# Unit-1
## ENERGY RESOURCES

## Introduction

**Renewable energy** is a term used to refer to forms of energy that are naturally obtained from the environment and from sources that can be replenished naturally. These include solar energy, wind energy, geothermal energy, hydropower, and biomass.

The term renewable energy should not be confused with alternative energy, which describes sources of energy outside the regular forms like gasoline that are considered more environment-friendly or less harmful.

**Perspective of renewable energy sources** **(April/May 2014) (April 2013)**

Life on the planet earth is the manifestation of energy. The origin of fire, heat and light is energy. It is required to grow food grains which enable humans and animals to survive and work. Energy causes the great universal movement on Earth on its axis and around the sun. The term 'energy' can be described as 'capacity to do work'. In early days, human beings used their own strength in carrying loads and collecting their food, and later started depending on natural energy sources like the power of falling water used for grinding corn and wind energy for sailing boats. In industry, initially the energy source was fire that used to be obtained by burning wood. Subsequently, wood become a source of charcoal that was used to extract metals from ores.

The fossil fuels were exploited as surface deposits of asphalt, peat and coal, oil from surface seepage and gas venting from underground reservoirs. The widespread use of petroleum began during $20^{th}$ century, particularly for cars and buses, aero planes and industries. The use of energy got enhanced with the invention of electricity and development of electric energy generating stations consuming either fossil fuels or potential energy of water. The Second World War ended in 1945 with the invention and use of nuclear energy.

**Common forms of energy.**

**Kinetic energy:**

The energy of an object in motion is called kinetic energy. If the mass of an object is moving with a velocity v, its kinetic energy in joules is expressed as K.E. = (1/2) $mV^2$, where m is in kg and V in m/s.

**Potential energy:**

The energy which a body possesses as a result of its position in earth's gravitational field is called potential energy and is expressed in joules as P.E.=mgh, where m is mass in kg, g is the acceleration due to gravity in $m/s^{2,}$ and h is the height in m.

**Heat energy:**

Heat is an intrinsic energy of all the combustible substances. It is the kinetic energy of molecules. Heat energy for example can cause gases to expand, drive engines and raise the temperature of water.

**Chemical Energy:**

Chemical energy is tied up in fossil fuels such as coal, oil and gas. Fossil fuels are used to generate electricity and power vehicles engines. Chemical energy in the food helps us to sustain our life.

**Radiant Energy:**

Solar radiation is the manifestation of radiant energy that is received on earth. Radio waves, X-rays, infra-red and ultra violet electromagnetic radiation contain radiant energy.

**Electrical Energy:**

Electrical energy arises out of the arrangement of movement of electrons to produce heat, magnetic field and electromagnetic radiations. It is highly versatile form of energy and can easily be converted to other forms of utilization.

**Nuclear Energy:**

Matter can be changed into energy when larger atoms are split into smaller ones (atomic fission) or when smaller ones combine to form larger atoms(atomic fusion).

**Various Conventional energy sources and their availability. (April/May 2012, December 2015)**

**WORLD ENERGY SCENARIO**

**Present situation**

The IEA estimated that in 2017 the world energy consumption was 157.93GWhr. But **in year 2018 the world energy consumption increased to 161.33GWhr. Around 82.6% of the total energy consumption of the world still comes from fossil fuels.**

| Energy resources | 2017 | | 2018 | |
|---|---|---|---|---|
| | GWhr | % | GWhr | % |
| Oil | 47.6 | 30.63 | 49.97 | 30.57 |
| Coal | 46.97 | 31.19 | 48.14 | 231.2 |
| Natural gas | 38.5 | 25.83 | 36.65 | 21.71 |
| Hydro electricity | 12.02 | 8.72 | 13.22 | 8.79 |
| Nuclear energy | 7.55 | 5.4 | 7.67 | 4.31 |
| Renewables | 5.29 | 3.2 | 5.68 | 4.45 |
| **Total** | **157.93** | | **161.33** | |

**The total installed utility power generation capacity as on 30 April 2018 with sector wise & type wise break up is as given below.**

Total installed utility power capacity with sector wise & type wise break up

| Sector | Thermal (MW) | | | | Nuclear (MW) | Renewable (MW) | | Total (MW) | % |
|---|---|---|---|---|---|---|---|---|---|
| | Coal | Gas | Diesel | Sub-Total Thermal | | Hydro | Other Renewable | | |
| State | 64,456.50 | 7,078.95 | 363.93 | 71,899.38 | 0.00 | 29,858.00 | 2,003.37 | 103,760.75 | 30 |
| Central | 56,955.00 | 7,237.91 | 0.00 | 64,192.91 | 6,780.00 | 12,041.42 | 1,502.30 | 84,516.63 | 25 |
| Private | 75,546.00 | 10,580.60 | 473.70 | 86,600.30 | 0.00 | 3,394.00 | 65,516.72 | 155,511.02 | 45 |
| All India | 196,957.50 | 24,897.46 | 837.63 | 222,692.59 | 6,780.00 | 45,293.42 | 69,022.39 | 343,788.39 | 100 |

**AVAILABILITY OF RESOURCES AND FUTURE TRENDS:**

**1. CONVENTIONAL RESOURCES**

**(i). Fossil fuel**

Fossil fuels are so called because these are in fact the fossils of old biological life that once existed on the surface of the earth**. It is formed in several parts of the earth at varying depths, during several million years by slow decomposition and chemical actions of buried organic matter under favorable pressure, heat and bacterial marine environment. The fossil fuels include coal, oil and gas.**

Fossil fuels have been a major of energy since about 1850, the start of the industrial era. **Presently, we are passing through the peak of the fossil age.** It is generally accepted that the rate of production of an economic commodity of which a finite quantity exists is governed by the law of supply and demand. **As the amount available depletes, the commodity becomes costlier, and its use gradually declines.** Also, new reserves are continuously being discovered and new technologies are being invented for those resources which were not considered economical earlier.

**Coal:**

**World total proved coal reserves are 891531 Million tonnes of oil equivalent (Mtoe) in 2018 were sufficient to meet 110 years of global production.** The coal reserve is found to be abundant in European countries followed by Asia Pacific then North America etc. **The total coal production is 3830.1 Mtoe out of this the highest coal production is in Asia pacific which is about 2798.5 million tonnes of oil equivalent.**

| Sl.No | Name of the country | Total coal reserve Million tonnes | Total coal production Million tonnes oil equivalent | Total coal consumption Million tonnes oil equivalent |
|---|---|---|---|---|
| 1. | Europe & Eurasia | 310,538 | 419.8 | 467.9 |
| 2. | Asia Pacific | 288,328 | 2702.6 | 2798.5 |
| 3. | North America | 245,088 | 494.3 | 429 |
| 4. | India | 60600 | 234.8 | 48.6 |
| 5. | Africa | 32,936 | 151.4 | 96.9 |
| 6. | Middle East | 32,936 | 0.7 | 10.5 |
| 7. | S. & Cent. America | 14,641 | 61.3 | 37.1 |
| **8.** | **Total World** | **891531** | **3830.1** | **3839.9** |

**Total coal production in world level:**

| Coal production (million tonnes) | | | | | | |
|---|---|---|---|---|---|---|
| **Rank** | **Country/Region** | **[1]2019** | **2016[2]** | **2015[3]** | **2014[4]** | **2013[2]** |
| — | *World* | 7727.3 | 7,460.4 | 7,861.1 | 8,164.9 | 8,074.6 |
| 1 | China | 3523.2 | 3,411.0 | 3,747.0 | 3,874.0 | 3,974.3 |
| 2 | India | 716.0 | 692.4 | 677.5 | 648.1 | 608.5 |
| 3 | United States | 702.3 | 660.6 | 812.8 | 906.9 | 893.4 |
| — | *European Union* | 490.1 | 484.7 | 528.1 | 491.5 | 557.9 |
| 4 | Australia | 481.3 | 492.8 | 484.5 | 503.2 | 472.8 |
| 5 | Indonesia | 461.0 | 434.0 | 392.0 | 458.0 | 474.6 |
| 6 | Russia | 411.2 | 385.4 | 373.3 | 357.6 | 355.2 |
| 7 | South Africa | 252.3 | 251.2 | 252.1 | 260.5 | 256.3 |
| 8 | Germany | 175.1 | 176.1 | 183.3 | 185.8 | 190.6 |
| 9 | Poland | 127.1 | 131.1 | 135.5 | 137.1 | 142.9 |
| 10 | Kazakhstan | 111.1 | 102.4 | 106.5 | 108.7 | 119.6 |
| 11 | Turkey | 99.8 | 70.6 | 58.4 | 65.2 | 60.4 |
| 12 | Colombia | 89.4 | 90.5 | 85.5 | 88.6 | 85.5 |
| 13 | Canada | 59.5 | 60.3 | 60.7 | 68.8 | 68.4 |
| 14 | Mongolia | 49.5 | 38.1 | 24.5 | 25.3 | 30.1 |
| 15 | Czech Republic | 44.9 | 46.0 | 46.2 | 46.9 | 49.0 |
| 16 | Serbia | 40.0 | 38.4 | 38.1 | 29.8 | 40.3 |
| 17 | Vietnam | 38.1 | 39.4 | 41.5 | 41.2 | 41.1 |
| 18 | Greece | 37.8 | 33.1 | 47.7 | 49.3 | 53.9 |

