |
| Electricity distribution and consumption statistics | Administrative records of Turkish Electricity trading and contracting company, Electricity Generation co Inc., other electricity distribution establishments. Distribution and consumption statistics are issued by the Electricity Trading and contracting company. |
| Petroleum and natural gas statistics | General directorate of Petroleum Affairs, annually, using administrative registers, disseminated at national level through website (www.pigm.gov.tr) |

| | |
|---|---|
| Market activities of Petroleum, natural gas and LPG | Energy market Regulatory authorities, , collected through the administrative records, published annually for natural gas market, annually and monthly for other markets. Website (www.epdk.gov.tr) |
| Statistics related to biofuels- ethanol | Administrative records of the Tobacco and Alcohol Market Regulatory Authority at national level, on quarterly basis, from annual sales reports of the other enterprises |
| Statistics related to biodiesel | Monthly reports of Energy Market Regulatory Authority through electronic media, and from other licensed owners , for the entire national level, (both domestic and foreign raw material requirement is considered) |
| Energy balances | Compiled by General Directorate of Energy affairs and disseminated through their website (www.enerji.gov.tr). The data is collected from the administrative records of the above sources and some items are through surveys. |
| Energy consumption statistics | Ministry of energy and Natural Resources conduct survey of all manufacturing industry establishments consuming more than a specified limit of energy under legal provisions. They also produce energy consumption statistics for buildings having more than a minimum specified area or using a minimum specified energy consumption. |
| Short term fuel statistics | Produced on monthly basis by TURKSTAT. Prices statistics of Electricity and Natural gas relevant to industry and households are also collected and sent to international organisations. Energy consumption statistics related to industry and service sectors are also collected and compiled by the TURKSTAT. |
| Energy densities, energy productivity indices | Ministry of energy and Natural Resources – General Directorate of Renewable Energy compiles them. |

Source : Turkey official statistics programme pp102-104

## UNIT 3

## Energy Statistics Standards, Energy balances and energy indicators

### 3.1 Importance, standards to be followed on Energy statistics,

*Learning Objectives*

1. To understand the importance of data collection requirement on energy statistics and standards to be followed
2. To learn about the data quality dimensions

Sound data base on Energy statistics are essential for effective policy formulation for electricity generation both at industry and national level. Further, comprehensive data is required for controlling the flow of both private and public investments into Energy sector. Introduction of state – of – the art technology in the complex operations of the electricity generation from fuels and planning for and use of sophisticated capital equipment and machinery for use in oil refineries, needs reliable data base both at entrepreneur level and economy level.

The data is generally collected either from establishments engaged in or from the employers or from administrative agencies or from specified Authorities. For this purpose, establishments engaged in production of electricity products, generation of Energy and Electricity, distribution of energy and list of customer groups by type need to be registered with an authorized agency.

Data is generally collected through regular surveys/ periodical returns. It needs to be collected in prescribed formats/questionnaires as per the time schedule and at periodic intervals (annual, quarterly and monthly).

While collecting and compiling the aggregates of energy statistics, indicators and disseminating the data/reports on the Energy sector, international recommendations for industrial statistics as given in IRIS 2008 and international recommendations for energy statistics as given in IRES 2011 need to be followed to enable the international comparability of data on the energy statistics.

The International Standard Industrial Classification of All Economic Activities (ISIC) consists of a classification structure of all economic activities based on a set of internationally agreed concepts, definitions, principles and classification rules. The classification structure gives an international standard format to organize detailed information about the state of an economy and useful to do economic analysis. It provides a comprehensive framework within which economic data can be collected, tabulated and disseminated.

Standard international activity classification (ISIC Rev 4) as suggested by the UNSD or an adjusted version prepared and adopted by the national economies need to be

followed while compiling the data on Energy consumption by the different industries at two digit level especially for manufacturing and transport sectors. This reduces the bias (under estimation or over estimation) in estimation of sector wise energy indicators/ and energy intensities.

The Central Product Classification (CPC) consists of a coherent classification structure of all products (goods and services) based on a set of internationally agreed concepts, definitions, principles and classification rules. It is intended to serve as an international standard for collecting, aggregating and disseminating all kinds of data requiring product details, especially in industrial production, national accounts, service industries, domestic and foreign commodity trade, international trade in services, balance of payments, consumption and price statistics. This provides a framework for international comparison and promote harmonization of various types of statistics dealing with goods and services.

The CPC ver 2 was completed as on 31 Dec 2008 and was in operation. The CPC ver 2.1 was released on 11$^{th}$ August 2015 and was in operation. The annex- 2 gives the CPC ver 2.1 at single digit (section) level. Product classification as suggested in the CPC ver 2.1 or a customized and adopted version by the national economies need to be followed to have international comparability of products (goods and services) on production, trade and consumption.

