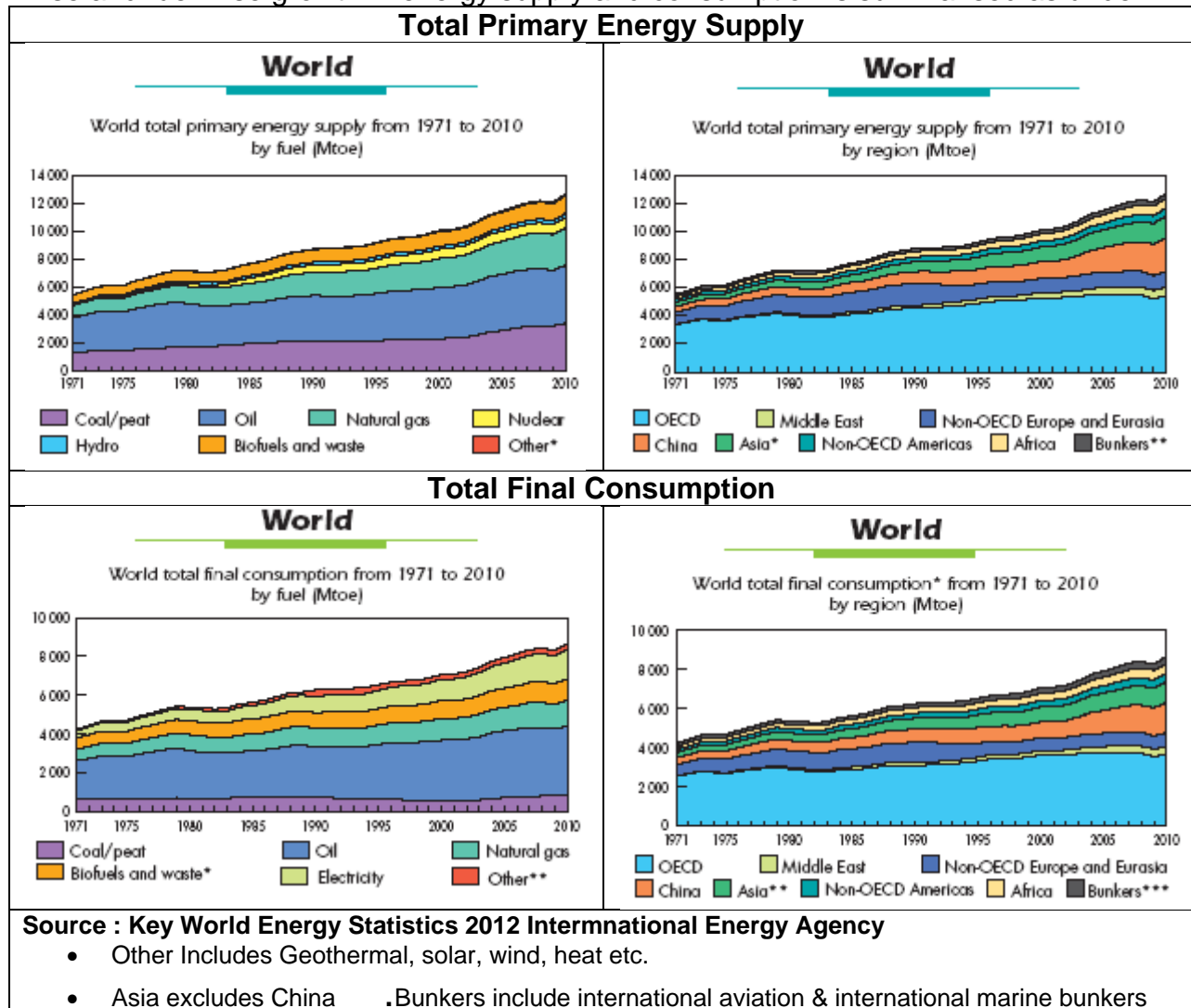


## CHAPTER 16 ENERGY

***“Indian Economy has witnessed rapid growth in the past decade and to sustain a similar growth trajectory of 9%, power sector needs to grow at at least 8.1 % per annum”..... Planning Commission***

**16.1 Background :** 16.1.1 Development of economies has seen concomitant increase in energy use across the world, with the pace being faster in the Asian economies like China which joined the wagon later. The demand for energy has also been spurred by burgeoning population in these economies (growth in population in developed economies has slowed down) as not only more heads use more energy but also due to increased energy consumption per head as individuals aspire for improved standards of living (Per capita consumption in developed economies being higher to start with ).

16.1.2 To meet the demand non conventional sources of energy like nuclear and environmental friendly renewable sources of energy have gained currency. The region wise and fuel wise growth in energy supply and consumption is summarised as under.



## 14.2 Indian Scenario: Issues & Policies

*“India’s power sector is a leaking bucket; the holes deliberately crafted and the leaks carefully collected as economic rents by various stakeholders that control the system. The logical thing to do would be to fix the bucket rather than to persistently emphasize shortages of power and forever make exaggerated estimates of future demands for power. Most initiatives in the power sector (IPPs and mega power projects) are nothing but ways of pouring more water into the bucket so that the consistency and quantity of leaks are assured...”*

Deepak S. Parekh, Chairman, Infrastructure Development Finance Corporation, September 2004

14.2.1 India is poised to become the 3rd largest energy consumer by 2020 after the USA and China. Surge in energy demand in India due to demographic and economic reasons places enormous pressure on its energy resources. As it walks the path of growth enormous burden due to subsidies specially in rural sector, cooking gas, diesel etc, higher T& D losses, power theft etc add to the woes in view of the already existing supply side constraints. Recent issues over mining, coal block allocation etc have further aggravated the problem. Consequently the energy situation has worsened in some states like Uttar Pradesh whereas some others like Gujrat have managed a turn around. However more villages have been electrified and electricity is increasingly substituting less cleaner fuels like kerosene with about 55.3 % rural households having access to electricity as per 2011 Census. Government has also taken steps to rationalize the subsidies, revised gas pricing formula linking price of domestic natural gas to international gas prices. Series of measures have been taken in the recent past regarding pricing of Petrol & other fuels. This includes capping the subsidized LPG cylinders at 6 per connection per year, raising the diesel price one time (by Rs 5 per litre) and permitting the Oil Marketing Companies (OMCs) to raise prices in small measures periodically. Oil companies were already allowed to revise price of petrol in accordance with international prices and exchange rate in June 2010.