| Coal production (million tonnes) | | | | | | |
|---|---|---|---|---|---|---|
| **Rank** | **Country/Region** | **[1]2019** | **2016[2]** | **2015[3]** | **2014[4]** | **2013[2]** |
| 19 | Bulgaria | 34.5 | 31.5 | 35.9 | 31.3 | 28.6 |
| 20 | Ukraine | 34.2 | 41.8 | 38.5 | 60.9 | 84.8 |
| 21 | Romania | 25.7 | 23.2 | 25.5 | 23.6 | 24.7 |
| 22 | Thailand | 16.3 | 17.0 | 15.2 | 18.0 | 18.1 |
| 23 | Mexico | 10.4 | 11.4 | 14.4 | 13.8 | 14.6 |
| 24 | Hungary | 8.0 | 9.3 | 9.6 | 0.1 | 9.6 |
| 25 | Brazil | 7.0 | 8.1 | 8.0 | 7.9 | 8.6 |
| - | North Korea | | | 38.8[5] | 34.0[5] | 33.0[5] |
| - | Kosovo | | | 9.1[5] | 7.9[5] | 9.1[5] |
| - | Philippines | | | 7.8[5] | 10.5[5] | 7.8[5] |
| - | Mozambique | | | 7.2[5] | 15.8[5] | 6.7[5] |
| - | Bosnia and Herzegovina | | | 6.7[5] | 6.8[5] | 6.9[5] |
| - | Macedonia | | | 6.5[5] | 7.9[5] | 7.4[5] |

**Oil:**

**Total world proved oil reserves reached 1697.6 Million barrels at the end of 2018 sufficient to meet 52.5 years of global production.** The largest reserve is from Middle East which is calculated as 803.5 million barrels whereas the lowest oil reserve is 5.7 million barrels which is from India. **The total oil production in India is 876 thousand barrels daily and the total oil consumption is 4159 thousand barrels daily.**

| Sl.No | Name of the country | Total oil reserve Million barrels | Total oil production Thousands barrels per day | Total oil consumption Thousands barrels per day |
|---|---|---|---|---|
| 1. | Middle East | 803.5 | 30098 | 9570 |
| 2. | S. & Cent. America | 329.2 | 7712 | 7083 |
| 3. | North America | 238 | 19676 | 23364 |
| 4. | Europe & Eurasia | 155.2 | 17463 | 18380 |
| 5. | Africa | 129.1 | 8375 | 3888 |
| 6. | Asia Pacific | 42.6 | 8346 | 32444 |
| 7. | India | 5.7 | 876 | 4159 |
| **8.** | **Total** | **1697.6** | **91670** | **95008** |

**Natural gas reserves:**

**World total proven natural gas reserves at end-2017 stood at 186.9 trillion cubic metres (tcm), sufficient to meet 54.1 years of global production.** The Total proved reserves grew by 0.3% relative to end-2018.In global Middle East hold the largest proved reserves. The total natural gas production is about 3538.6 bcm . World natural gas production increased by 1.6% in 2017 below its 10-year average of 2.5%, four times the growth rate of global consumption (+0.4%). **The total natural gas consumption is about 3468.6 bcm. The world largest natural gas consumption is 1003.5 bcm.**

| Sl.No | Name of the country | Total natural gas reserve Trillion cubic meters | Total natural gas production billion cubic meters | Total natural gas consumption billion cubic meters |
|---|---|---|---|---|
| 1. | Middle East | 80 | 617.9 | 490.2 |
| 2. | Europe & Eurasia | 56.8 | 989.5 | 1003.5 |
| 3. | Asia Pacific | 15.6 | 556.7 | 701.1 |
| 4. | Africa | 14.1 | 211.8 | 135.5 |
| 5. | North America | 12.8 | 984 | 963.6 |
| 6. | S. & Cent. America | 7.6 | 178.5 | 174.8 |
| 7. | India | 1.5 | 29.2 | 50.6 |
| **8.** | **Total** | **186.9** | **3538.6** | **3468.6** |

**(ii). Hydro Resources:**

**Among all renewables, hydro power is the most advanced and flexible source of power.** It is a well-developed and established source of electric power. The early generation of electricity from about 1880, was often derived from hydro turbines. A number of large and medium sized hydro schemes have been developed. **Due to requirements of huge capital investment and strong environmental concerns about large plants, only about one third of the realistic potential has been tapped so far.**

Hydro installation and plants are long lasting. This is due to continuous steady operation without high temperature or other stresses. Therefore, it often produces electricity at low cost with consequent economic benefits. But it consume a huge money at the time of erecting the plant

At the end of 2015, over 160 countries had hydropower resources capacity, with a total capacity of 22464 GWh across 11,000 hydropower stations. **In 2018 the world total installed capacity is about 1.21TWh across all over world which accounts for about 16.6% of the world's total installed electric power generation capacity and about 70% of the world's primary energy supply from renewable Energy source.** Five countries make up more than the half of the world's hydro power production: in China 96.6 Mtoe, Brazil 32.9 Mtoe, Canada 32.3MtoeUSA 21.5 Mtoe and Russia 13.8 Mtoe. **The world's biggest power plant is the Three Gorge Dam in China which at 22,500MWh is more than 50% larger than the 2nd biggest power station in the world and with the Itaipu Dam in Brazil/Paraguay in second place (14,000 MWh).**

**(iii). Nuclear resources**

**$U^{235}$, $U^{233}$ (Isotopes of Uranium) and $Pu^{239}$ (Plutonium) are used as nuclear reactors (thermal reactors) and are known as fissile(or fissionable) materials. Out of this, only $U^{235}$ occurs in nature. $U^{233}$ and $Pu^{235}$ are produced from $Th^{232}$ (Thorium) and $U^{238}$ respectively in fast breeder reactors. $Th^{232}$ and $U^{238}$ are known as fertile materials. Natural Uranium contains of 0.71% of $U^{235}$ and 99.29% of $U^{238}$.**

Uranium reserves in the world are small and its recovery is expensive. Major top five available sources of uranium are in Asia (3.42 Million tonnes), South East Asia and Pacific (1.79 Million tonnes), Africa (1.58 Million tonnes), Europe (1.39 Million tonnes) and in North America (824 thousand tonnes).

Global nuclear power capacity reached 390 GWe at the end of 2017, generating about 11% of the world electricity. The development of nuclear power is today concentrated in a relatively small group of countries. As of December 2017, 65 reactors were under construction (6 more than in July 2012) with a total capacity of 64 GW. Two-thirds (40) of the units under

construction are located in four countries: China, India, Russia and South Korea, all of which have ambitious targets for new nuclear construction.

The USA has the largest installed capacity for generation, with 99.2 GWe of nuclear power capacity currently in operation. France is close behind, with over 63.1 GWe of capacity available in 2015; but this counts for far more of France's total electricity supply, a total of 76.3% of the market share. In comparison, the USA's nuclear share is only 19.5% of their total electricity generation.

## 2. NON-CONVENTIONAL SOURCES

**Non-conventional technologies are presently under the development stage. At present their share is very small.**

**Installed capacity of non-conventional renewable power**[2]

| Type | Capacity (in MW) |
|---|---|
| Wind | 34,046.00 |
| Solar | 21,651.48 |
| Small Hydro Power Projects | 4,485.81 |
| Biomass Power & Gasification and Bagasse Cogeneration | 8,700.80 |
| Waste to Power | 138.30 |
| ***Total non-conventional renewable Power - Grid Connected*** | ***69,022.39*** |

**Captive Power Sector**

| Source | Captive Power Capacity (MW) | Share | Electricity generated (GWh) | Share |
|---|---|---|---|---|
| Coal | 32,843 | 59.72% | 147,036 | 80.35% |
| Hydroelectricity | 70 | 0.13% | 148 | 0.09% |
| Renewable energy source | 1540 | 2.80% | 2,461 | 1.34% |
| Natural Gas | 6,225 | 11.32% | 23,316 | 12.74% |
| Oil | 14,318 | 26.03% | 10,038 | 5.49% |
| **Total** | **54,997** | 100.00% | **183,000** | 100.00% |

### (i). Solar energy

**Solar energy can be a major source of power and can be utilized by using thermal and photo voltaic conversion systems. The solar radiations receive on the surface of the earth on a bright sunny day at noon is approximately 1 KW/m$^2$. The earth continuously intercepts solar power of 178 billion megawatt which is about 10000 times the world demand.** But so far, could not be developed on a large scale. According to one estimate if all the buildings of the world are covered with solar PV panels it can fulfil electrical power requirements of the world**. Solar power is considered an expensive source of power.** At present, the capital cost of a solar PV system is Rs.200 per Watt(Rs.20 crore /MW as against Rs.4 crore /MW for coal fires thermal power plant.