International Recommendations for energy statistics IRES were prepared and these are endorsed by the United Nations Statistical Commission in Feb 2011. This gives the Standard International Energy Product classification (SIEC) for energy products. It is developed by the Inter secretariat working group on Energy Statistics as per the recommendations of United Nations Statistical Commission. This is also adopted in the February 2011. It is prepared based on internationally agreed energy product definitions[4]. It gives a unified and harmonised definitions of energy products. It also provides the standard coding scheme with a common hierarchy of categories (sections, divisions, groups and classes of products. The classification along with the IRES guidelines helps the official statisticians in proper collection and compilation of energy statistics. The classification helps in international comparability of Energy statistics and integration of energy statistics with economic statistics etc. The SIEC provides links to the Central Product Classification CPC ver 2 and to the Harmonised commodity description and coding systems (HS 2007)[4].

CPC - SIEC correspondence is available for many energy products. When the coverage of e CPC version 2 divisions is seen in terms of SIEC, it is noted that three divisions of CPC which do contain energy products are fully covered in to SIEC (divisions (11- coal and lignite, and peat, 12- Crude petroleum and natural gas, 13-

uranium and thorium ores and concentrates of CPC 2). Nine divisions of CPC 2 namely 01,03,17,21, 31, 33, 34, 35 and 39 are partly covered in the SIEC, Eighteen (18) divisions of CPC 2, were not covered in SIEC as these divisions do not have any energy product in them. However, for SIEC classes 4300- refinery feed stocks, 5230- Bio jet kerosene, 5290- Other liquid biofuels, 5320- Bio gases from thermal processes, and 9900 - other fuels n.e.c, have no current link with the CPC classes[4].

The five dimensions of the data quality namely (i) assurances of integrity, (ii) methodological soundness, (iii) accuracy and reliability, (iv) serviceability, and (v) accessibility, as suggested by the IMF through its data quality frame work, need to be followed at all stages of collection, processing and dissemination of data[18].

### 3.2 Energy balances , indicators

*Learning Objectives*

1.To understand the importance of energy balance for each energy product

2.To know about the format used by the IEA for France

3. To understand the set of indicators recommended by the international agencies and the world bank

The energy balance sheets present the data on all energy products relevant to the national economy for a given accounting period in a systematic way. The sheets give the supply information (production, imports, exports, international bunkers and stock changes), use of the energy (transformation of inputs, by the energy industries for own use, by other industries) in the domestic economy for each product. They give the energy profile of the country at one place (production and consumption of energy) so that suitable policy measures could be taken to ensure energy security in times to come. It also provides a yardstick to view the international comparability of the statistics disseminated. The data is acquired from the administrative records of the producers, importers, exporters, big consumers and trough sample surveys of large establishments in the industry and through the Energy consumption surveys.

The energy balance formats are appropriate for the energy commodities/ products provided they are homogeneous at each point in the balance sheet. Further, the products should also be expressed in common energy units. Volume units are not preferred as they are dependent on pressure and temperatures.

The balance sheet format for one energy commodity namely Gas and Diesel oil, prepared by the IEA for the country France for the year 1999 is given in the box 3.1 for illustration. As the energy supply and use are not balanced, a statistical discrepancy term is recorded and the two estimates are balanced.

| Box 3.1 Gas /Diesel oil balance format used by IEA | |
|---|---|
| France year 1999 | |
| Gas /Diesel oil | unit : kilotonnes |
| | |
| Total domestic production | 32621 |
| Imports | 11668 |
| Exports | -2230 |
| Int Marine Bunkers | -419 |
| Stock change | 1213 |
| | |
| domestic supply | 42853 |
| Product Transfers | -529 |
| Statistical difference | 2265 |
| | |
| Transformation | 384 |
| Electricity plants | 41 |
| petrochemical plants | 336 |
| others | 7 |
| | |
| Energy Sector for own use | 4 |
| Petroleum refineries | 4 |
| | |
| Final Consumption | 44201 |
| By Industry sector | 2475 |
| Iron and steel | 35 |
| chemicals and petro chemicals* | 1383 |
| of which feed stock* | 1383 |
| nonferrous metals | 15 |
| nonmetallic minerals | 122 |
| transport equipment | 48 |
| machinery equipment | 152 |
| Mining and quarrying | 1 |
| food and beverages | 110 |
| paper and pulp | 14 |
| construction | 409 |
| textiles | 38 |
| others | 148 |

| | |
|---|---|
| **Transport sector** | **26801** |
| **road** | **25948** |
| **rail** | **368** |
| **internal navigation** | **485** |
| | |
| **Other sectors** | **14925** |
| **Agriculture** | **2026** |
| **commerce and pub services** | **4450** |
| **residential** | **8442** |
| **Others** | **7** |
| | |
| *** non energy consumption** | |
| | |
| **Source: Energy statistics Manual 2004 IEA, pp34-35** | |

The total supply of energy is obtained from different source components. They are

(i) Domestic production

(ii) Imports

(iii) Exports

(iv) International marine bunkers

(v) Stock changes.

