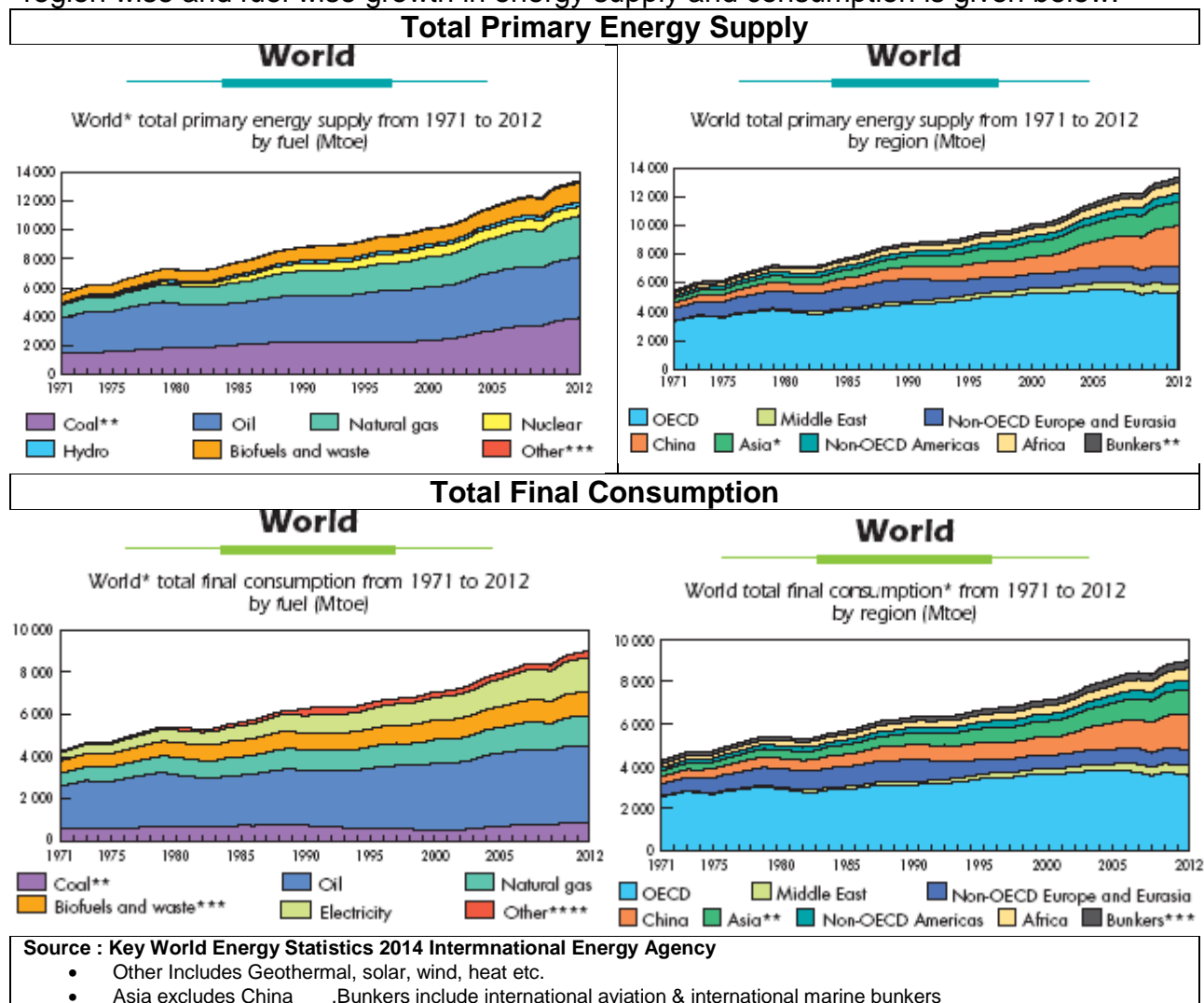


## Chapter 16 ENERGY

***“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 :** 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 ).

**16.2** To meet the demand non conventional sources of energy like nuclear energy and environmental friendly renewable sources of energy have also gained currency. The region wise and fuel wise growth in energy supply and consumption is given below.



## 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

16.3 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 Gujarat 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.

16.4 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.