14.2.2 Petroleum pricing in India has been largely viewed as **black hole of subsidies**. Balancing the social and economic considerations has confronted the governments since independence. From ‘import parity’ type of pricing, known as the ‘Value Stock Pricing’ (VSA) after the independence (a cost-plus formula to the import price, which included added elements of all the costs such as shipping charges upto the Indian ports, insurance, transit losses, import duties and other levies and charges) to Administered Price Mechanism (APM) which actually involved artificial price fixing by the government from time to time and hike or reduction in the prices and the present return to market prices, governments effort to partially insulate the prices of petroleum products in the country from volatile international crude oil prices and to ensure that the prices of certain products like kerosene, used predominantly by poor, remain subsidised have costed a lot in terms of subsidies.

14.2.3 However, India's retail prices for petrol and diesel are relatively high despite subsidies. In fact, the total Government (central and states) taxes and surcharges on petrol products exceed by far the annual budget subsidies for these products.

14.2.4 Development of renewable sources of energy in view of sustainability and cleaner greener environment is also becoming increasingly important. More so to

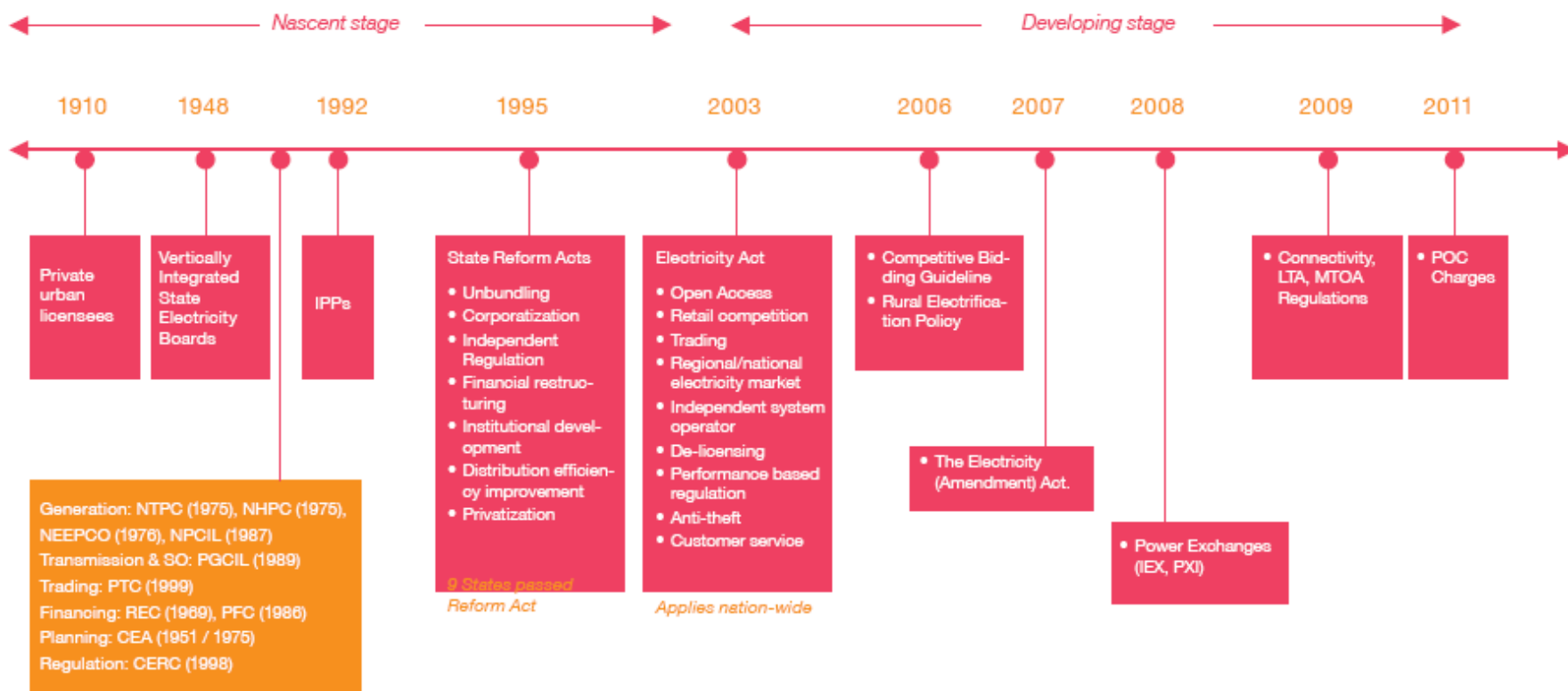
reduce excessive reliance on conventional sources involving significant import costs. The Jawaharlal Nehru National Solar Mission envisages establishing India as a global leader in solar energy. An ambitious target of 20,000MW of solar power by the year 2022 has been set under the Mission. Hydro electricity provides an alternative in hilly states. However several big hydro electric projects like the ones in Uttarakhand face a lot of criticism on the account of displacement of humans and ecological considerations etc. Several initiatives like introduction of Generator Based Incentive Mechanism for grid interactive wind power projects (introduced in December 2009) have been taken by Ministry of New & Renewable Energy

14.2.5 To ensure energy security, besides fixing up the already existing systems viz reduction of transmission & distribution losses of electricity, entering into strategic collaborations, bilateral/multilateral agreements with countries rich in energy reservoirs, harnessing renewable energy, explorations for additional reservoirs of conventional sources of energy etc, increasing the generation of nuclear energy might prove to be a solution for rapidly developing & urbanizing country like India where population also continues to grow. Recent Nuclear deal with USA was a step in the by allowing India to import nuclear power plants and uranium fuel. The US initiative with IAEA support and accepted by the Nuclear Suppliers Group, has the practical effect of making India a sixth nuclear weapons state alongside, if not eventually within, the NPT system. However, setting up of nuclear power plants requires handling resettlement, environmental and other issues even after discounting for adverse international dispositions of some countries in view of India not having signed the Nuclear Non Proliferation Treaty. Though India is self sufficient in reactor design, its uranium resources are limited. So its focussing on developing the Thorium fuel cycle.

14.2.6 There are plethora of issues concerning Rural electrification, generation, transmission & distribution of electricity, recovery of cost of services & targeted subsidies, technology development and research and development(R&D), competition aimed at consumer benefits, financing power sector programmes including private sector participation, energy conservation, environmental issues, training and human resource development, protection of Consumer interest etc. National Electricity Policy 2005 aims to address these. However, Some of the objectives including access of Electricity to all, overcoming electricity shortages etc are yet to be realised. The aim of protection of consumers interest while maintaining commercial viability of electricity sector also continues to be a matter of discord as significant price hikes by private distribution companies creates much furore in the public, often forcing the governments to step in by subsidizing household consumption.

14.2.7 The Indian Energy Market has matured over the years. Introduction of independent power producers (IPPs) has been a mixed bag with disastrous Dabhol Power Plant Project in Maharashtra to modestly successful GVK project in Andhra Pradesh and Paguthan project in Gujarat and many more IPPS joining the wagon in recent past. Indian Energy Exchange(IX) operating since June 2008 provides nation wise automated online electricity trading platform.