The total supply of the energy commodity is obtained as sum of them (Production +Imports-Exports- Bunkers+ stock draw from stocks). Stock change is calculated as the difference of opening stock at the beginning and closing stock at the closing of the period. If the closing stock is more than the opening stock, they it is said that there is increase in stock and termed as stock build. If the closing is less than the opening then there is stock drag. If the stock change is stock build then it is added with a negative sign to the supplies. If the stock change is stock drag, then it is added with a positive side to the supplies. The supply figure arrived at is adjusted with the transfers between the commodities to arrive at the total supply available for domestic consumption.

The uses side is arrived as the sum of

(i) transformation input

(ii) energy sector own use

(iii) distribution and other losses

(iv) energy used for non-energy uses and

(v) For final energy consumption.

The final energy consumption is divided further into the energy demand of three major groups namely (a) Industry, (b) Transport and (c) Others. The industry major group is sub grouped into other economic industries namely (i) mining and quarrying, (ii) important divisions of manufacturing, (iii) construction and (iv) other economic sectors. The Transport major group covers the energy demand of (i) air transport,(ii) road transport, (iii) rail transport and (iv) national navigation. The 'Others' major group covers the energy demand of (i) Agriculture (ii) Commerce and Public services (iii) all others. To balance the supply and uses sides, a term known as statistical difference is included in the balance sheet. Different countries follow different energy balance formats and sector classifications suiting to their needs[1].

Energy Balances are presented in the form of a matrix of products and flows with different levels of disaggregation for each energy product. Once, the energy balances are done, many useful energy indicators are prepared. Sectoral energy densities, energy productivity indices are also compiled by some countries[1].

Energy balances are genrally prepared by the coordinating agency/ disseminating agency of the Energy statistics (usually the National Statistical Organisations). The data is collected through electronic media or by post/courier from all the source organisations including import and export organisations and energy balances are compiled for each energy product as per the prescribed methodology. The actual formats used by different countries vary from one another. There is slight difference in treating some aspects of energy consumption like pipeline transport of materials. The international recommendations laid down on the formats of energy balance sheets , concepts and methodologies laid down for preparation of the energy balances ( as elaborated in IRES guidelines ) are to be followed. To ensure international comparability, one needs to follow the Standard Units of measurement, and recognised conversion factors while compiling the energy balances. Over estimation or under estimation involved in energy consumption due to the multi-level and multi stage use of some energy products such as coal and naphtha (consumption by non-energy generating industries) should be taken note of.

## Energy indicators

Energy indicators are used as tools to monitor the energy policies that were taken earlier. They also help in identifying the programs taken up by the countries for sustainable development[6].

The International Atomic Energy Agency (IAEA) in cooperation with the United Nations Department of Economic and Social Affairs (UNDESA), the International Energy Agency ( IEA) , the Statistical office of European Communities ( EUROSTAT) and the European Environment Agency (EEA) had developed and recommended common set of Energy indicators to monitor the implications and impacts of energy development and consumption programs. These indicators are useful to monitor the past energy related programs and alternative policies, trends in production, consumption and their use in social development/ well-being in the economies, effect of energy production and use on the environment. They also help in structuring the collection and compilation of energy statistics[6].

The above said international organizations recommended a set of 30 core indicators to be compiled by each country to monitor the sustainable energy development programs and policies. They are classified into three sets of indicators representing social, economic and environmental dimensions. (4 indicators to depict the impact with respect to social dimension, 16 indicators for economic dimension and 10 indicators with respect to the environmental dimension.

The set of indicators compiled in view of the social dimension, look at the accessibility to households, affordability to users, disparities in use by households by their income size class, safety to the users in terms of no fatal accidents occurred etc.

The set of indicators compiled in view of the economic dimension, look at the overall use of energy per capita, GDP productivity per unit of energy, supply efficiency in terms of energy conversion and distribution, production in terms of reserves to production ratio, resource to production ratio, end use intensities ( industrial energy intensities, agriculture, service, transport, house hold intensities etc), imports and stocks, prices of energy products, energy type in terms of fuel mix in energy and electricity etc.

The set of indicators prepared in view of environment dimension look at the periodic changes in climate in terms of GHG emissions, air quality in terms of concentration of air pollutants due to energy generation in urban areas, water quality in terms of discharges in liquid effluents from energy systems, soil quality in terms of acidification, rate of deforestation attributed to energy use, solid waste generation in terms of waste generation to units of energy generated[6].

The methodology of compiling the indicators, components required, units of measurement, any international recommendations on the indicator, source of the data, limitations of the indicator alternative definitions etc. are given for each indicator.

Two of the core indicators falling under the economic dimension are illustrated below.

Energy use per capita: It measures the level of energy use on per head basis. The relevant components to prepare this indicator are total energy supply, total final consumption and electricity use and total population. From the energy balance sheets the energy production, consumption for each product, total electricity consumed by the population are taken and the ratios are compiled using the total population. When prepared for each region within the economy, these indicators reflect the trend caused by social, economic and geographical factors.