**By the end of 2015, cumulative photovoltaic capacity increased and reached 227 GW, sufficient to supply 1 percent of the world's total electricity consumption. The top installers of 2017 were Europe (98.9GW), followed by Asia (93.1GW) and in East Asia (80.3 GW)**

**(ii). Wind energy:**

**Wind power has emerged as the most economical of all renewable energy sources.** The installation cost of wind power is Rs. 4 crore/MW(which is comparable to that conventional thermal power plants). There has been remarkable growth of wind power installation in the world. Wind power generation is the fastest growing energy source.

World wind power generation capacity has reached 435 GW at the end of 2017, around 7% of total global power generation capacity. Global wind power generation amounted to 950 TWh in 2015, nearly 4% of total global power generation.

The wind power market can be divided into large wind onshore (422 GW, around 210,000 machines), small wind onshore (less than 1 GW installed end 2015, more than 800,000 machines), and offshore (around 12 GW installed end 2016, around 4,000 machines). Large onshore and offshore wind turbines are typically arranged in a wind park. The largest wind parks exceed 1 GW in size, such as Gansu Wind Farm in China, Muppandal Wind Park in India or Alta Wind Energy Center in USA.

China has the largest wind energy installed capacity with 145 GW, followed by the United States with 73 GW, Germany 45 GW, India 25 GW, Spain 23 GW and the UK 14 GW.

**(iii). Biomass energy:**

**Energy resources available from animal and vegetation are called bio mass energy resources.** This is an important resource for developing countries, especially in rural areas. The principle biomass resources are

- **Trees(wood, leaves and forest industry waste)**
- **Cultivated plants grown for energy**
- **Algae and other vegetation from oceans and lakes**
- **Urban waste(Municipal and industrial waste)**
- **Rural waste(agricultural and animal waste, crop residue etc)**

**At present there are about 227 biogas plants all over the world with a total capacity of about4454 TWh. USA is the leading country which produces about 79 TWh power, followed by Brazil(57 TWh), Germany (44 TWh), China(44 TWh) and Japan 35(TWh)**

**(iv). Geothermal energy**

**Geothermal thermal energy is derived from huge amounts of stored thermal energy in the interior of the earth, though its economic recovery on the surface of the earth is not feasible everywhere.** Its overall contribution in total energy requirement is negligible. **The total electric power generation from Geo thermal energy is 83.4 GW. The countries like China (4.18 Mtoe), USA(3.26 Mtoe), and India (103 ktoe).**

**(v). Ocean tidal energy**

**Tidal energy is a form of hydro power that converts energy of ocean tides into electricity are other useful forms of power.** It is in the developing stage and although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power. There are a number of large commercial scale tidal power sites in operation around the world. **The largest tidal power station in the world was commissioned in South Korea in 2011 and has a maximum generating capacity of 254 MW. It is known as the Sihwa Lake Tidal Power Station** and is an interesting construction because it retrofitted an existing seawall with ten 25.4 MW submerged turbines to produce electricity from the tidal flows. **The next largest is a 240 MW bulb turbine at the mouth of La Rance estuary in France.** That site powers a city of 300,000 people. Another of the older barrage tidal dams is the Annapolis Royal Generating Station which is located on the Annapolis River in Nova Scotia, Canada. With a generating capacity of 20 MW the power station was commissioned in 1984. It has the capability to power around 4500 houses in the area.

**(vi). Ocean Wave energy**

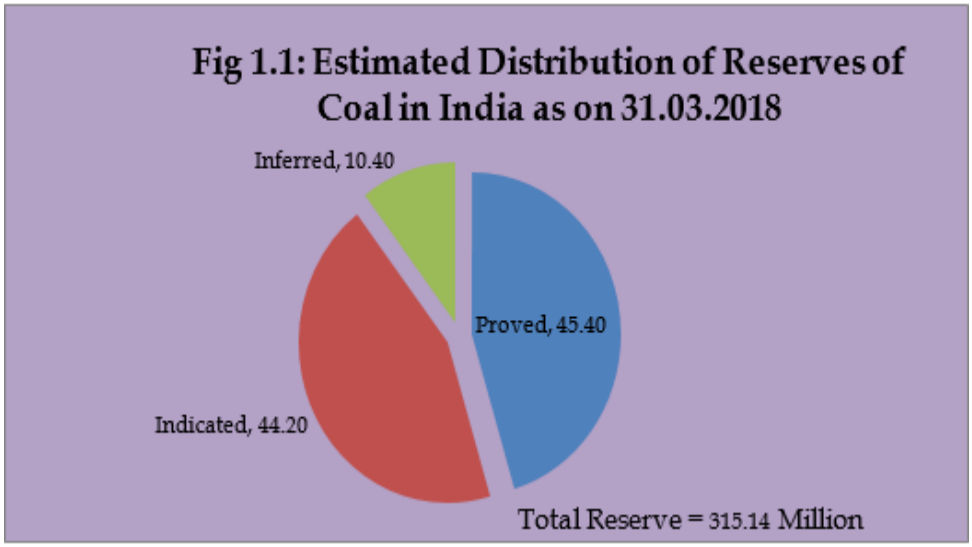
Ocean Thermal Energy Conversion (OTEC) uses the temperature difference between the warm tropical surface water and the cooler, deep water in the ocean to generate energy. Although still being developed, OTEC technology promises a renewable, constant source of

energy that may even serve to reduce levels of heat and carbon dioxide from the ocean's surface layer, currently increasing due to global warming and emissions. OTEC plants can be land-based, 'floating' (offshore fixed plants), or 'grazing' plants that are allowed to drift through the areas of the ocean with high temperature differences, storing the energy they produce as liquid hydrogen.

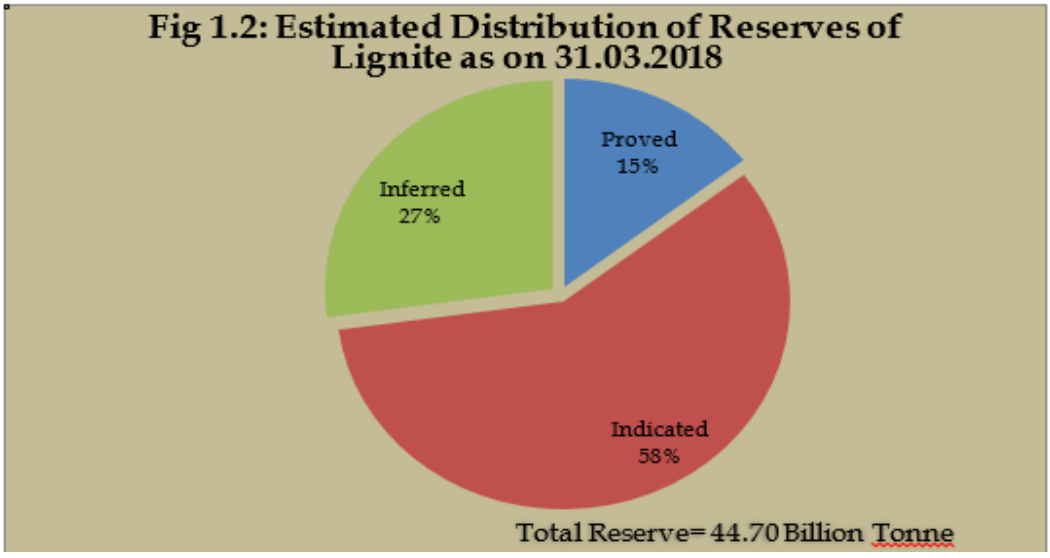
**Resources for power generation in India. (April/May 2014)**

**(i) Coal and Lignite**

- Coal deposits are mainly confined to eastern and south central parts of the country. The states of Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, Telangana and Maharashtra account for 99.08% of the total coal reserves in the country. The State of Jharkhand had the maximum share (26.44%) in the overall reserves of coal in the country as on 31st March 2018 followed by the State of Odisha (24.72%)




- As on 31.03.18, the estimated reserve of coal was 315.14 billion tonnes, an addition of 5.04 billion over the last year (Table 1.1). There has been an increase of 1.67% in the estimated coal reserves during the year 2017-18 with Chattisgarh accounting for maximum increase of 4.53%.
- The estimated total reserve of lignite as on 31.03.18 was 44.70 billion Tonne which is equivalent to the total reserve as on 31.03.17.