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

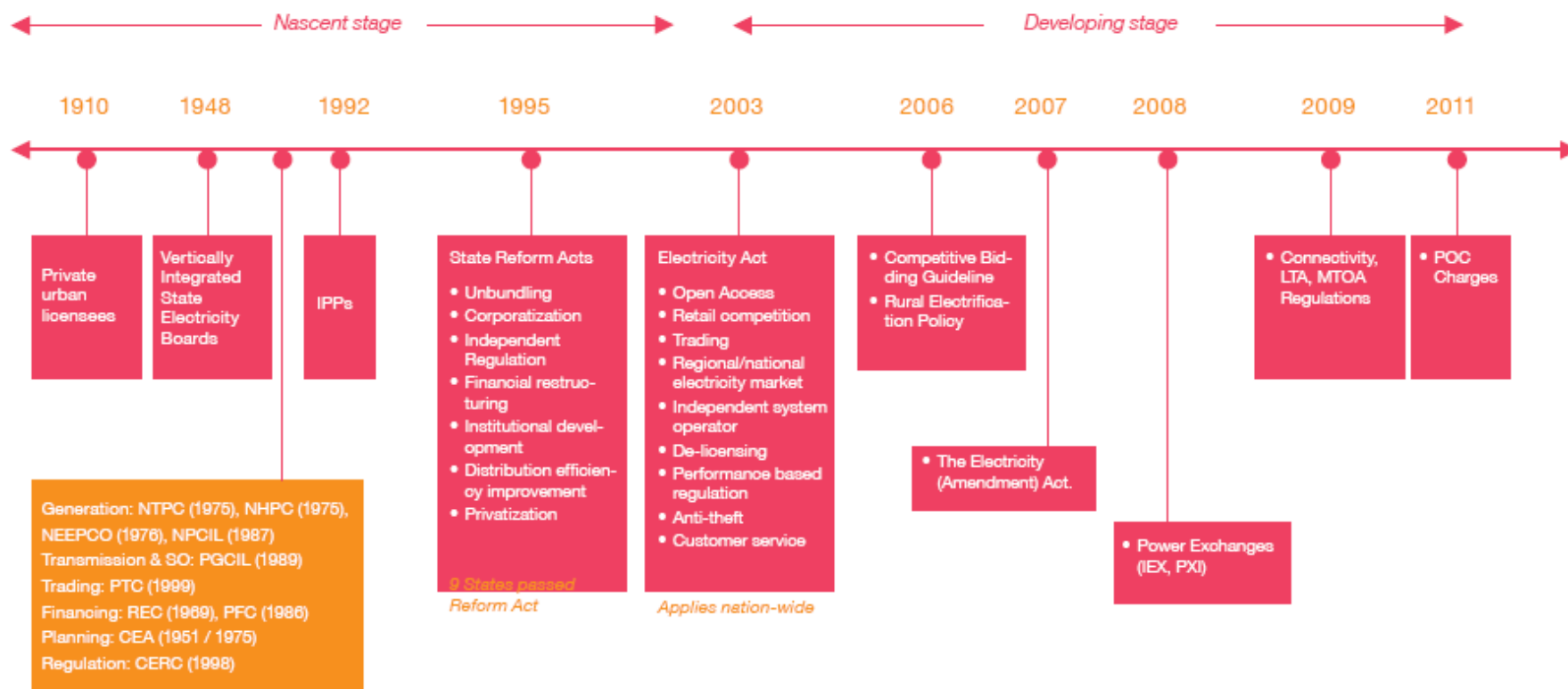
excessive reliance on conventional sources involving significant import costs. The **Jawaharlal Nehru National Solar Mission** envisages establishing India as a global leader in solar energy. An ambitious target of 20,000MW of solar power by the year 2022 has been set under the Mission. Hydro electricity 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 Generation Based Incentive Mechanism for grid interactive wind power projects (introduced in December 2009 ) have been taken by Ministry of New & Renewable Energy

16.6 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.

16.7 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.

16.8 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.