The Energy use per unit of GDP: This is also called aggregate energy intensity of the economy. This is calculated as the ratio of energy use to economic output. The output (GDP) is taken in USD, converted from the real national currency at PPP (purchasing power parity) for the base year to which the national currency was deflated. The total energy use is in terms of oil equivalent. This gives the economic intensity. Similarly, sectoral intensities could also be compiled (industrial, transport, service sector, agriculture and households). The World Bank also covers this indicator but as GDP per unit of total energy used, exactly as the reciprocal to this indicator.

The world bank[5] also collects energy statistics from all countries in a prescribed questionnaire and compiles energy indicators and upload them in its data base (data.worldbank.org) on indicators. The following indicators are prepared

1. Alternative and nuclear energy as percentage of total energy use. The alternative and nuclear energy is also known as the clean energy. it comprises hydro power and nuclear, geothermal, and solar power energies.
2. Combustible renewables and waste energy as a percentage of total energy use. This includes energy produced from solid biomass, liquid biomass, biogas, industrial waste and municipal waste.
3. Energy imports net as percentage energy use. The net energy imports are estimated as
   Total primary energy use before transformation to other end use fuels – production. These two estimates are measure in oil equivalents.
4. Energy use per capita
5. Fossil fuel energy consumption as percentage of total energy use. The fossil fuels includes coal, oil, natural gas products.
6. Gross domestic product (GDP) per unit of energy. This is measured in GDP in USD per kilogram of oil equivalent. For this purpose PPP GDP with 2011 constant international dollars is taken.
7. Pump price of diesel in USD and pump gasoline price in USD are also taken for looking at the trends.

The above said indicators are used to see the relative position of the countries in the use of alternative energies and price position of the gasoline products.

## UNIT 4

## Issues in Data collection and data processing and Data dissemination Practices

### 4.1 Issues in data collection and processing

*Learning Objectives*

1.Understand various issues existing in various source agencies, data collection practices

2. To understand about various cases for the under coverage or over coverage in energy statistics

For important fuels, there are no coverage issues. Conventions are well developed and documented[9]. But for some of the biomass-fuels which are available mostly in developing economies, conventions for coverage and statistical measurement are yet to be developed and documented especially on production, trade and consumption. This is because of the fact that the biomass fuels take many forms like vegetable residues, animal wastes etc. These fuels are used in small scale and that too mostly used by households for their own consumption, widely spread over the rural areas. Divergent practices of energy production and consumption are involved. Some biofuels like firewood, round wood fuel, animal dung/ cakes etc. are measured and traded in quantity in some areas and by count in some other areas within the nation. Moreover, most of the energy produced from these biofuels is consumed for own use and not marketed. Regulatory mechanisms governing the design of the energy producing plants used in biofuels, and data collection mechanisms for recording of production and consumption of the energy produced from these biofuels plants on a regular basis are yet to be put in place in some of these developing countries. However, in some countries, where subsidies are given by the governments to install the biofuel energy producing plants, data on number of installations, installed capacity, capital involved, and subsidies given etc. are collected. But regular data flow on production, consumption etc. from these systems are not collected and published regularly.

Earlier, due to technical limitation of production processes, heat generated by combustion of fuels is partly wasted. In geothermal plants, the quantity of heat available, being harnessed, and the quantity being utilised either for direct use or for converting into electricity etc. are sometimes not directly measurable[9]. The final energy could only be measurable. But now due to the development of new technologies, most

of the heat generated is harnessed and converted to electricity. The increased efficiency rates shall not be used for all plants without verifying the nature of actual technology used. This demands comprehensive data on installations, technologies being used along with the production and consumption of energy produced from the biofuels.

Fuels and energy are measured differently in different countries and units of measurements vary depending on the physical state of the fuels, country's historic conventions and earlier measurement practices. Various units used in measuring the mass in different countries are Kilogramme, Tonne, Long ton, Short ton, and Pound. For volume measurements, units like US gallon, UK gallon, Barrel, Cubic foot, Litre and Cubic metre are used. Different units being used for the energy measurement in different countries are Tera joule, Giga calorie, Million tonnes of oil equivalent, Million British thermal unit (Btu), Million ton coal equivalent and Giga watt-hour. The Internationally recommended and recognised units for measurement are SI units : The common SI units suggested for the fuels are kilogram or tonnes and for energy it is joule.

In practice, the fuels are measured in their natural/ physical units. Solid fuels are measured generally in mass units ( kilograms or tonnes). Liquids and gases fuels are measured in volume units (litres or cubic metres). There are some exceptions like fuel wood is measured in cubic metres. The unit of energy is the joule. The electricity energy is measured in kilowatt-hour(kWh). The higher multiples and sub multiples for the units used for measurement are given in box 4.1.