## State wise estimated Reserves of Coal in India as on 1.04.2018 (in Million Tonnes)

- As a result of exploration carried out up to the maximum depth of 1200m by the GSI, CMPDI, SCCL and MECL etc, a cumulative total of 319.02 Billion tonnes of Geological Resources of Coal have so far been estimated in the country as on 1.4.2018. The details of state-wise geological resources of Coal are given as under:
  - Million Tonnes

| State | Proved | Indicated | Inferred | Total |
|---|---|---|---|---|
| **Total** | **148787** | **139164** | **31069** | **319020** |
| JHARKHAND | 45563 | 31439 | 6150 | 83152 |
| ODISHA | 37391 | 34165 | 7739 | 79295 |
| CHHATTISGARH | 20428 | 34576 | 2202 | 57206 |
| WEST BENGAL | 14156 | 12869 | 4643 | 31667 |
| MADHYA PRADESH | 11958 | 12154 | 3875 | 27987 |
| TELANGANA | 10475 | 8576 | 2651 | 21702 |
| MAHARASHTRA | 7178 | 3074 | 2048 | 12299 |
| ANDHRA PRADESH | 0 | 1149 | 432 | 1581 |
| BIHAR | 161 | 813 | 392 | 1367 |
| UTTAR PRADESH | 884 | 178 | 0 | 1062 |
| MEGHALAYA | 89 | 17 | 471 | 576 |
| ASSAM | 465 | 57 | 3 | 525 |
| NAGALAND | 9 | 0 | 402 | 410 |
| SIKKIM | 0 | 58 | 43 | 101 |
| ARUNACHAL PRADESH | 31 | 40 | 19 | 90 |
| **Total** | **148787** | **139164** | **31069** | **319020** |

## State wise Estimated Reserves of Lignite in India as on 31.03.2018

| State/District | Proved | Indicated | Inferred | Total |
|---|---|---|---|---|
| **All India : Total** | **6540.71** | **26014.39** | **12143.03** | **44698.13** |
| Gujarat | 1278.65 | 283.70 | 1159.70 | 2722.05 |
| Jammu & Kashmir | – | 20.25 | 7.30 | 27.55 |
| Kerala | – | – | 9.65 | 9.65 |
| Rajasthan | 1168.53 | 2670.83 | 1896.60 | 5735.96 |
| Tamil Nadu | 4093.53 | 22632.87 | 9055.98 | 35782.38 |
| Puducherry | – | 405.61 | 11.00 | 416.61 |
| West Bengal | – | 1.13 | 2.80 | 3.93 |

- The estimated reserve of crude oil in India as on 31.03.2018 stood at 763.48 million tonne (MT).
- Geographical distribution of Crude oil indicates that the maximum reserves are in the Western Offshore (43.67%) followed by Assam (22.19%), whereas the maximum reserves of Natural Gas are in the Eastern Offshore (37.10%) followed by Western offshore (29.34%).
- There was increase of 0.10% in the estimated reserve of crude oil for the country as a whole during 2017-18 as compared to the position a year ago. During the same period, estimated reserves of crude oil in Arunachal Pradesh, Rajasthan and Assam decreased by 44.75%, 17.04% and 2.11% respectively, while the same in Tamil Nadu, Andhra Pradesh, Gujarat, Western Offshore and Eastern Offshore increased by 18.42 %, 15.30%, 2.58%, 1.88% and 0.59% respectively.

The estimated reserves of natural gas in India as on 31.03.2018 stood at 1488.49 billion cubic meters (BCM)

**(ii) Renewable energy sources**

- There is high potential for generation of renewable energy from various sources- wind, solar, biomass, small hydro and cogeneration bagasse.
- The total potential for renewable power generation in the country as on 31.03.18 is estimated at 896603 MW.
- . This includes wind power potential of 102772 MW (11.46%), SHP (small-hydro power) potential of 19749 MW (2.20%), Biomass power potential of 17,538 MW (1.96%), 5000 MW (0.56%) from bagasse-based cogeneration in sugar mills and solar power potential of 748990 MW(83.54%)

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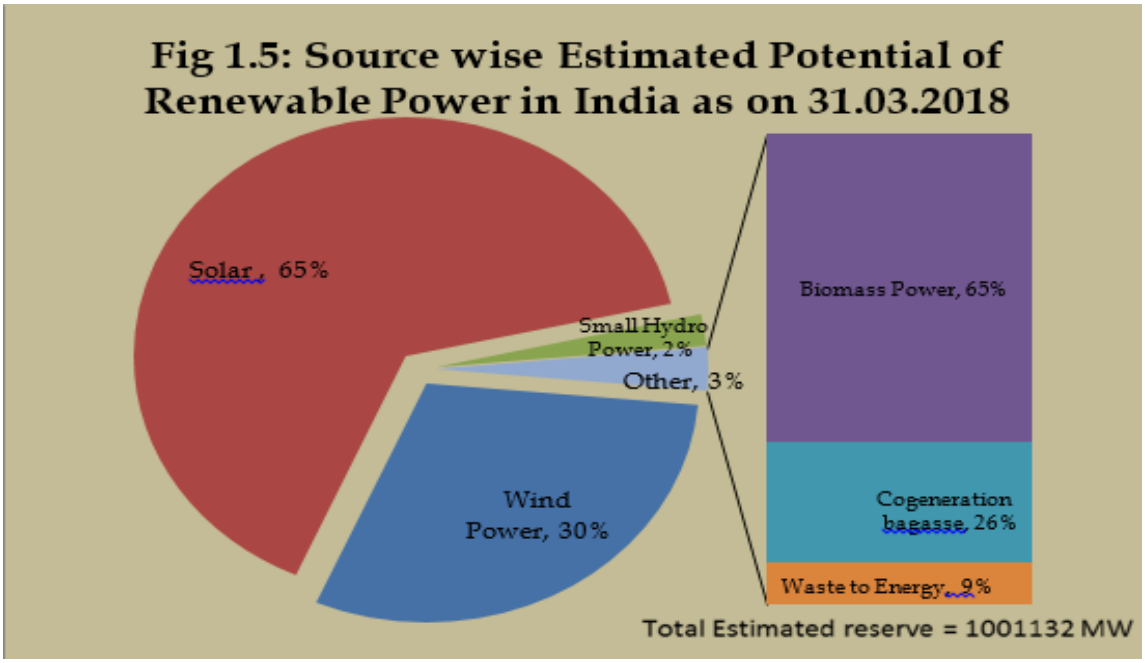
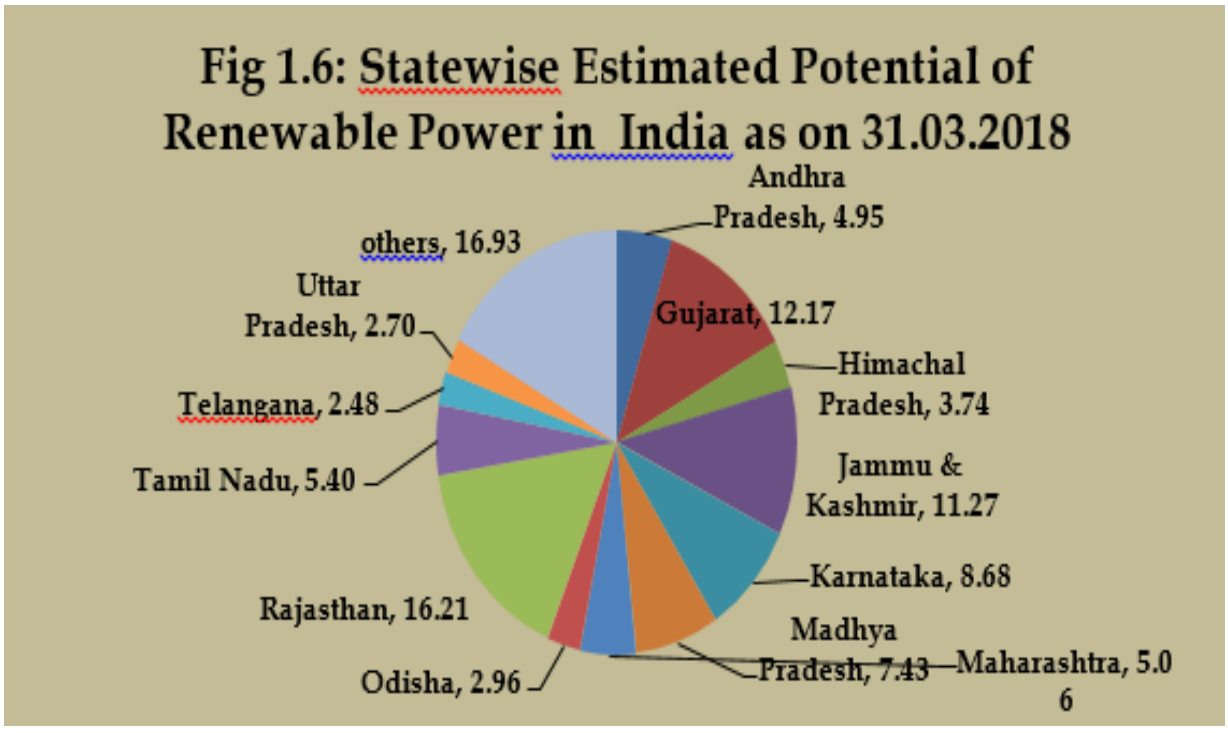