**16.9 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.

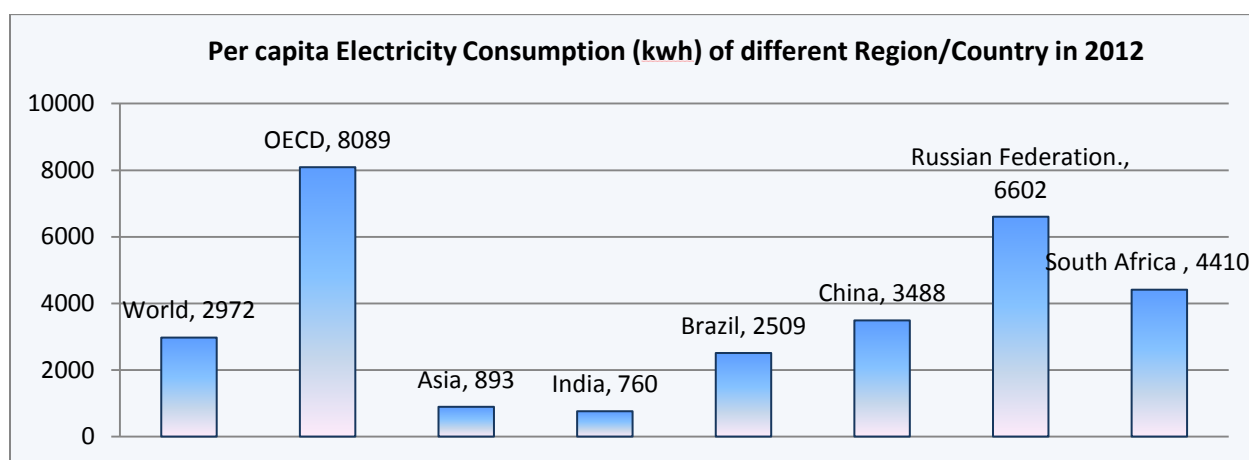
LTA : Long Term Access

MTOA: Medium Term Open Access

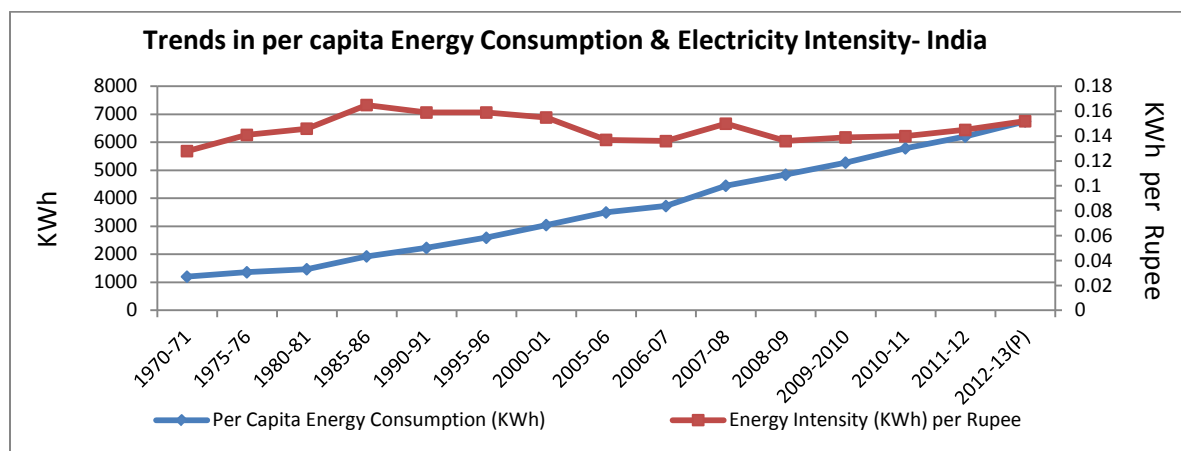
POC : Point of Connection

**16.10 Recent Trends in Production & Consumption of Energy :** 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.

**16.11 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.

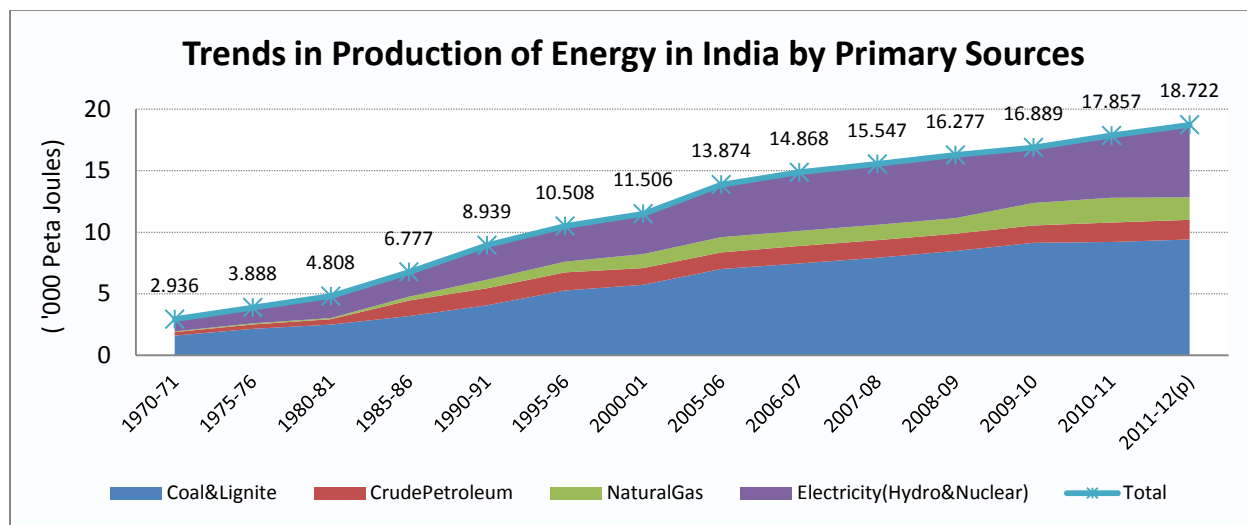


**16.12 Per capita energy consumption increased from 1,204.3 KWh in 1970-71 to 6205.25 KWh in 2011-12 and 6748.61 KWh in 2012-13 an increase of 8.76 % over previous year. The energy intensity increased from 0.128 KWh in 1970-71 to 0.165 KWh in 1985-86, but it was only 0.1518 KWh ( at 2004-05 prices) in 2012-13, though it has shown an increasing trend after 2008-09.**