Box 4.1. List of higher multiples and sub multiple prefixes used in energy statistics

| | | | |
|---|---|---|---|
| $10^{1}$ | Deca (da) | 10-1 | Deci (d) |
| $10^{2}$ | Hector (h) | 10-2 | Centi (c) |
| $10^{3}$ | Kilo (k) | $10^{-3}$ | Milli (m) |
| $10^{6}$ | Mega (M) | $10^{-6}$ | Micro (µ) |
| $10^{9}$ | Giga (G) | $10^{-9}$ | Nano (n) |

| | | | |
|---|---|---|---|
| $10^{12}$ | Tera (T) | $10^{-12}$ | Pico (p) |
| $10^{15}$ | Peta (P) | $10^{-15}$ | Femto (f) |
| $10^{18}$ | Exa (E) | $10^{-18}$ | Atto (a) |

For historical reasons, the energy unit is measured as the number of joules of one ton of coal equivalent (tce). Currently, it is measured as number of joules of one tonne of oil equivalent (toe) (41.868 giga joules). As per the recommendations of the international standards organisation (ISO), the higher multiples of energy is to be measured in tera joules ($10^{12}$ joules). The quantities of heat in steam flows are measured in calories or in joules. Using the densities of the liquids, the measurements made in volume units are converted to mass terms. The quantities of various fuel products expressed in their natural units could be compared only when they are all given in a common unit[1]. For this purpose, all the natural units of the fuels are to be converted into a common energy unit. This enables comparability and also one can arrive at the total energy content of different fuels which are in different physical states. For each fuel, the heating value, also known as calorific value of the fuel is measured and expressed in terms of common energy unit –joules/calories. The calorific values by the type of fuel and commonly used conversion factors are given in the box 4.2.

Box 4.2 : Calorific values by type of the fuel

| Fuel Type | GCV (MJ/kg) | NCV(MJ/kg) | |
|---|---|---|---|
| Anthracite hard coal | 29.65 to 30.35 | 28.95 to 30.35 | |
| Coking coals | 27.80 to 30.80 | 26.60 to 29.80 | |
| Low pressure coke | 26.30 | 25.40 | |
| Petroleum coke (green) | 30.5 to 35.8 | 30.0 to 35.3 | |
| Coke oven gas | 19.01 MJ/$m^3$ | 16.90 MJ/$m^3$ | |
| Blast furnace gas | 2.89 MJ/$m^3$ | 2.89 MJ/$m^3$ | |
| LPG* | 50.08 GJ/t | 46.15 GJ/t | |
| Naphtha | 47.73 GJ/t | 45.34 GJ/t | |
| Aviation gasoline | 47.40 GJ/t | 45.03 GJ/t | |
| Methane | 55.52 MJ/$m^3$ | 50.03 MJ/$m^3$ | |

Notes: (i) GCV is gas calorific value, and NCV is net calorific value

(ii) for naphtha, the net calorific value is assumed to be of 95% of gross

(iii) *a mixture of 70% propane and 30% butane by mass

Source: energy statistics manual 2005 of IEA

Usually the conversion factors are expressed in gigajoules or mega joules per unit of mass or per unit of volume. The calorific values of a natural gas varies according to its composition[1]. The NCV of natural gas is generally taken as 0.9 of its Gross calorific value. Other conversions used in Energy statistics and some plant efficiency factors are given in box 4.3

Box 4.3 : Conversion factors and plant efficiency factors used in compilation of energy statistics

| | |
|---|---|
| 1 kilo gram | 2.2046 pounds |
| 1 cubic metre | 35.3 cubic feet gas |
| 1 pound | 454 gms |
| 1 Metric tonne | 1000 kilograms |
| 1 joule | 0.23884 calories |
| 1 million tonnes of coal | 16.14 peta joules of energy |
| 1 million tonnes of oil equivalent | 4.1868 peta joules of energy |
| 1 million tonnes of oil equivalent | 11.6 MWh |
| 1 billion cubic metre of natural gas | 38.52 peta joules of energy |
| 1 cubic metre at $15^0$C of LNG | 40.00 MJ of energy |
| 1 Kilogramme of LNG | 54.40 MJ of energy |
| 1 billion kilowatt hour of electricity | 3.60 peta joules of energy |
| Plant efficiencies | |
| From hydro, wind , tide, wave, ocean and solar photovoltaic systems | 100% efficiency in converting to electricity |
| Nuclear heat from nuclear fission reactors and solar thermal heat panels | About 33% efficiency in converting to electricity |
| Geothermal heat plants | 50% of heat produced |
| From solar thermal heat panels | 100% of heat produced |
| Geothermal heat | 10% efficiency in converting to electricity |

Source: Energy statistics 2014 MOSPI, CSO of India, Energy statistics manual 2004 of IEA and UN Energy statistics year Book 2012.

Some of the concepts which create issues at measurement stage and further consolidation stage are discussed below.