**14.3 Policy measures & maturity of market :** The evolution of energy sector through reforms and Institutional set ups is summarized below :



NTPC: National Thermal Power Corporation

NHPC: National Hydro Power Corporation

NPCIL: National Power Corporation of India Ltd

PGCIL: Power Grid Corporation of India Ltd

REC: Rural electrification Corporation Ltd

PFC: Power Finance Corporation Ltd

CEA: Central electricity Authority

CERC: Central electricity Regulatory Commission

IPPs: Independent Power Producers

IEX: Indian Energy Exchange

PXIL: Power Exchange India Ltd.

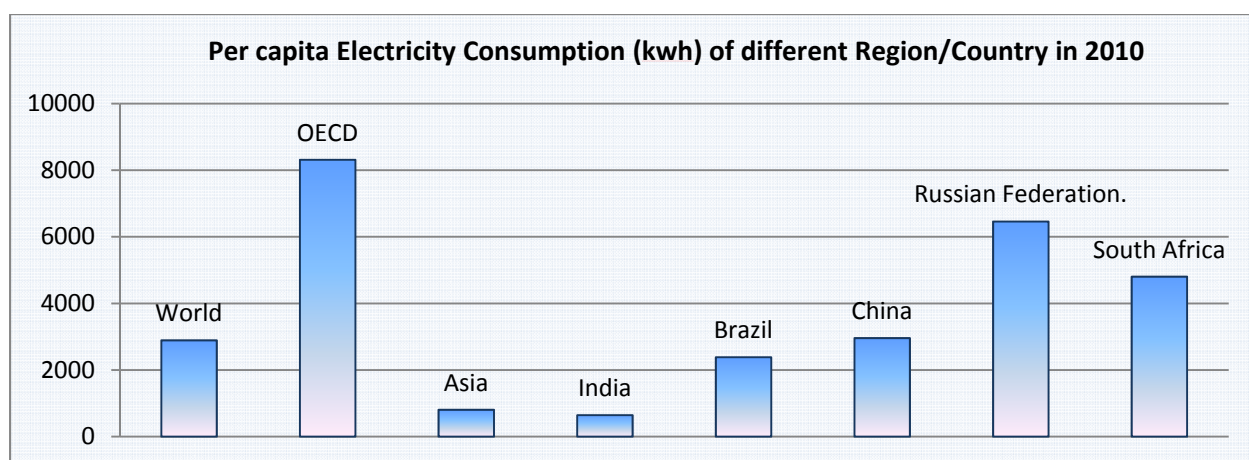
LTA: Long Term Access

MTOA: Medium Term Open Access

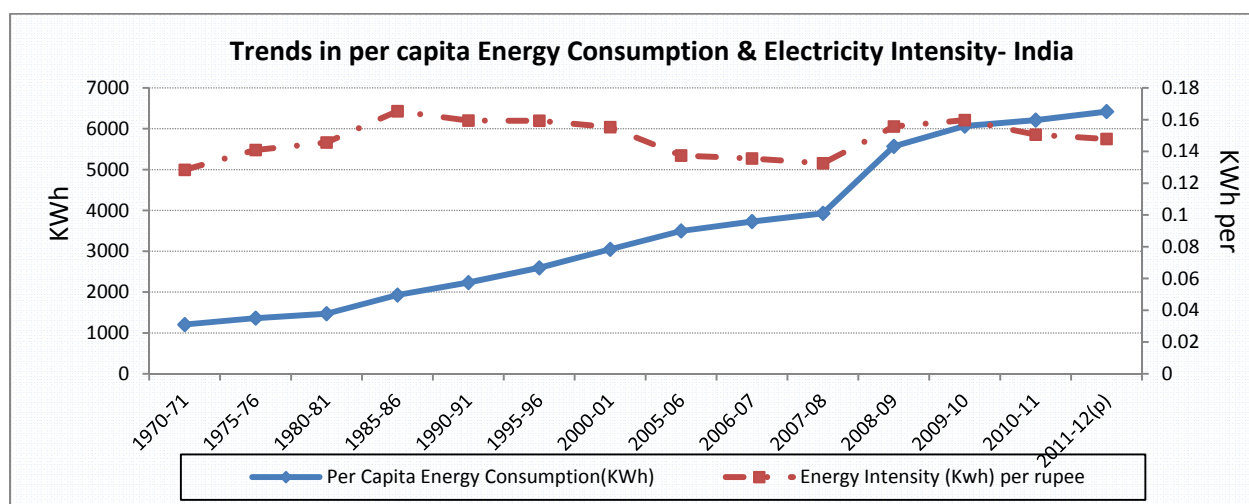
POC: Point of Connection

**14.4 Recent Trends in Production & Consumption of Energy :** 14.4.1 During the Eleventh Five year Plan , nearly 55,000 MW of new generation capacity was created ,yet there continued to be an overall energy deficit of 8.7 % and peak shortage of 9 %. A projection in the Twelfth Plan document of the Planning Commission indicates that total domestic energy production of 669.6 million tons of oil equivalent (MTOE) will be reached by 2016-17 and 844 MTOE by 2021-22. This will meet around 71 per cent and 69 per cent of expected energy consumption, with the balance to be met from imports, projected to be about 267.8 MTOE by 2016-17 and 375.6 MTOE by 2021-22.

**14.4.2 Per capita Electricity Consumption (PEC) & Energy Intensity :** Despite of rapidly increasing energy demand in India, the present levels of per capita electricity consumption is much less compared to developed countries, world average or even the average per capita consumption in Asia.