- The geographic distribution of the estimated potential of renewable power as on 31.03.2018 reveals that Rajasthan has the highest share of about 17% (148518MW), followed by Jammu and Kashmir with 13% share (118208) and Gujarat with 8% share (72726MW), mainly on account of solar power potential



**(iv) Refineries of crude oil**

- As on 31.03.15 there were a total of 22 refineries in the country (Table 2.2), 17 in the Public Sector, 3 in the Private sector and 2 in Joint Venture.
- There is no change in refining capacity in the country (215 MMT) over the period of one year.
- The Refinery production (crude throughput) achievement was 222.938 MMT during 2014-15 which marks net increase of 0.20% over 2017-18(222.497 MMT).
- Capacity utilization of the refineries was 103.5% during 2017-18 which increased to 103.7% during 2017-18. In the Public Sector the maximum increase in capacity utilization (23.4%) was at IOC, Mathura, and Uttar Pradesh.
- Indian Oil Corporation, the state owned corporation had highest refining capacity of 54,200 TMTY. All units of IOC together processed 53,585 TMT during 2017-18 as compared to 53,127 TMT during 2017-18. The capacity utilization of these refineries was 98.9% during 2014-15 as against 98% during 2013-14.
- All the private refineries taken together processed 88,229 TMT during 2017-18 which is equivalent to the amount processed in 2017-18. The capacity utilization of these refineries during 2012-13 and 2017-18 was same i.e. 110.3%.

**Energy sources with special reference to Indian content. (April/ May 2014)(April 2013)**

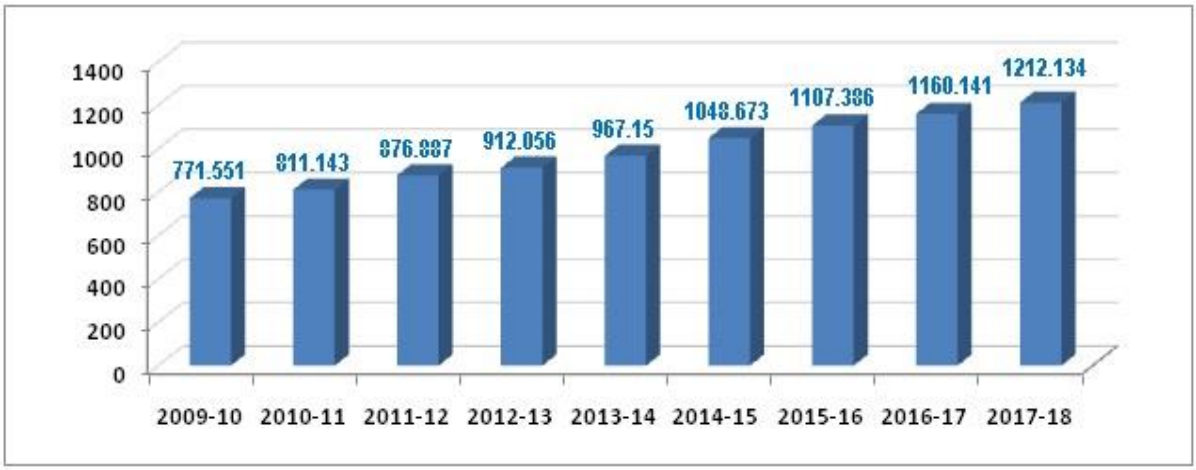
**Yearly gross Electricity generation:**

| Yearly gross electricity generation by source (GWh) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Fossil Fuel | | | Nuclear | Hydro* | Sub total | RES[69] | | | | | | Utility and Captive Power | | | |
| | Coal | Oil | Gas | | | | Mini hydro | Solar | Wind | Bio mass | Other | Sub total | Utility | Captive | Misc | Total |
| 2011-12 | 612,497 | 2,649 | 93,281 | 32,286 | 130,511 | 871,224 | na | na | na | na | na | 51,226 | 922,451 | 134,387 | na | 1,056,838 |
| 2012-13 | 691,341 | 2,449 | 66,664 | 32,866 | 113,720 | 907,040 | na | na | na | na | na | 57,449 | 964,489 | 144,009 | na | 1,108,498 |
| 2013-14 | 746,087 | 1,868 | 44,522 | 34,228 | 134,847 | 961,552 | na | 3,350 | na | na | na | 59,615 | 1,021,167 | 156,643 | na | 1,177,810 |
| 2014-15 | 835,838 | 1,407 | 41,075 | 36,102 | 129,244 | 1,043,666 | 8,060 | 4,600 | 28,214 | 14,944 | 414 | 61,780 | 1,105,446 | 166,426 | na | 1,271,872 |
| 2015-16[70] | 896,260 | 406 | 47,122 | 37,413 | 121,377 | 1,102,578 | 8,355 | 7,450 | 28,604 | 16,681 | 269 | 65,781 | 1,168,359 | 183,611 | na | 1,351,970 |
| 2016-17[71] | 944,861 | 275 | 49,094 | 37,916 | 122,313 | 1,154,523 | 7,673 | 12,086 | 46,011 | 14,159 | 213 | 81,869 | 1,236,392 | 197,000 | na | 1,433,392 |
| 2017-18[5] | 986,591 | 386 | 50,208 | 38,346 | 126,123 | 1,201,653 | 5,056 | 25,871 | 52,666 | 15,252 | 358 | 101,839 | 1,303,493 | 183,000 | na | 1,486,493 |
| 2018-19[72][73] | 1,021,997 | 129 | 49,886 | 37,706 | 135,040 | 1,244,758 | 8,703 | 39,268 | 62,036 | 16,325 | 425 | 126,757 | 1,371,517 | | na | |

**Overall Production and Consumption**

India is both a major energy producer and consumer. India became the world's third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia and as the world's fourth greatest energy consumer after China, USA and Russia. Thus, India is a net energy importer, mostly due to the large imbalance between oil production and consumption. The **India** had an installed capacity of 281.423 GW as of 30 November 2015, Renewable Power plants constituted 28% of total installed capacity and Non-Renewable Power Plants constituted the remaining 72%. The Sector wise energy consumption as on 31.12.2016 shown in figure below

**Electricity production in India:**




**Market Size**

Indian power sector is undergoing a significant change that has redefined the industry outlook. Sustained economic growth continues to drive electricity demand in India. The Government of India's focus on attaining 'Power for all' has accelerated capacity addition in the country. At the same time, the competitive intensity is increasing at both the market and supply sides (fuel, logistics, finances, and manpower).

Total installed capacity of power stations in India stood at 344.69 Gigawatt (GW) between as of August 2018.

**Investment Scenario**

Between April 2000 and June 2018, the industry attracted US$ 14.18 billion in Foreign Direct Investment (FDI), accounting for 3.64 per cent of total FDI inflows in India.

Some major investments and developments in the Indian power sector are as follows:

- In August 2018, Kohlberg Kravis Roberts & Co (KKR) acquired Ramky Enviro Engineers Limited for worth US$ 530 million.
- In April 2018 ReNew Power made the largest M&A deal by acquiring Ostro Energy for US$ 1,668.21 million.