**16.13 Trends in production of energy in India :** Coal production in the country during the year 2012-13 was 551.71 million tonnes(MTs) as compared to 539.95 MTs during 2011-12, registering a growth of 3.29% The Lignite production during the same period increased by 10.08%. 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 52.22 Billion Cubic Metres(BCM) in 2010-11 to 47.56 BCM in 2011-12 and 39.83 in 2012 -13 whereas 47 million tonnes lignite was produced during 2012-13. Production of crude petroleum during 2012-13 declined by 0.6 % to 37.86 million tonnes. Electricity (Hydro & Nuclear) declined by 10 % during 2012-13 (146,497GWh) from 163,796 Gwh during 2011-12.

16.14 The total production of energy from conventional sources decreased from 18,722 peta joules during 2011-12 to 18,180 peta joules during 2012-13, showing a decrease of 2.90%.The production of energy in peta joules by primary sources shows that coal & lignite were the major sources of energy , accounting for about 62 % of the total production during 2012-13 . Electricity contributed about 29 % to total primary energy production whereas share of natural gas was 9 %.



16.15 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

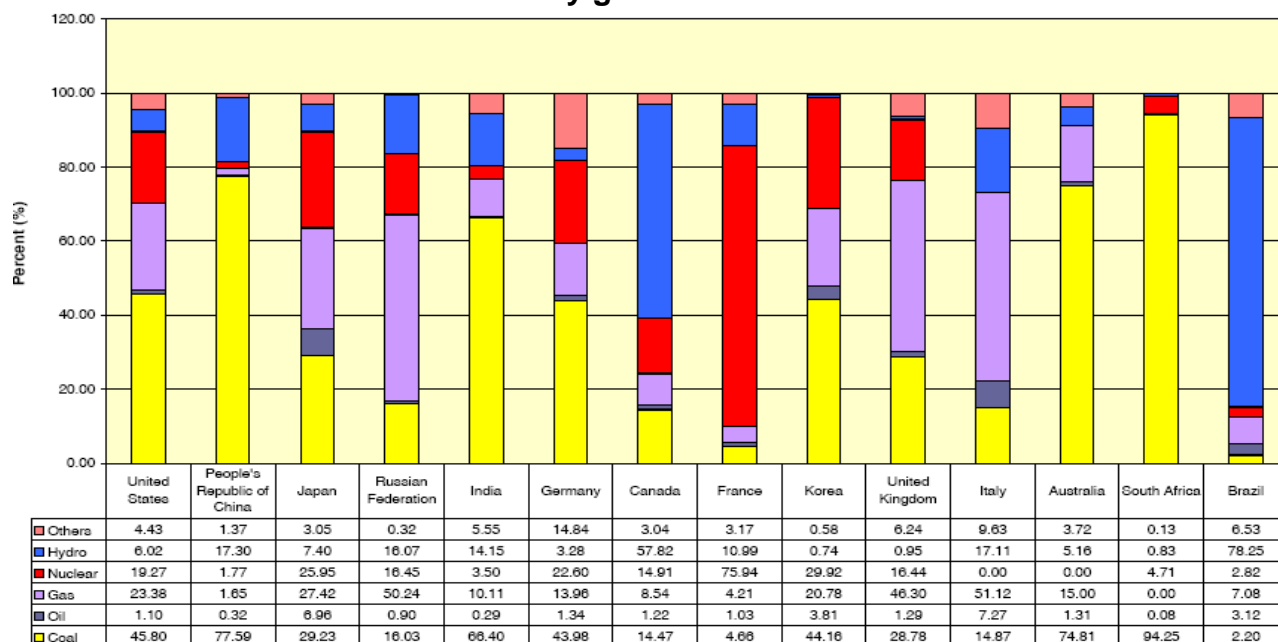
needs to be improved to reduce costs. Share of nuclear power in the overall capacity profile is presently less but is increasing significantly.