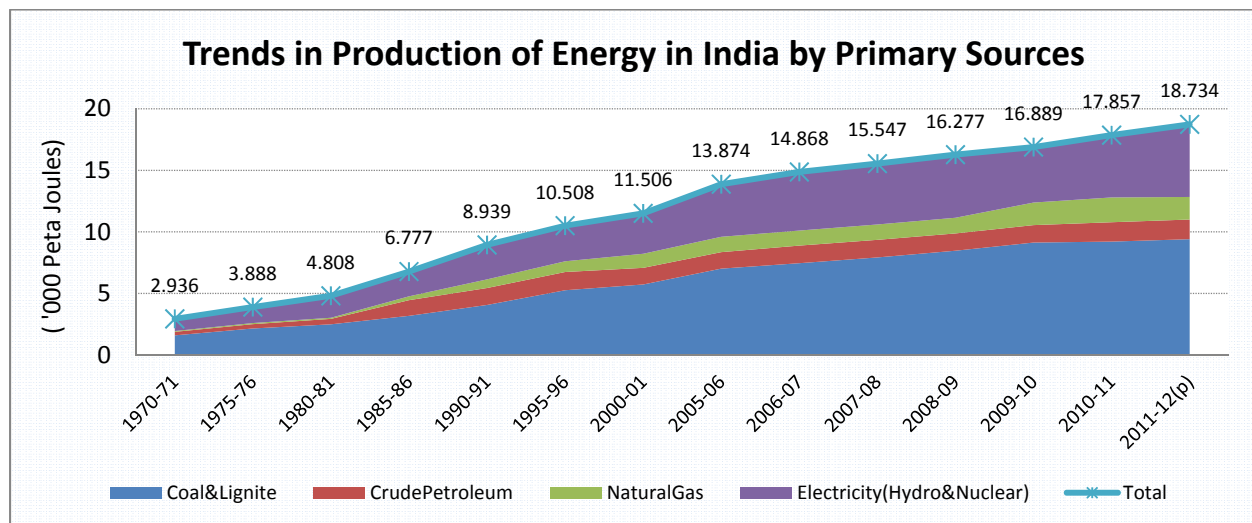


14.4.3 Per capita energy consumption increased from 1,204.3 KWh in 1970-71 to 6419.53 KWh in 2011-12 , a CAGR of 4.06% . The annual increase in PEC from 2010-11 to 2011-12 was 3.36 % . The energy intensity increased from 0.128 KWh in 1970-71 to 0.165 KWh in 1985-86 , but it has again come down to 0.148 KWh ( at 2004-05 prices) in 2011-12.



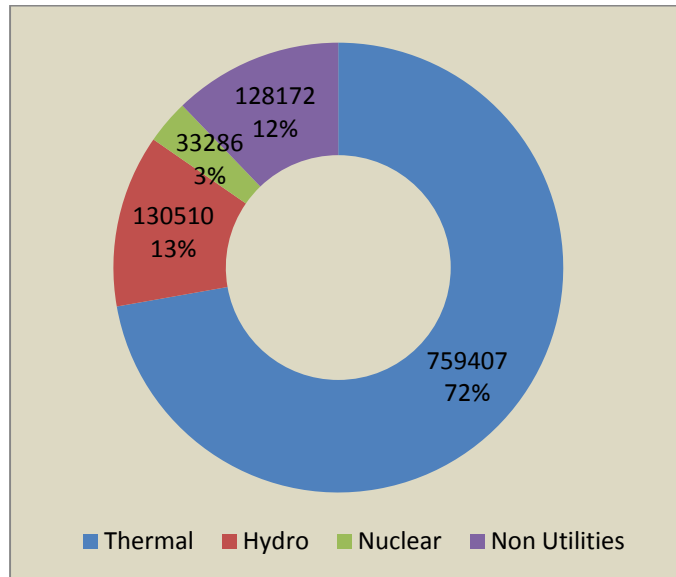
**14.4 Trends in production of energy in India :** 14.4.1 Coal production during the year 2011-12 was 539.94 million tonnes MTs as compared to 532.69 MTs during 2010-11 , registering a growth of 1.36 %. The lignite production during the same period increased by 12.19 %. Considering the trend of production from 1970-71 to 2011-12 , coal production in India increased with CAGR of 4.88 % ( from 72.95 MTs to 539.94 MTs ) while that of lignite increased with 6.2 % (from 3.39 MTs to 42.33 MTs) crude petroleum with 4.18% ( 6.82 MTs to 38.09 MTs ) , natural gas with 8.67 % and electricity with 4.33 % . Production of natural gas (net) decreased from 51.25 Billion Cubic Metres(BCM) in 2010-11 to 46.48 BCM in 2011-12 registering a negative growth of 9.30 %.

14.4.2 The total production of energy from conventional sources increased from 17,857 peta joules during 2010-11 to 18, 734 peta joules during 2011-12, showing an increase of 4.91 % . The production of energy in peta joules by primary sources shows that coal & lignite were the major sources of energy , accounting for about 50.23 % of the total production during 2011-12 . Electricity was second ( 31.48 % ) while natural gas was third( 9.78 %).



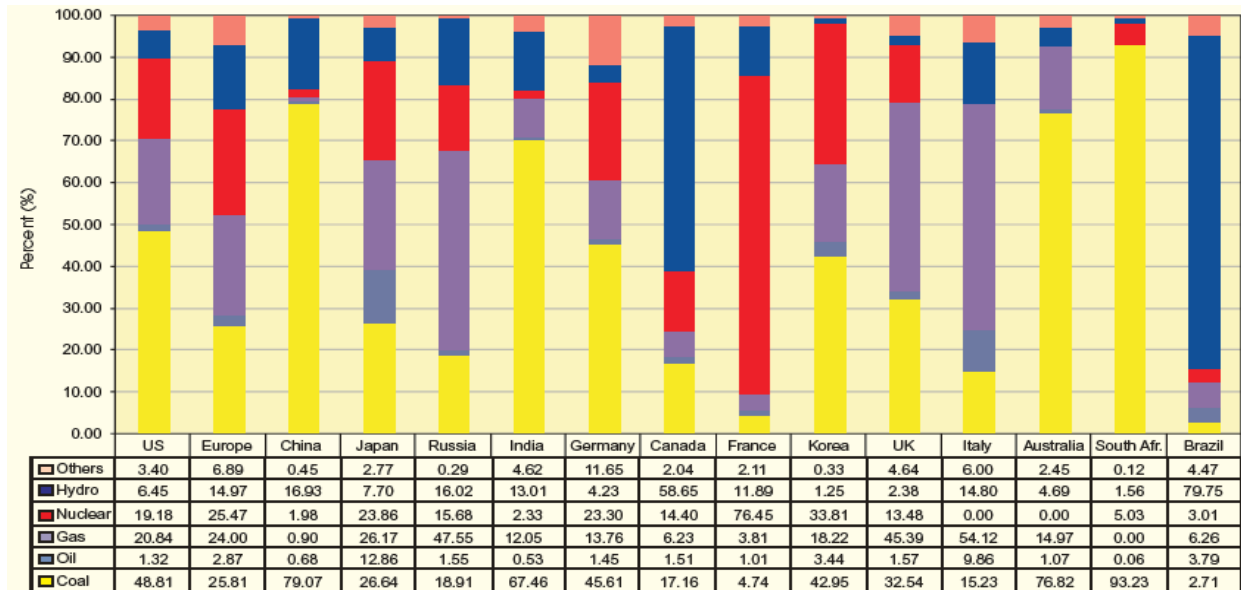
14.4.3 Thermal production accounts for about three fourths of the electricity production followed by hydro electricity . Besides being cleaner, harnessing hydro potential holds the key for economic development of hilly states , particularly North-Eastern States, Sikkim, Uttarakhand, Himachal Pradesh and J&K, since a large proportion of our hydro power potential is located in these states. But even with full development of the feasible hydro potential in the country, coal would necessarily continue to remain the primary fuel for meeting future electricity demand. Imported coal based thermal power stations, particularly at coastal locations, is encouraged based on their economic viability. Use of low ash content coal also helps in reducing the problem of fly ash emissions. Significant Lignite resources in the country are located in Tamil Nadu, Gujarat and Rajasthan and these should be increasingly utilized for power generation. Lignite mining technology needs to be improved to reduce costs. Share of nuclear power in the overall capacity profile is presently less but is increasing significantly.