## ALL INDIA INSTALLED CAPACITY (IN MW) OF POWER STATIONS

(As on 31.03.2018)

(UTILITIES)

| Region | Ownership/ Sector | Modewise breakup | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Thermal | | | | Nuclear | Hydro | RES * (MNRE) | |
| | | Coal | Gas | Diesel | Total | | | | |
| Northern Region | State | 16888.00 | 2879.20 | 0.00 | 19767.20 | 0.00 | 8643.55 | 689.56 | 29100.31 |
| | Private | 22760.83 | 558.00 | 0.00 | 23318.83 | 0.00 | 2514.00 | 11854.66 | 37687.49 |
| | Central | 13290.37 | 2344.06 | 0.00 | 15634.43 | 1620.00 | 8596.22 | 329.00 | 26179.65 |
| | **Sub Total** | **52939.20** | **5781.26** | **0.00** | **58720.46** | **1620.00** | **19753.77** | **12873.22** | **92967.45** |
| Western Region | State | 21280.00 | 2849.82 | 0.00 | 24129.82 | 0.00 | 5446.50 | 311.19 | 29887.51 |
| | Private | 34285.67 | 4676.00 | 0.00 | 38961.67 | 0.00 | 481.00 | 19473.89 | 58916.56 |
| | Central | 15042.95 | 3280.67 | 0.00 | 18323.62 | 1840.00 | 1520.00 | 661.30 | 22344.92 |
| | **Sub Total** | **70608.62** | **10806.49** | **0.00** | **81415.11** | **1840.00** | **7447.50** | **20446.38** | **111148.99** |
| Southern Region | State | 19432.50 | 791.98 | 287.88 | 20512.36 | 0.00 | 11808.03 | 518.02 | 32838.41 |
| | Private | 12124.50 | 5322.10 | 473.70 | 17920.30 | 0.00 | 0.00 | 33359.36 | 51279.66 |
| | Central | 14225.02 | 359.58 | 0.00 | 14584.60 | 3320.00 | 0.00 | 491.90 | 18396.50 |
| | **Sub Total** | **45782.02** | **6473.66** | **761.58** | **53017.26** | **3320.00** | **11808.03** | **34369.28** | **102514.57** |
| Eastern Region | State | 7070.00 | 100.00 | 0.00 | 7170.00 | 0.00 | 3537.92 | 225.11 | 10933.03 |
| | Private | 6375.00 | 0.00 | 0.00 | 6375.00 | 0.00 | 399.00 | 803.29 | 7577.29 |
| | Central | 13876.64 | 0.00 | 0.00 | 13876.64 | 0.00 | 1005.20 | 10.00 | 14891.84 |
| | **Sub Total** | **27321.64** | **100.00** | **0.00** | **27421.64** | **0.00** | **4942.12** | **1038.40** | **33402.16** |
| North Eastern Region | State | 0.00 | 457.95 | 36.00 | 493.95 | 0.00 | 422.00 | 254.25 | 1170.20 |
| | Private | 0.00 | 24.50 | 0.00 | 24.50 | 0.00 | 0.00 | 23.31 | 47.81 |
| | Central | 520.02 | 1253.60 | 0.00 | 1773.62 | 0.00 | 920.00 | 5.00 | 2698.62 |
| | **Sub Total** | **520.02** | **1736.05** | **36.00** | **2292.07** | **0.00** | **1342.00** | **282.56** | **3916.63** |
| Islands | State | 0.00 | 0.00 | 40.05 | 40.05 | 0.00 | 0.00 | 5.25 | 45.30 |
| | Private | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.21 | 2.21 |
| | Central | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.10 | 5.10 |
| | **Sub Total** | **0.00** | **0.00** | **40.05** | **40.05** | **0.00** | **0.00** | **12.56** | **52.61** |
| ALL INDIA | State | 64670.50 | 7078.95 | 363.93 | 72113.38 | 0.00 | 29858.00 | 2003.37 | 103974.75 |
| | Private | 75546.00 | 10580.60 | 473.70 | 86600.30 | 0.00 | 3394.00 | 65516.72 | 155511.02 |
| | Central | 56955.00 | 7237.91 | 0.00 | 64192.91 | 6780.00 | 12041.42 | 1502.30 | 84516.63 |
| | **Total** | **197171.50** | **24897.46** | **837.63** | **222906.59** | **6780.00** | **45293.42** | **69022.39** | **344002.39** |

# Installed capacity

**The total installed power generation capacity is sum of utility capacity, captive power capacity and other non-utilities**

Growth of Installed Capacity in India[5]

| Installed Capacity as on | Thermal (MW) | | | | Nuclear (MW) | Renewable (MW) | | | Total (MW) | % Growth (on yearly basis) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coal | Gas | Diesel | Sub-Total Thermal | | Hydro | Other Renewable | Sub-Total Renewable | | |
| 31-Dec-1947 | 756 | - | 98 | 854 | - | 508 | - | 508 | 1,362 | - |
| 31-Dec-1950 | 1,004 | - | 149 | 1,153 | - | 560 | - | 560 | 1,713 | 8.59% |
| 31-Mar-1956 | 1,597 | - | 228 | 1,825 | - | 1,061 | - | 1,061 | 2,886 | 13.04% |
| 31-Mar-1961 | 2,436 | - | 300 | 2,736 | - | 1,917 | - | 1,917 | 4,653 | 12.25% |
| 31-Mar-1966 | 4,417 | 137 | 352 | 4,903 | - | 4,124 | - | 4,124 | 9,027 | 18.80% |
| 31-Mar-1974 | 8,652 | 165 | 241 | 9,058 | 640 | 6,966 | - | 6,966 | 16,664 | 10.58% |
| 31-Mar-1979 | 14,875 | 168 | 164 | 15,207 | 640 | 10,833 | - | 10,833 | 26,680 | 12.02% |
| 31-Mar-1985 | 26,311 | 542 | 177 | 27,030 | 1,095 | 14,460 | - | 14,460 | 42,585 | 9.94% |
| 31-Mar-1990 | 41,236 | 2,343 | 165 | 43,764 | 1,565 | 18,307 | - | 18,307 | 63,636 | 9.89% |
| 31-Mar-1997 | 54,154 | 6,562 | 294 | 61,010 | 2,225 | 21,658 | 902 | 22,560 | 85,795 | 4.94% |
| 31-Mar-2002 | 62,131 | 11,163 | 1,135 | 74,429 | 2,720 | 26,269 | 1,628 | 27,897 | 105,046 | 4.49% |
| 31-Mar-2007 | 71,121 | 13,692 | 1,202 | 86,015 | 3,900 | 34,654 | 7,760 | 42,414 | 132,329 | 5.19% |
| 31-Mar-2012 | 112,022 | 18,381 | 1,200 | 131,603 | 4,780 | 38,990 | 24,503 | 63,493 | 199,877 | 9.00% |
| 31-Mar-2017 | 192,163 | 25,329 | 838 | 218,330 | 6,780 | 44,478 | 57,260 | 101,138 | 326,841 | 10.31% |
| 31-Mar-2018 | 197,171 | 24,897 | 838 | 222,906 | 6,780 | 45,293 | 69,022 | 114,315 | 344,002 | 5.25% |
| 31-Mar-2019[3] | 200,704 | 24,937 | 637 | 226,279 | 6,780 | 45,399 | 77,641 | 123,040 | 356,100 | 3.52% |

## AVAILABILITY OF PRIMARY ENERGY RESOURCES

### A. Conventional

(i) **Fossil fuel :**Coal is the most abundant fossil fuel resource in India, which is the world's third largest coal producer. The principal deposits of hard coal are in the eastern half of the country, ranging from Andhra Pradesh, bordering the Indian Ocean, to Arunachal Pradesh in the extreme northeast: the eastern States of Chhattisgarh, Jharkhand, Orissa and West Bengal together account for about 77% of reserves. The Ministry of Coal (quoting the Geological Survey of India) states that at 1 April 2009, India's geological resources of bituminous coal comprised 105.8 billion tonnes of 'proved resources', 123.5 billion tonnes of 'indicated resources' and 37.9 billion tonnes of 'inferred resources'. Coking coals constitute 17% of the tonnage of proved resources. The resources quoted are the result of exploration down to a depth of 1 200 m.

Lignite deposits mostly occur in the southern State of Tamil Nadu. All-India resources of lignite are quoted in the 11th Five Year Plan as 38.27 billion tonnes as at 1 April 2006, with proved reserves put at 4.5 billion tonnes. About 2.4 billion tonnes in the Neyveli area of Tamil Nadu have been stated to be regarded as 'mineable under the presently adopted mining parameters'. Annual production of lignite is currently in the region of 32 million tonnes, almost all of which is used for electricity generation.

(ii) **Hydro resources:** India is the 6th largest producer of hydroelectric power. the list The present installed capacity as on July 31, 2015 is **41,997.42 MW** which is 15.22% of total electricity generation in India. Huge installation cost, environmental and social problems are major difficulties in its development.