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

Year	Utilities				Non-Utilities	Grand Total
	Thermal *	Hydro	Nuclear	Total		
1	2	3	4	5 = 2 to 4	7	9=5+8
2005-06	505,001	101,494	17,324	623,819	73,640	697,459
2006-07	538,350	113,502	18,802	670,654	81,800	752,454
2007-08	585,282	120,387	16,957	722,626	90,477	813,102
2008-09	617,832	113,081	14,713	745,626	95,905	842,531
2009-10	670,965	106,680	18,636	796,281	109,693	905,974
2010-11	704,323	114,257	26,266	844,846	114,224	959,070
2011-12	708,427	130,511	32,287	922,451	128,172	1,051,375
2012-13(p)	817,225	113,626	32,871	963,722	148,000	1,111,722
Growth rate of 2012-13 over 2011-12(%)	0.58	14.23	22.92	9.19	12.21	9.62
CAGR 2005-06 to 2012-13(%)	6.20	1.42	8.34	5.59	9.12	6.00

16.16 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 :2010

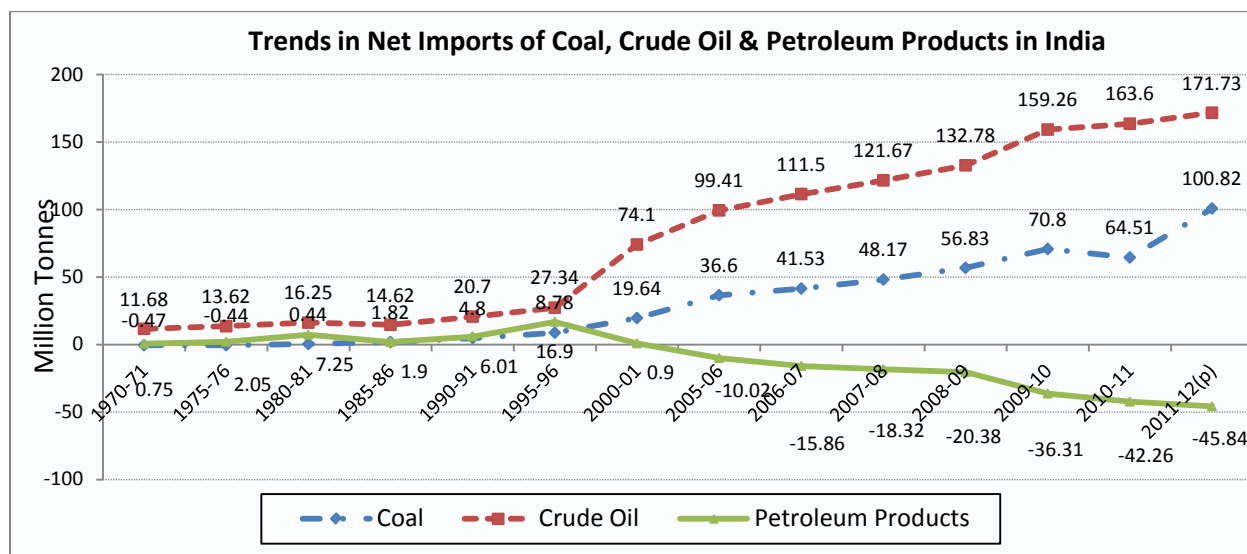


Source :- International Energy Agency ( IEA).

Note :- India data pertains to 2011-12.

**16.17 Trade :** 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 134.73 MTs during 2012-13 along with an increase in export also from 1.29 MTs to 2.83 MTs during the same period. There was an increase of 33.74% in gross import and 33.63% in net imports of coal in 2012-13 over the previous year along with an increase of 40.10% in export of coal during the same period. Net imports of coal during 2012-13 increased by 33.6 % to 134.73 million tonnes vis a vis 100.82 million tonnes of net coal imports during 2011-12.

**16.18** India is highly dependent on import of crude oil. Net imports of crude oil increased from 11.68 MTs during 1970-71 to 184.80 MTs during 2012-13 . There has been an increase of 7.61% in the net imports of crude oil during 2012-13 over 2011-12, as the net import increased from 171.73 MTs to 184.80 MTs. Although more than 70% of its crude oil requirements and part of the petroleum products is met from imports, India has developed sufficient processing capacity over the years to produce different petroleum products so as to 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 , 40.78 MTs during 2007-08 and 63.41MTs during 2012-13 (an increase of 4.23 % compared to 2011 -12 when it was 60.84 million tonnes). There was an increase of 3.9 % in net imports as the value reached (-) 47.63 during 2012-13 from (-) 45.84 a year ago.



**16.19 Consumption:** The highest consumption of conventional energy ( in peta Joules) was in the form of electricity which accounted for about 59% of the total conventional energy consumption during 2012-13. Coal and Lignite accounted for about 20 % and Crude Petroleum for about 18 % share in total consumption of conventional energy in India during 2012-13.