### Gross Generation of Electricity in Utilities(Thermal, Hydro & Nuclear) and non Utility in India (GWh): 2011-12



14.4.4 In contrast to India's predominant use of thermal energy for electricity generation, in Canada & Brazil the chief mode is hydro electricity, in Russia it is gas while France predominantly uses nuclear energy. However, the primary source in case of US, China & South Africa etc is also thermal energy.

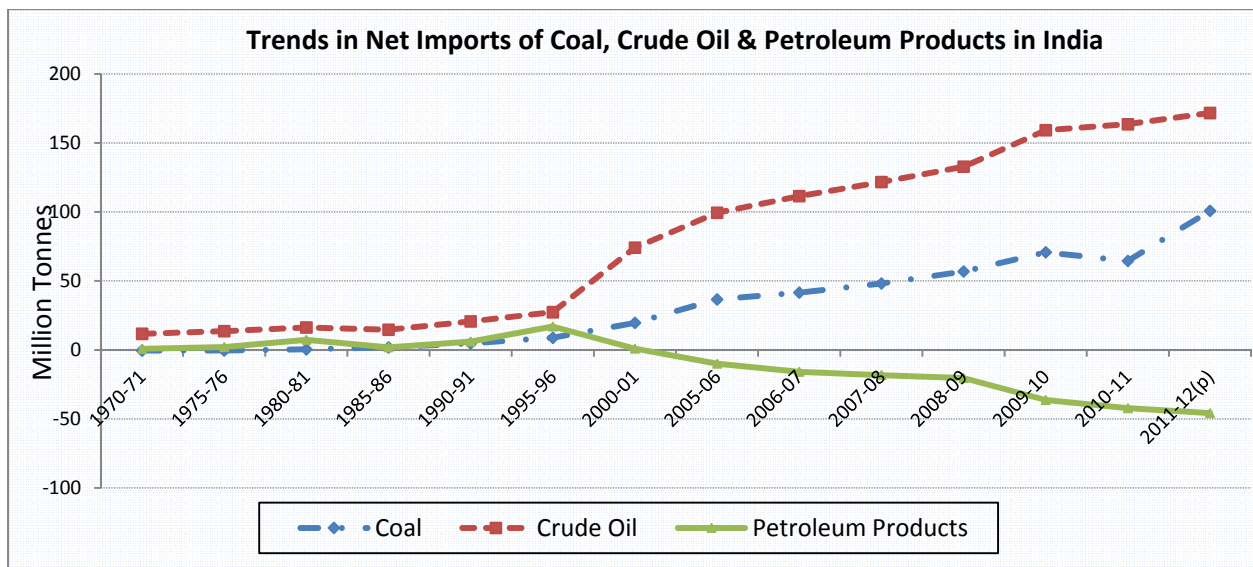
### Mode Wise Share of electricity generation in various countries :2008



14.5 Trade in Energy : 14.5.1 There has been an increasing trend of coal import to meet the high quality coal requirements of steel plants from 20.93 MTs during 2000-01

to 102.85 MTs during 2011-12 along with an increase in export also from 1.29 MTs to 2.03 MTs during the same period. There was an increase of 49.24 % in gross import and 56.29 % in net imports of coal in 2011-12 over the previous year. However there was a decline of 53.91 % in export of coal during the same period.

14.5.2 India is highly dependent on import of crude oil. Both gross and net imports of crude oil have increased from 11.68 MTs during 1970-71 to 171.73 MTs during 2011-12 . Net imports of crude oil increased by 4.97 % during 2010-11 to 2011-12 . However, due to development of sufficient processing capabilities India has now become a net exporter of petroleum products . The export of petroleum products has increased from mere 0.33 MT during 1970-71 to 8.37 MTs during 2000-01 and to 40.78 MTs during 2007-08 . During 2011-12 exports stood at 60,084 MTs recording an increase of 2.98 % over the previous year.



**14.6 Consumption of Energy :** 14.6.1 The highest consumption of energy in peta Joules was in the form of electricity which accounted for about 57.57% of the total consumption during 2011-12. Coal and Lignite were second (19.91%), while Crude Petroleum (18.75%) was third.

14.6.2 The consumption of energy in peta Joules was in the form of Electricity which accounted for about 57.57% of the total consumption during 2011-12. Coal and Lignite were second (19.91%), while Crude Petroleum (18.75%) was third.

14.6.3 The estimated total consumption of raw coal by industry has increased from 72.95 MTs during 1970-71 to 535.88 MTs during 2011-12, with a CAGR of 4.86% (Table 6.1). The annual growth rate from 2010-11 to 2011-12 was 0.60%. Railways were the major consumer of coal during 1970-71, followed by Steel & Washer Industry, Electricity generation & Cement . However, from the year 1975-76 electricity generation is the biggest consumer of coal, followed by steel industries. Estimated coal