**(iii) Nuclear Energy:**

- India has 21 reactor units in operation, with an aggregate net generating capacity of 5302 MWe, nearly all of which are relatively small PHWRs that have been built using a domestically developed supply chain. Output from India's nuclear plants accounts for about 3.5% of its net electricity generation. According to the IAEA, six reactor units were under construction at the end of 2015, with an aggregate net generating capacity of 3907 MWe. Four 630 MWe PHWRs were under construction at end-2015: Kakraper 3-4, Rajasthan 7-8, as well as a 917 MWe VVER (Kudankulam2) and a 470 MWe fast breeder reactor (PFBR). India has an active nuclear power programme and expects to have 14,600 MWe nuclear capacity on line by 2024. In July 2014 the new Prime Minister urged the nuclear sector to raise capacity to 17 GWe by 2024.
- The objective is to supply 25% of electricity from nuclear power by 2050. The success of the sector in meeting these objectives depends on a degree of foreign participation, however, since 2010, a fundamental incompatibility between India's civil liability law and international nuclear liability conventions limits foreign technology provision.
- In addition to a conventional uranium-based nuclear programme, India has been developing uniquely a nuclear fuel cycle to exploit its reserves of thorium.

**List of top three nuclear power plants in India**

- Tarapur is the largest nuclear power station in India having a total capacity of 1400 MW.
- Rajasthan Atomic Power Station-1180 MW
- Kudankulam Nuclear Power Plant- 1000MW

Kudankulam Nuclear Power Plant is a nuclear power station of the southern Indian state of Tamil Nadu. It constructed first reactor plant (1000MW) critically in 13th July 2013.Another new plant of 1000 MW is under construction.

**B. Non-Conventional**

Located in the tropical region, India is endowed with abundant renewable energy resources, i.e, solar, wind and biomass including agricultural residue which is perennial in nature. Harnessing these resources is the best suited to meet the energy requirement in rural areas in a decentralized manner. India has the potential of generating more than **1,47,615 MW** from non-conventional resources. Up to July 31,2015, the power is produced from renewable source is **78,468.06 MW** which is about 12.14% of the total installed electrical power generation capacity. The current status of various resources are given in table

**(i) Wind Energy**

The highly successful wind power programme in India was initiated in 1983-84 and is entirely market driven. This sector has been growing at over 35% in the last three years. India has the fifth largest installed wind power capacity in the world
After USA, China, Spain and Germany. The current installed capacity for wind power stands at 23,447.5 MW, and is located in Tamil Nadu, Gujarat, Maharashtra and Rajasthan.

**(ii) Solar energy**

India receives a solar energy equivalent of more than 4346.82 MW per year, which is far more than its total annual consumption. India is a fast-growing industry and as of 30 September 2016, the country's solar grid had a cumulative capacity of 8,626 megawatts (MW) or 8.63 gigawatts (GW). In January 2015, the Indian government expanded its solar plans, targeting US$100 billion of investment and 100 GW of solar capacity, including 40 GW's directly from rooftop solar, by 2022. The rapid growth in deployment of solar power is recorded and updated monthly on the Indian Government's Ministry of New and Renewable Energy website. Large scale solar power deployment began only as recently as 2010, yet the ambitious targets would see India installing more than double that achieved by world leaders China or Germany in all of the period up to 2015 year end. 6763MW is the installed solar power capacity of India as of 2016.

**(iii)Biomass Energy**

A large quantity of biomass is available in our country in the form of dry waste like agro residues, fuel wood, twigs, etc., and wet wastes like cattle dung, organic effluents, sugarcane bagasse, banana stems, etc. The potential for generation of electric power is 1,365.20 MW from biomass and 2,800.35 from bagasse through cogeneration. The potential from urban waste is 107.58 MW. Also, there is a vast scope for production of bio-diesel from some plants. These plants require little care, can be grown on fallow land and can survive in harsh climatic conditions.

**(iv) Small Hydro Resources**

Hydro resources of capacity less than 25 MW are called small, less than 1MW are called mini and less than 100KW are called micro hydro resources. The total potential is 20,000 MW. out of which 3,990.83 MW has been realized by approximately 611 plants.

**(v) Geothermal Energy**

The potential in geothermal resources in the country is 10,000MW. As a result of various resource assessment studies/surveys, nearly 340 potential hot springs have been identified throughout the country. Only some of them are considered suitable for power generation. The reservoirs suitable for power generation have been located in Tattapani. Hot-water resources are located at Badrinath, Kedarnath and few other locations in the Himalayan ranges and elsewhere. They are being used mostly for heating purposes and very little has been developed. Andaman and Nicobar arc is the only place in India where volcanic activity geo-thermal energy is present.

India is planned to have first geothermal power plant with 10,600 MW of potential in the geothermal provinces at Chattishgar.

**(vi) Ocean Tidal Energy**

There is no function tidal plant at present and the total potential has been estimated to 9,000MW. Three sites have been identified.

***West Coast***

- Gulf of Cambay (7000 MW)
- Gulf of Kutch (1200 MW)

***East Coast***

The Ganges Delta in the Sunderbans in West Bengal for small scale tidal power development. Estimates peg the potential in this region to be about 100 MW.

The Gujarat state government has approved Rs 25 crore for setting up the 50 MW plant at the Gulf of Kutch. The government has signed a MOU with Atlantis Resource Corporation to setup the plant. The Gujarat government last year also approved a 10 MW tidal energy plant proposed by Urja Global Limited in association with a US-based company Ocean Energy Industries. MNRE sanctioned a demonstration project for setting up 3.75 MW capacity tidal energy power plant at the Durgaduani Creek in Sunderbans region.

**(vii) Ocean Wave and OTEC Resources**

The potential along the 6000 Km of India's coast is estimated to be about 40,000 MW – these are preliminary estimates. This energy is however less intensive than what is available in more northern and southern latitudes.

A 150KW pilot plant has been installed at Vizhingum harbour near Thiruvananthapuram, Kerala. The average potential for Indian coasts has been estimated at around 0.02MW/m of wavefront. There is a proposal for an OTEC plant at the Minicoy Island of Lakshadweep.

Emerging technologies like 'fuel cell' and 'hydrogen energy' are suited for stationary and portable power generation, which suits transportation purposes. In view of the growing importance of the fuel cells and hydrogen, a National Hydrogen Energy Board has been created. The board will provide guidance for the preparation and implementation of the National Hydrogen Energy Road Map, covering all aspects of hydrogen energy starting from production, storage, delivery, application, safety issues, codes and standards, public awareness and capacity buildings. Eco-friendly electric vehicles for transportation are being fields tested for improving their performance.

**Energy parameters- energy intensity and GDP.**

**DEFINITION of 'Gross Domestic Product - GDP'**

Gross domestic product (GDP) is the monetary value of all the finished goods and services produced within a country's borders in a specific time period. Though GDP is usually calculated on an annual basis, it can be calculated on a quarterly basis as well. **GDP includes all private and public consumption, government expenses, investments and exports minus imports that occur within a defined territory**. Put simply, GDP is a broad measurement of a nation's overall economic activity.

Gross domestic product can be calculated using the following formula:

$$GDP = C + G + I + NX$$

Where **C**- is equal to all private consumption, or consumer spending, in a nation's economy,

**G**- is the sum of government spending,

**I** - is the sum of all the country's investment, including businesses capital expenditures and **NX** is the nation's total net exports, calculated as total exports minus total imports (NX = Exports - Imports).

**GDP:**

It is the market value for all final goods and services produced within a given period of time by factors of production located within the country.

a. GDP is concerned only with new and current production.

b. GDP also excludes output produced abroad by domestically owned factors of production.

c. Intermediate goods (those goods that are produced by one firm for use in further processing by another firm) are not counted in the GDP.

**GNP:**

Is the total market value of all final goods and services produced within a given period by factors of production owned by a country's citizens regardless of where the output is produced.