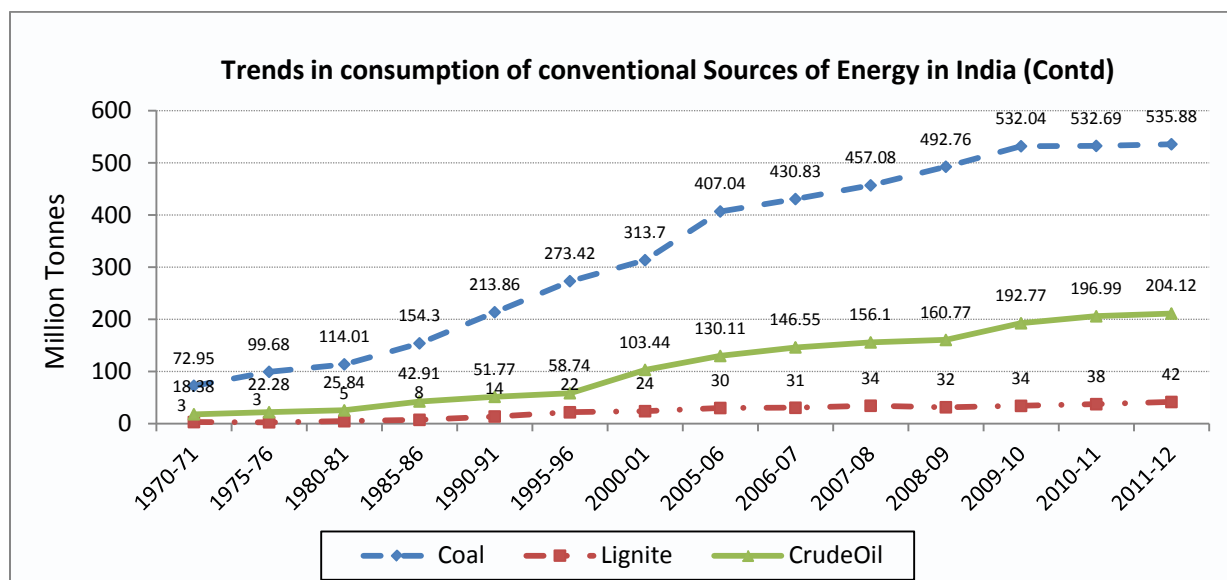


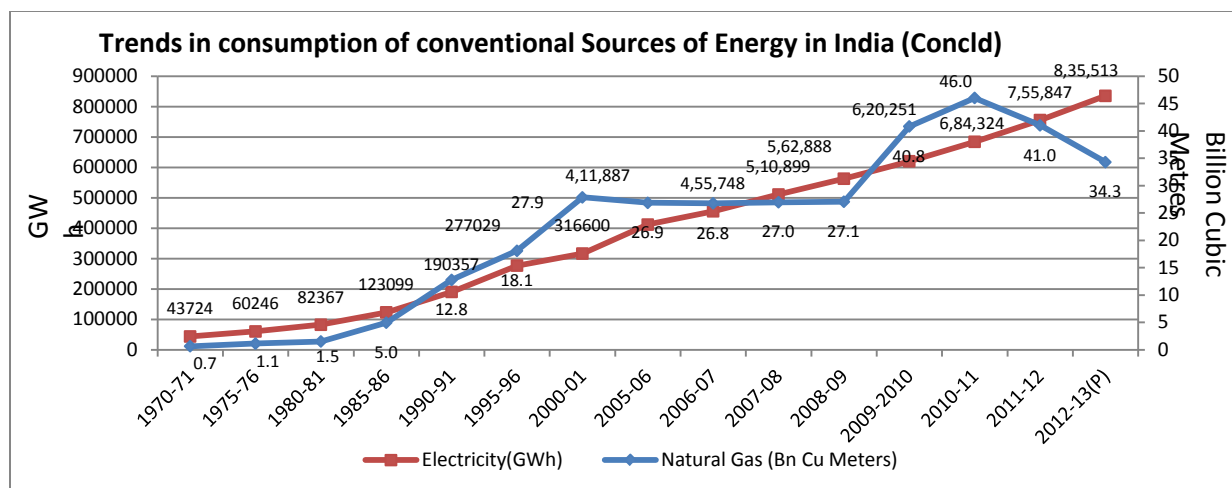
16.20 The estimated total consumption of raw coal by industry has increased from 72.95 MTs during 1970-71 to 535.88 MTs during 2011-12, with a CAGR of 4.86% and to 570.23 MT during 2012-13, annual growth of 6.41 % over 2011-12 .Railways were the major consumer of coal during 1970-71, followed by Steel & 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 444.29 MTs during 2012-13.