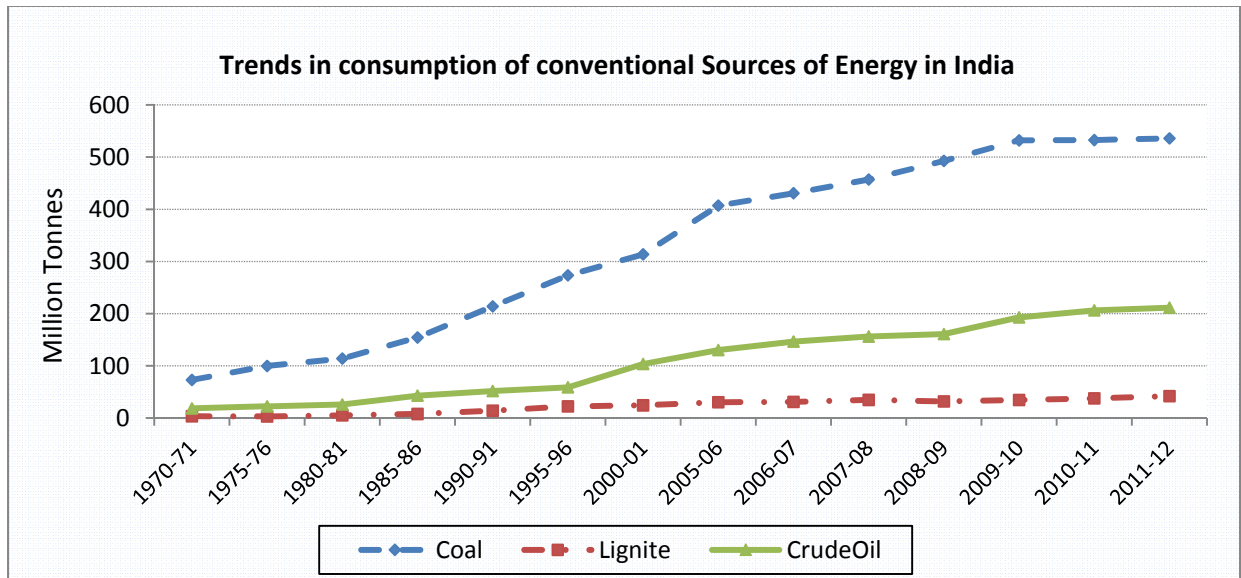


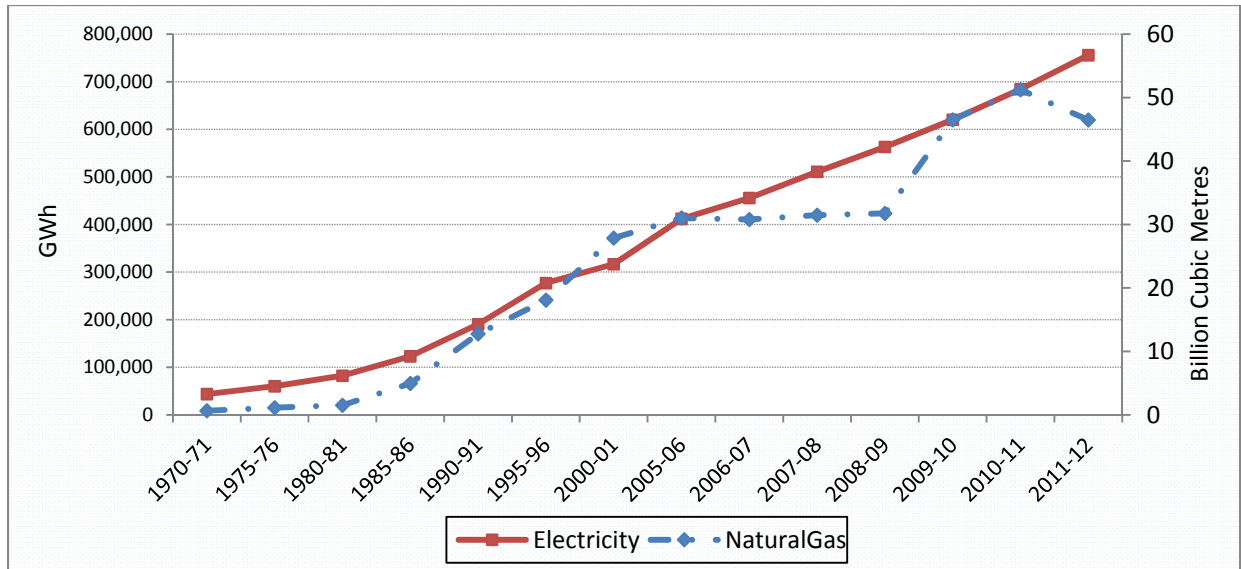
consumption for electricity generation increased from 23 MTs during 1975-76 to 403.91 MTs during 2011-12.

14.6.4 The estimated production of crude oil has a steady increase , from 18.38 MTs during 1970-71 to 211.42 MTs during 2011-12 with CAGR of 5.99 % . It increased from 206.15 MTs in 2010-11 to 211.42 MTs in 2011-12. Industry wise off take of natural gas shows that it has been used both for energy & non energy purposes . Maximum use of gas is in power generation (44.28%) followed by fertilizer industry (24.68%) & 6.20 % natural gas was used for domestic fuel.

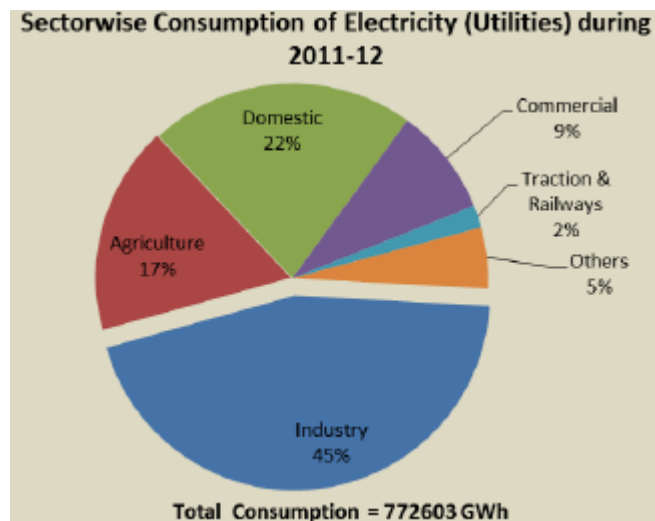
14.6.5 High speed diesel oil accounted for 39.62 % of total consumption of all types of petroleum products in 2011-12. This was followed by Refinery (9.44 %), LPG(9.4 % ) , Petrol (9.17 % ) & Naptha (6.8 % ) . Consumption of light diesel oil continuously decreased from 1970-71( 1.1 MTs) to 2011-12 (0.42MTs)

14.6.6 The estimated electricity consumption increased from 43, 724 GWh during 1970-71 to 7,72,603 GWh during 2011-12 , showing a CAGR of 7.08 % . The increase in electricity consumption is 11.26 % from 2010-11 ( 6,94,392GWh ) to 2011-12 ( 7,72,603 GWh).