## Gross and Net calorific values

As discussed earlier, the fuels provide the heat during the process of combustion. The hydrogen in the fuel combines with oxygen and gives some amount of water vapour in high temperatures of combustion. The exhaust gases carry away some of the heat generated in the form of latent heat but it is wasted in the atmosphere. The gross value includes all of the heat released from the fuel including any carried away in the water vapour formed during combustion. The net value excludes the latent heat of the water formed during combustion. This fact is to be noted when obtaining a calorific value of the fuel. It is estimated that the difference between the gross and net calorific values is around 5% in solid fuels, around 6% in liquid fuels whereas it is around 10% in the gaseous fuels. Methods of determining the net calorific values vary with fuel to fuel. The net calorific value of natural gas is highly dependent on its composition. These calorific values also varies from country to country. Standard conversion factors for various fuels by types (for all solid, liquid and gaseous fuels), are to be developed utilising the scientific results on the subject and these standard conversion factors are to be used[1]. Box 4.2 gives some examples of GCV and NCV values.

In transmitting and distribution of energy through networks, energy wastages bound to happen. The energy loss depends on the infrastructure systems, efficiency of the networks used and vary from country to country. These rates of wastage are to be evolved through well documented scientific processes and the rates are utilised to arrive at the final estimates of the energy loss.

## Other related issues:

Another issue that arises in compilation of energy statistics is : the quantity of fuel produced at mines site is not the same quantity used for electricity generation. For example coal produced at mine site is washed/ treated so that other impurities and waste materials are removed. Moreover, the coal mined may be a mixture of different grades of coal with different specifications in terms of heating value. The coal consumed finally for generation of electricity in thermal plant may be of higher grades.

This imbalances the estimation of coal quantities and values of coal consumed as the prices vary by the grade of the coal and thus disturbs the energy balances.

It is estimated that the electricity and heat sector was responsible for 42% of global Carbon dioxide ($CO_2$) emissions. It is doubled during the period 1990 to 2012. It is mainly attributed to the electricity generation process from coal. Thus it is suggested to decarbonise the power sector in near future. Developing climate friendly technologies, higher use of renewable energy, maintaining higher energy efficiency levels in the generation plants and use of new carbon capture storage technologies are some of the measures that will help to reduce the carbon dioxide emissions[1]. There are many other related environmental issues like environment change, air quality, generation of air pollutants, acidity of soil, water contamination due to the liquid wastes generated in energy production, deforestation, fear of high voltage fatal accidents etc. These issues need to be addressed on priority as many human rights and environment protection organisations are agitating on these issues. This demands a wider scope of data on energy statistics and enhances the responsibility of energy statisticians for producing qualitative data/ indicators on the issues.

It is inferred that the buildings represent 32% of total final energy consumption (for heating, cooling and lighting purposes) in most of the IEA countries. Efforts are being made to construct buildings with zero energy requirements (buildings making low energy demand or consume energy which is directly supplied by renewable sources) by integrating the designs with the nature, use energy efficient materials for the walls and energy efficient appliances. With this in view, buildings are being constructed having maximum benefit of sun light and wind directions, and also using suitable energy efficient materials for the roofs, walls, suitably insulated doors and windows and use of most efficient electrical and electronic appliances within the buildings[1] ( use of led lights or fluorescent lights instead of incandescent bulbs etc.).

Most of the countries follow the calendar year as the reference period for energy statistics. However, some countries like India, Newzeland, Myanmar, follow the fiscal year April to March. Countries like Afghanistan and Iran follow 21$^{st}$ March to 20 th March period, whereas Pakistan, Australia, Egypt, Bangladesh, Bhutan and Nepal follows July to Jun period. A uniform reference period needs to be followed for better international comparability.

Indicators compiled per capita basis use population data as a denominator. Usually, mid year population is taken for this purpose. Comparison of provisional and final values of the indicators should be made with due vigilance whether the difference is due to energy data or population data (there may be a revisions in the population data)[6].

Certain indicators as recommended by the international agencies do have limitations in compilation and interpretations. As they are not only effected by the components variables but also by other factors such as climatic change, level of aggregation, geography and structure of the economy. So care should be taken while doing the international comparability and interpreting relative positions[6] of the countries.

**4.2 Data Dissemination practices**

*Learning Objectives*

*1.To know about the national level publications that provide data on energy statistics*

*2.To understand about the international level publications / data bases related to Energy statistics .*

As detailed in the unit 2.1, many specialised agencies are involved in collection and compilation of energy statistics. They disseminate periodical reports on the energy products concerned to them. Besides these specialised resource agencies, the national statistical coordination office of the country (usually known as the National Statistical Office or Central Statistical Office) is the nodal agency to coordinate, collect, compile reliable data on Energy Statistics and disseminate the data in the form of periodical reports and publications. The energy statistics are given at one place by the NSO through these publications.