16.21 The estimated consumption of crude oil increased steadily , from 18.38 MMTs during 1970-71 to 204.12 MMTs during 2011-12 and 219.21 MMT during 2012-13, an annual growth of 7.39 % over 2011-12 . During 2012-13 Industry wise off-take of natural gas shows that natural gas has been used both for Energy (65.91%) and Non-energy (34.09%) purposes. The maximum use of Natural Gas is in power generation (33.46%) followed by fertilizers industry (27.87%) and 5.20% natural gas was used for domestic fuel.

16.22 High speed diesel oil accounted for 39.55% of total consumption of all types of petroleum products in 2012-13. This was followed by Refinery(10.49%), Petrol(9.0%), LPG(8.92%) and Naptha(7.05%). Consumption of Light Diesel oil continuously decreased from 1970-71( 1.1 MTs) to 2012-13(0.40 MTs)

16.23 The estimated electricity consumption increased from 43, 724 GWh during 1970-71 to 8,52,900 GWh during 2012-13 . The increase in electricity consumption was 8.62% from 2011-12 (7,85,193 GWh) to 2012-13 (8,52,900 GWh)

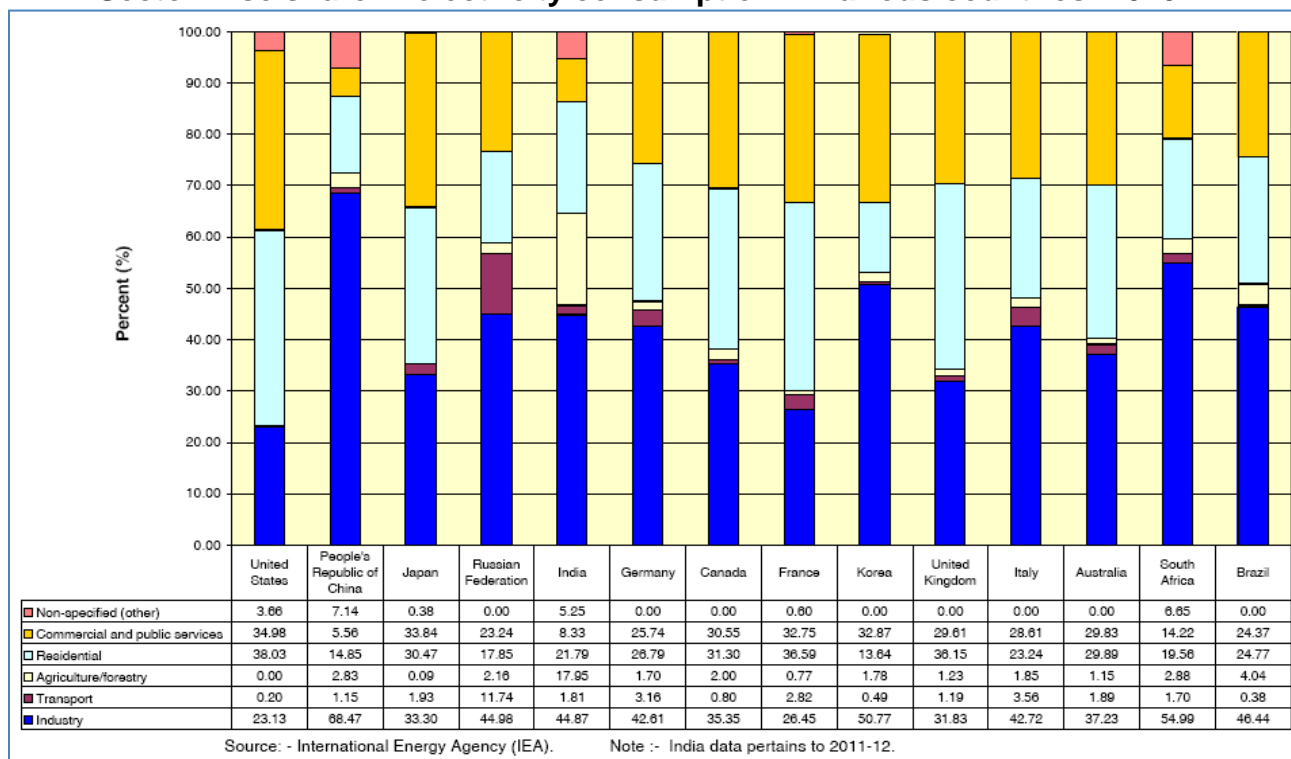




16.24 Of the total consumption of electricity in 2012-13, industry sector accounted for the largest share(44.87%), followed by domestic(21.79%), agriculture(17.95%) and commercial sectors (8.33%).The electricity consumption in domestic & agriculture sector has increased at a much faster pace compared to other sectors during 1970-71 to 2011-12 , with CAGRs of 9.44 % and 8.43 % respectively .