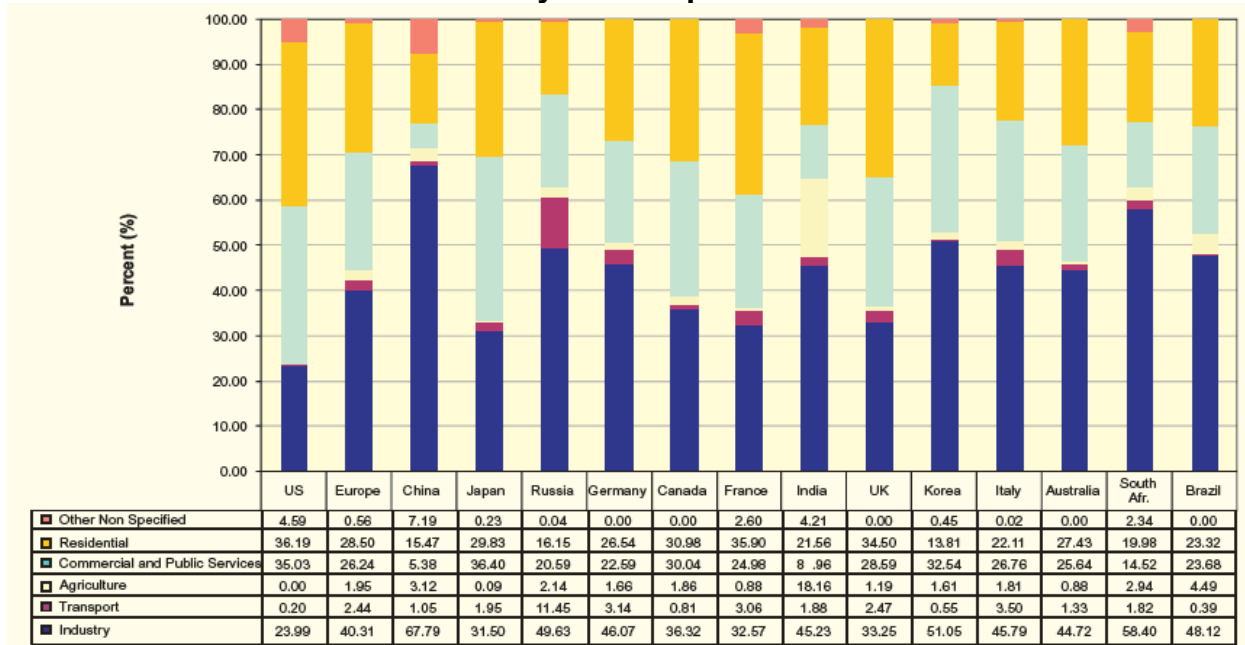


14.6.7 Of the total electricity sales in 2011-12 , industry sector accounted for largest share (44.84 % ) , followed by domestic (22.01 % ) , agriculture (17.30 % ) and commercial sector ( 8.97 % ) . The electricity consumption in domestic & agriculture sector has increased at a much faster pace compared to other sectors during 1970-71 to 2011-12 , with CAGRs of 9.44 % and 8.43 % respectively



14.6.8 Usually, Industrial commercial & residential consumption of energy accounts for the major consumption in countries with agriculture also accounting for significant share in case of agrarian economies.

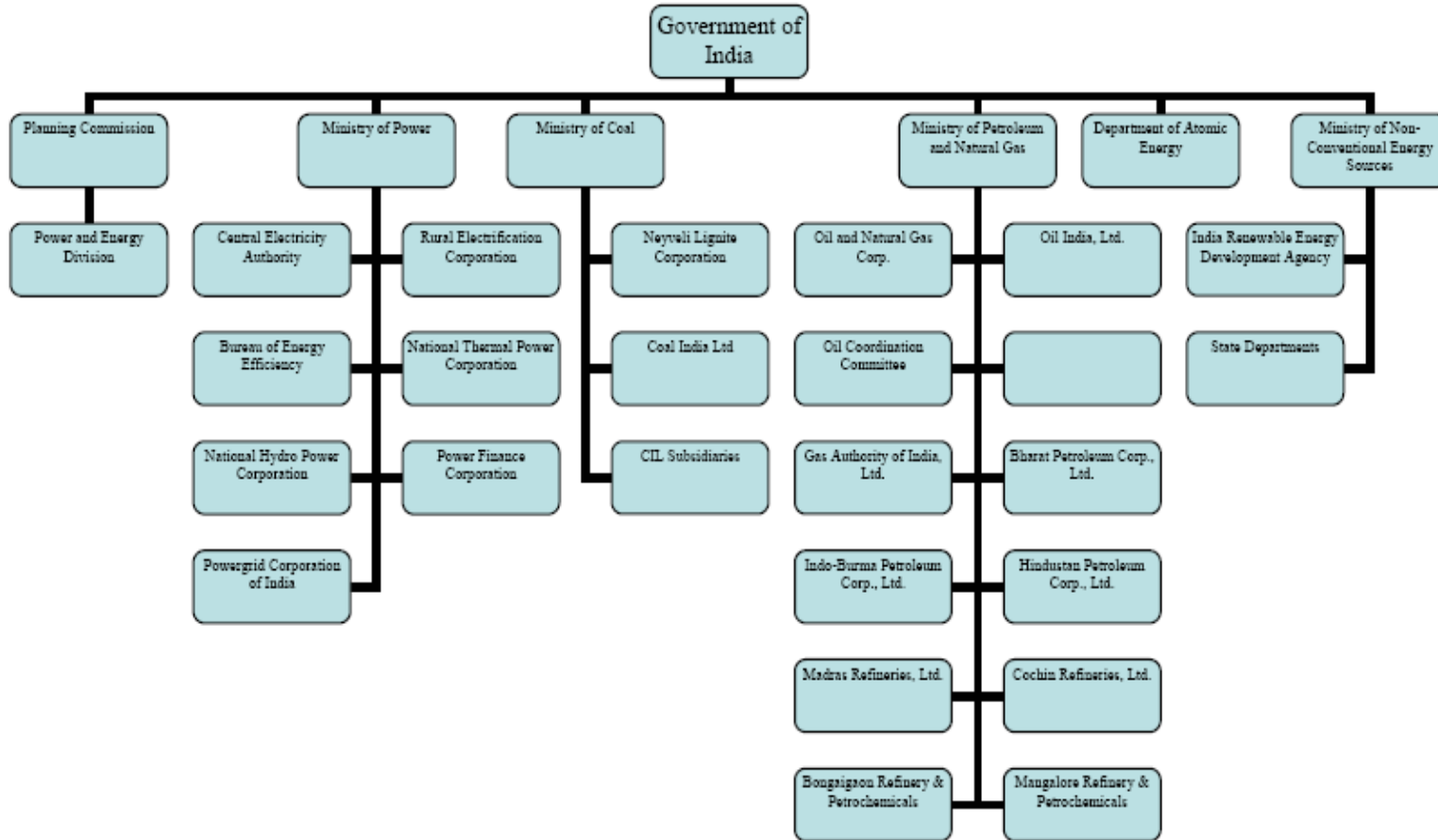
## Sector wise share in electricity consumption in various countries: 2008



14.6.9 In India, loss of electricity due to transmission has increased from 17.55 % during 1970-71 to 32.86 during 2000-01 and it has decreased since then to around 24 % during 2011-12. Transmission and distribution losses are much lower in US (6.06%) , China (6.32%) etc and even the world average (8.99%) is much lower compared to India as per the available data for 2008.