The national coordinating offices collect the relevant data and tables from the source agencies. They apply various validation checks for consistency and look at the growth rates and comment on the results. They compile the relevant aggregates on energy statistics. Thus they ensure for the overall accuracy of the data collected and supplied. They publish the energy product distribution tables and write the reports for dissemination. Some energy indicators are also compiled and incorporated in the tables. In some countries, the nodal agencies make seasonal adjustments for the

energy consumption data before they are published. They maintain timeliness at each stage of collection and publication and punctuality in releasing the publication.

They disseminate the energy statistics periodically following the data dissemination principles as per the data release calendar giving simultaneous access to all concerned users (government institutions, international organisations, private organisations, and public) at the same time through their annual /periodic publications and websites. Meta data giving the methodology of collection, compilation of tables, definitions and concepts used, units of measurement followed for each fuel/ energy product along with the conversion factors is also usually recorded in the publication.

When new surveys are launched or additional data are incorporated or base years are changed by source agencies, data revisions are also done and back series data is also made available by the nodal agencies. Data revision policy is also invariably followed and explanatory notes recorded as footnotes whenever data for a set of more than 3 to 5 years is published.

Some of the national publications on energy statistics are

a) Energy Statistics year book
b) Annual Energy Statistics
c) Reports on electricity generation and distribution
d) Annual reports of the Public Authorities engaged in Energy generation, transmission and distribution
e) Monthly bulletin on coal statistics
f) Coal directories
g) Coal consumption in steel industries, a publication by Steel Authority
h) Coal consumption in electricity industries , a publication by electricity generating authority
i) Publication of annual basic statistics on Petroleum and natural gas products
j) Monthly and quarterly report on Petroleum statistics
k) Annual Renewable energy statistics published by the nodal agency of the renewal energies
l) Directories of end users of oil, gas, and electricity
m) List of Importers and Exporter in Oil and gas

These publications do contain detailed data on the fuel reserves, fuels extracted, despatched and stocks at pithead etc. production of crude, despatches to refineries and refinery products to various users, energy produced, electricity and gas generated, transmitted, distributed and used by industry and by different consumer groups, renewable energy generated by type of fuel and supplied to grids or final users etc.

At international level, various organisations do collect comprehensive data on core energy products through prescribed questionnaires and compile energy statistics and aggregates, energy balances for each product following the internationally acceptable methodologies, standard units of measurement. They publish data periodically and upload to their websites and maintain the energy product data bases. The principal organisation among them is the Industrial and Energy Statistics Section of UNSD. It collects energy data annually, through an annual questionnaire from all the countries. From this data, various tables are prepared and published in the Annual Energy Statistics year book. The latest published one is for the year 2012. Many other organisations like International Atomic Energy Agency (IAEA), International Energy Agency of the Organisation for Economic Cooperation Development (IEA/ OECD), Organisation of the petroleum exporting countries (OPEC), Statistical office of the European Communities (EUROSTAT), International Energy Agency (IEA) and US Energy Information Administration collect data on energy products and publish data in their publications and data uploaded in their websites.

The IEA prepares and publishes many reports on the energy statistics and also keep many reports on its website for free download. Some of the important publications of the IEA are

World energy outlook 2015

1) Coal information 2015
2) Natural Gas information 2015
3) Electricity information 2015
4) Renewable energy information 2015
5) Energy statistics of Non OECD countries 2015
6) Energy balances of non OECD countries etc.

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# GLOSSARY

| Item | Units | Definition |
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| Bio fuels | | They are made from new or used vegetable oils and may be blended with other petroleum based fuels. Biofuels cover bioethanol, biodiesel, bio methanol, bio methyl ether and bio oil. |
| Bio gases | | Gases arising from the anaerobic fermentation of biomass and the gasification of solid biomass including the biomass in wastes. Composed mainly of methane and carbon dioxide. |
| Bitumen | | A solid semi solid or viscous hydrocarbon with a colloidal structure, brown to black in color. It is obtained as a residue in crude oil distillation. Used as an adhesive, binding material. It is also used for generation of electricity in special plants. |
| C.I.F Prices | National currency or USD | The c.i.f price is the price of a good delivered at the custom boarder of importing country and includes cost, insurance and freight |
| Coal | | A substance mainly composed of carbon. It also contains some amount of hydrogen, nitrogen, Sulphur and oxygen. Its physical characteristics vary. On combustion, it gives heat and energy. It includes primary solid fuels such as hard coal and lignite and derived fuels. |
| Combustible renewables | | Consists of biomass and animal products, municipal wastes and industrial wastes |
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| Conventional crude oil | | This includes crude oil and natural gas liquids and condensate liquids |
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| Crude oil | | Is a mineral oil consisting of a mixture of hydrocarbons of natural origin and associated impurities such as Sulphur. It exists in liquid form under normal surface temperatures and pressure. Physical characteristics are highly variable. It comprises crude oil, natural gas liquids, refinery feed stocks and additives as well as other hydrocarbons such as mineral oils, synthetic oils and oils from coal and natural gas |