16.25 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: 2010



In India, loss of electricity due to transmission has increased from 17.55 % during 1970-71 to 33.98% during 2001-02 and it has decreased since then to around 24 % during 2011-12. Transmission and distribution losses are much lower in US (6.8%) , China (6.5%) etc and even the world average (9.8%) is much lower compared to India as per the available data for 2010.

#### 16.26 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**

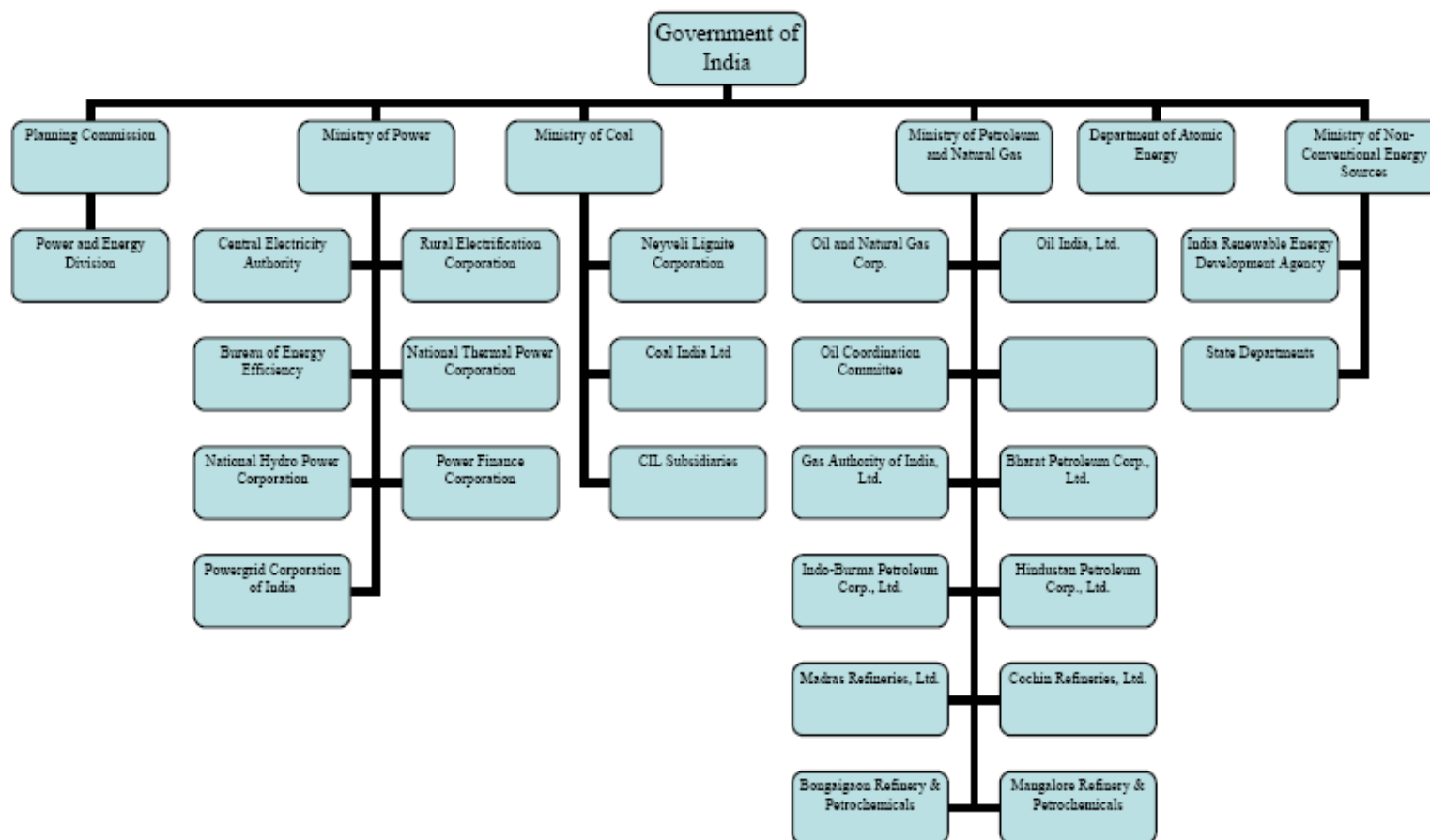
Structure of the Central Electricity Sector Institutions is given on next page.

#### Terms & Definitions :

16.27 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.

## Structure of Central Energy Sector Institutions



- **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).

16.28 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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