**14.7 Sources of Energy Statistics :** Depending upon the fuels , the information relating to energy scenario( production, reserve, offtake/consumption etc) in India is provided by variety of organizations ranging from **M/o Petroleum & Natural Gas** to **O/o Coal Controller, Ministry of Mines** to **Department of Atomic Energy & Ministry of New & Renewable Energy**. Information on Electricity generation, transmission & distribution along with rural electrification is maintained by **Central Electricity Authority, Ministry of Power . Central Statistics Office, Ministry of Statistics & PI** brings out a publication Energy Statistics which draws information from various source agencies and provides a comprehensive report on the subject. Various Surveys conducted by **National Sample Survey Office , MOSPI** also provide information on the usage of energy by households for lighting , cooking etc providing an idea about penetration and expenditure besides the coverage / extent of use of different modes by households also being covered by decennial Population Census conducted by **O/o Registrar General, Ministry of Home Affairs**

## Structure of Central Energy Sector Institutions



## 14.8 Terms & Definitions :

The Definitions of the terms in this chapter are as follows:

- **Hard Coal:** Coal has a high degree of coalification with a gross calorific value over 24 MJ/Kg (5700 Kcal/kg) on an ash-free but moist basis. Included are fines, middling, slurry produced in the installations at pitheads.
- **Lignite :** Brown coal is a coal with low degree of coalification . Its gross calorific value is 5,700 K.cal./kg or less on an ash-free but moist basis.
- **Coke :** The solid product obtained from carbonization of coal or lignite at high temperature.
- **Crude petroleum:** Data for crude petroleum include shale oil and field condensate but exclude natural gas liquids from plants and oils obtained from the distillation of solid fuels.
- **Liquefied petroleum gases:** include (i) hydrocarbons extracted by stripping natural gas at crude petroleum and natural gas sources; (ii) hydrocarbons extracted by stripping of imported natural gas in installations of the importing country; and (iii) hydrocarbons produced both in refineries and outside refineries in the course of processing of crude petroleum or its derivatives. Included are mainly propane, butane, isobutene and ethane.
- **Motor gasoline:** comprises of a mixture of relatively volatile hydrocarbons with or without small quantities of additives, which have been blended to form a fuel suitable for use in spark-ignition internal combustion engines. Natural gasoline, aviation gasoline and naphtha's are excluded.
- **Naphtha's:** are refined or partly refined light which are to be further blended or mixed with other materials to make high grade motor gasoline or jet fuel, or to be used as raw materials for town gas or feed stocks to make various kinds of chemical products, or to be used as various solvents, depending on the character of naphtha's derived and the demands of various industries.
- **Kerosene:** It is used as an illuminant and as a fuel in certain types of spark-ignition engines such as those used for agricultural tractors and stationary engines. The data include those products; commonly named as burning oil, vaporizing oil, power kerosene and illuminating oil. Jet fuel, white spirit and naphtha's are excluded.
- **Jet fuels:** comprise of fuel meeting of the required properties for use in jet engines and aircraft-turbine engines, mainly refined from kerosene. Gasoline-type jet fuel (light hydrocarbons, also naphtha's type, intended for use in aviation gas-turbine units as opposed to piston power units) is included.
- **Lubricants:** They are heavy liquid distillates obtained by refining crude petroleum and are used for lubricating purposes. They may be produced either from petroleum distillates or residues at refineries. Solid lubricants (e.g. grease) are excluded.
- **Petroleum coke:** is a solid residue consisting mainly of carbon, obtained by the distillation of heavier petroleum oils; used mainly in metallurgical process (excluding those solid residues obtained from carbonization of coal).

- **Bitumen (Asphalt):** is a brown to black solid or semi-solid material obtained as a residue in the distillation of crude petroleum. It is used mainly in road construction. Natural asphalt is excluded.
- **Natural Gas:** is a mixture of hydrocarbon compounds and small quantities of non hydrocarbons existing in the gaseous phase, or in solution with oil in natural
- underground reservoirs. It may be sub-classified as associated gas (that originating from fields producing both liquid and gaseous hydrocarbons), dissolved gas, or non- associated gas (that originating from fields producing only hydrocarbons in gaseous form). Included are methane (CH<sub>4</sub>) recovered from coal mines, sewage gas and natural gas liquefied for transportation. Excluded, however, are gases used for re- pressuring and reinjection, as well as gas flared, vented or otherwise wasted, and shrinkage accruing to processing for the extraction of natural gas liquids.
- **Coke Oven Gas :** It is a by-product of the carbonization process in the production of coke in coke ovens.
- **Bio Gas :** It is a by-product of the fermentation of biomass, principally animal wastes by bacteria. It consists mainly of methane gas and carbon dioxide.
- **Installed capacity:** The net capacity measured at the terminals of the stations, i.e., after deduction of the power absorbed by the auxiliary installations and the losses in the station transformers.
- **Utilities:** undertakings of which the essential purpose is the production, transmission and distribution of electric energy. These may be private companies, cooperative organisations, local or regional authorities, nationalised undertakings or governmental organisations.
- **Hydro Electricity:** as energy value of electricity is obtained by dividing the electricity
  - generation by the average efficiency of all hydro-power stations.
- **Thermal Electricity:** comprises conventional thermal plants of all types, whether or not equipped for the combined generation of heat and electric energy. Accordingly, they include steam-operated generating plants, with condensation (with or without extraction) or with back-pressure turbines, and plants using internal combustion engines or gas turbines whether or not these are equipped for heat recovery.
- **Nuclear Electricity:** is defined as the heat released by the reactors during the accounting period and is obtained by dividing the generation of nuclear electricity by
  - average efficiency of all nuclear power stations.
- **Production:** comprises gross production, i.e. the amount of electric energy produced, including that consumed by station auxiliaries and any losses in the transformers
  - that are considered integral parts of the station. Included is the total production of electric energy produced by pump storage installations.
- **Imports:** refer to the amounts of electric energy transferred to the countries concerned, which are measured at the metering points on the lines crossing the frontiers. Included are imports of electric energy made by means of high voltage

lines crossing frontiers as well as imports of electric energy made by means of low-voltage lines for use in the immediate vicinity of the frontier, if the quantities so transferred are known.

- **Exports:** refer to the amounts of electric energy transferred from the countries concerned, which are measured at the metering points on the lines crossing the frontiers. Included are exports of electric energy made by means of high voltage lines crossing frontiers as well as exports of electric energy made by means of low voltage lines for use in the immediate vicinity of the frontier, if the quantities so transferred are known
- **Per-capita Energy Consumption (PEC):** PEC during a year is computed as the ratio of the
- estimate of total energy consumption during the year to the estimated mid-year population of that year.
- **Energy Intensity :** It is defined as the amount of energy consumed for generating one unit of Gross Domestic Product (At constant prices).

**Note :** In the absence of data on consumption of non-conventional energy from various sources, particularly in rural areas in the developing countries, including India, PEC & Energy Intensity are generally computed on the basis of consumption of conventional energy.

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