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| | | liquefaction. |
| Unconventional crude oil | | This includes a wider variety of liquid oils like oil sands, extra heavy oil, gas to liquids and other liquids. |
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| Export price index | number | The export price index measures the percentage change in prices received by the country's producers for goods and services sold outside the country. This index is calculated for the prices of one or any specified group of commodities entering into the international trade using f.o.b export prices. |
| Energy balance | | It is a frame work that provides the demand and supply of each energy product furnished in a format. It expresses all data in a common energy unit which makes it possible to define the total product. |
| F.O.B. Prices | National currency or USD | The f.0.b prices are free on board prices. It is the market value of goods at the point of custom's frontier of the economy. |
| Gasoline type jet fuel | | Light hydro carbons for use in aviation turbine power units distilled between $100^0$C to $250^0$C. |
| Gas oil/Diesel oil | | Gas oils are middle distillates with carbon number range from C11 to C25 with distillation range of $160^0$C to $420^0$C |
| GDP at current prices | National currency or USD | Gross domestic product at current prices is GDP for current reporting period at current prices, also known as the nominal GDP. It is an aggregate measure of production equal to the sum of the gross value added of all resident institutional units engaged in production. |
| GDP per capita | National currency or USD | Gross Domestic product per capita is calculated as the aggregate of production divided by the population |
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| Hydro electricity | | Energy produced from devices/hydro power plants which are driven by fresh, flowing or falling water. |
| Kerosene | | A mixture of hydro carbons .it is distilled in the range of $145^0$C to $300^0$C. |
| Liquid biofuels | | Liquid biofuels are mainly biodiesel and bioethanol used as transport. |
| Lignite | | Brown coal with a gross calorific value less than 20Mj/kg |
| LNG | | Liquefied Natural gas is the natural gas that has been liquefied for transport purpose. |
| Lubricants | | Oils produced from crude oil in the distillation process. It is used to reduce friction between two sliding surfaces and during metal cutting operations. |

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| Motor gasoline | | A mixture of aromatics and aliphatic hydro carbons. It is distilled in the range of $25^0$C to $220^0$C. |
| Noncombustible renewables | | Includes geothermal, solar, wind, hydro, tide and wage energy. |
| Naphtha | | Light and medium oil distilling between $30^0$C and $210^0$C which do not meet the specifications of the motor gasoline |
| Natural gas | Different units like cubic metres for volume, tera joules or British thermal units etc. for energy | A mixture of several hydro carbon gases including methane, ethane, propane, butane and pentane, carbon dioxide, nitrogen and hydrogen sulphide. It is known as wet when other hydrocarbons other than methane are present, dry when it is almost pure methane and sour when it contains significant amounts of Hydrogen sulphide. |
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| Nuclear energy | | The energy produced in nuclear reactors through fission and fusion of nuclear materials like uranium 235 etc. Nuclear power is the largest source of low carbon electricity in many countries. |
| Nuclear electricity | | Electricity generated from the heat produced in the nuclear reactors. The heat is generated due to the radiation that arises through the fusion or fission of nuclear materials like uranium 235. |
| Petroleum products | | Comprise of refinery gas, ethane, liquefied petroleum gas, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil naphtha white spirit, lubricants, bitumen, paraffin waxes, petroleum coke and other petroleum products. |
| Proved coal reserves | | The coal resources falling in an area within 200m radius from the borehole point. |
| Indicated coal reserves | | The coal resources falling in an area within 200m to 1Km radius from the borehole point. |
| Inferred coal reserves | | The coal resources falling in an area within 1Km radius to 2Km from the borehole point. |
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| Renewable energy | | Energy derived from natural processes like sunlight and wind that are replenished at a faster rate than they are consumed. Solar, wind, geothermal, hydro and some forms of biomass are common sources of renewable energy. |
| Solar energy | | Solar radiation exploited for hot water production and electricity generation by flat plate collectors, photovoltaic cells, and solar thermal electric plants |

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| Solid biomass | | Covers organic non fossil material of biological origin which may be used as fuel for heat and electricity generation. It comprises of charcoal etc. |
| Utilities | | Undertakings of which the essential purpose is the production, transmission and distribution of electric energy. These may be public authorities or government authorities or private organizations. |
| Non utilities | | An independent power producer which is not public utility. The power could be sold to public utilities or final end users |
| Electricity only plants | | Produce electricity through the alternators driven by turbines that are propelled by steam produced by combustible fuels, nuclear heat or gas turbines. |
| Heat only plants | | Produces heat through boilers using combustible fuels or geothermal heat and supplied to end users. |
| Combined heat and power plants (CHP) | | They produce both heat and power. They are also known as cogeneration units. They use one generating unit or multiple units to generate heat and electricity. They are many types of CHP power plants. |

Source: Energy statistics manual 2005 of IEA, Energy statistics 2014 of MOSPI, CSO India



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