**CALCULATING GROSS DOMESTIC PRODUCT (GDP)**

1. **EXPENDITURE APPROACH**

$$GDP = C + I + G + (EX - IM)$$

where:

C = Personal Consumption expenditures – household spending on consumer goods

I = Gross Domestic Investment – spending by firms and households on new capital, plant, equipment, inventory and new residential structures

G = government consumption and investment

EX – IM = net exports – net spending by rest of the world or exports minus imports

**C = PERSONAL CONSUMER EXPENDITURES CATEGORIES**

i. Durable goods – goods that last a relatively long time such as cars and household appliances

ii. Nondurable goods – goods that are used up fairly quickly such as food and clothing

iii. Services – things we buy that do not involve the production of physical things such as legal and medical services and education

**I = GROSS PRIVATE DOMESTIC INVESTMENT**

TYPES OF INVESTMENT:

i. Gross Private Investment – total investment in capital, it is the purchase of new housing, equipment and plants by private sector

ii. Nonresidential Investment – expenditures by firms for machines, tools, plants and so on

iii. Residential Investment – expenditures by firms and on new houses and buildings

iv. Change in Business Inventories – amount by which firms inventories change during a period, inventories are goods that firms produce now but intend to sell later

**GOVERNMENT CONSUMPTION AND INVESTMENT** refers to federal, state and local governments for final goods and services.

**NET EXPORTS (EX – IM)** is the difference between exports and imports, figure can be negative or positive

**2. INCOME APPROACH**

GDP = National Income + Depreciation + (indirect taxes – Subsidies) + Net factor payments to the rest of the world

**A. NATIONAL INCOME**

Is the total income earned by the factors of production owned by country's citizen

a. Compensation of employees – includes wages, salaries and various supplements

b. Proprietor's income – income of unincorporated businesses

c. Corporate profits – income of corporate businesses

d. Net interest – interest paid by business

e. Rental income – income received by property owners in from of rent

**B. DEPRECIATION** is the amount by which asset's value falls in a given period

**C. INDIRECT TAXES** are taxes like sales tax, customs duties and license fee

**D. SUBSIDIES** are payments made by the government for which it receives no goods or services in return

**E. NET FACTOR PAYMENTS TO THE REST OF THE WORLD** payments of factor income to the rest of the world minus receipt of factor income from the rest of the world

**India: a rising force in global energy demand**

Energy demand in India is projected to soar over the coming decades, propelled by an economy that grows to reach more than five-times its current size by 2040 and a demographic boom that sees India become the most populous country in the world by 2025. Energy use more than doubles to reach 1 900 million tonnes of oil equivalent (Mtoe) by 2040 (Figure ). The rise in energy use is slower than the increase in gross domestic product (GDP) , but still represents around one-quarter of the total increase in global energy consumption over the period to 2040. Because of India's strong population growth, consumption per capita falls slightly short of doubling; the level reached in 2040 is around 60% of the global average, up from 33% today.

The relationship between GDP growth and energy demand is affected by a range of economic, structural and technological factors. Energy demand tends to rise faster than household income as people get access to reliable electricity, prompting purchases of an increasing number of appliances (e.g. lighting, refrigerators, cookers, fans, air conditioners). Energy demand also grows more rapidly than economic output when growth is concentrated in energy-intensive industrial sectors or when people shift their transport habits from trains or buses to individual vehicles. On the other hand, GDP growth from the services sector of the economy tends to require relatively little energy and the relationship between GDP and energy consumption can be further loosened by improvements in energy efficiency. In our projections for India, even with relatively strong growth in manufacturing, it is these latter effects that dominate, with the result of a gradual reduction in the overall energy intensity of India's economy – from 0.11 tonnes of oil equivalent (toe) per $1 000 in 2013 to 0.05 toe per $1 000 in 2040.

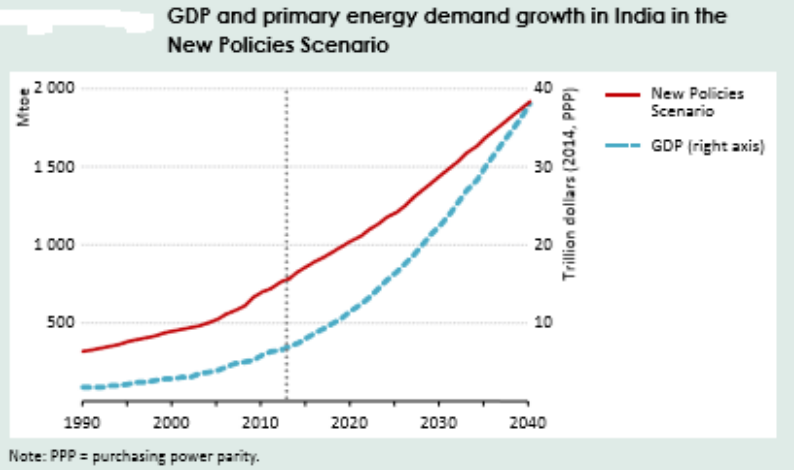



**Figure GDP and primary energy demand growth in India in the New Policies Scenario**

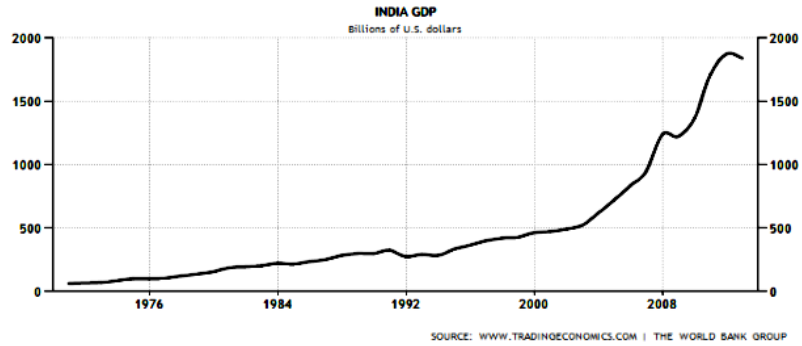
With energy use declining in many OECD countries and China moving into a much less energy-intensive phase in its development, India is emerging as a major driving force in many areas of global energy. It takes over from China as the largest single source of rising demand both for coal and oil in the period to 2040 and becomes a significant player in a series of other markets, from wind and solar to nuclear, hydropower and natural gas. In the case of coal, the increase in demand in India makes by far the largest contribution to growth in global consumption to 2040. In the case of oil, India accounts for more than 45% of the projected net increase in global consumption.

In the electricity sector, demand growth that averages 4.9% per year puts all other major countries and regions in the shade: to meet this demand, India needs to build more than 880 gigawatts(GW) of new power generation capacity over the period to 2040 (for comparison, the entire installed capacity of the European Union is currently around 1 000 GW

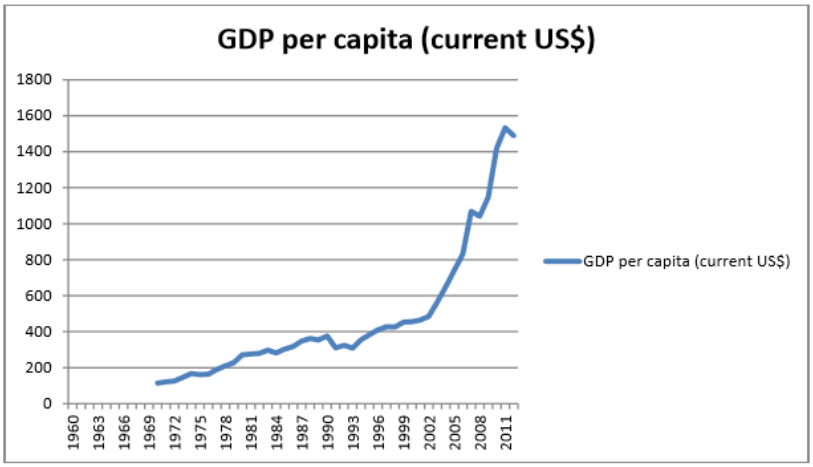
The Gross Domestic Product per capita in India was last recorded at 1106.80 US dollars in 2012. The GDP per Capita in India is equivalent to 9% of the world's average. GDP per capita in India is reported by the World Bank. India GDP per capita averaged 448.91 USD from 1960 until 2012, reaching an all-time high of 1106.80 USD in December of 2012 and a record low of 228.34 USD in December of 1960. The GDP per capita is obtained by dividing the country's gross domestic product, adjusted by inflation, by the total population.

Energy Demand Growth in India

**Line graph of Indian GDP in Billions of US dollars**




**Line graph of GDP per capita in current US$**




**General Considerations** : Figures 4 and 5 depict the energy consumption per capita and energy consumption per GDP for all the countries. Each continent was considered separately for further analysis and comparison. When a country is said to be more energy efficient than another, it means that it uses less energy to perform the same task compared to the other. At each step in energy production and utilization, loss can occur. Therefore, in order to point out where the losses are found, further analysis was carried out. Initially, energy consumption was compared with a country's gross domestic product. Later, precipitate energy consumption for many countries was plotted against GDP per capita. In order to make a quantitative estimate of the response of energy consumption per capita to GDP per capita, regression analysis was carried out for the set of the database. Both linear and nonlinear regression analyses were effected based on the lowest percentage of error and best correlation coefficient, and the best-fit relationship for this set of data was found to be a power law of the form,

$$EC = A*GDPpcB$$

where

EC = energy consumption per capita in kilograms of oil equivalent and
GDPpc= grossdomesticproductper capitain U.S.dollars.
EC = 0.9184*GDPpc0.8939

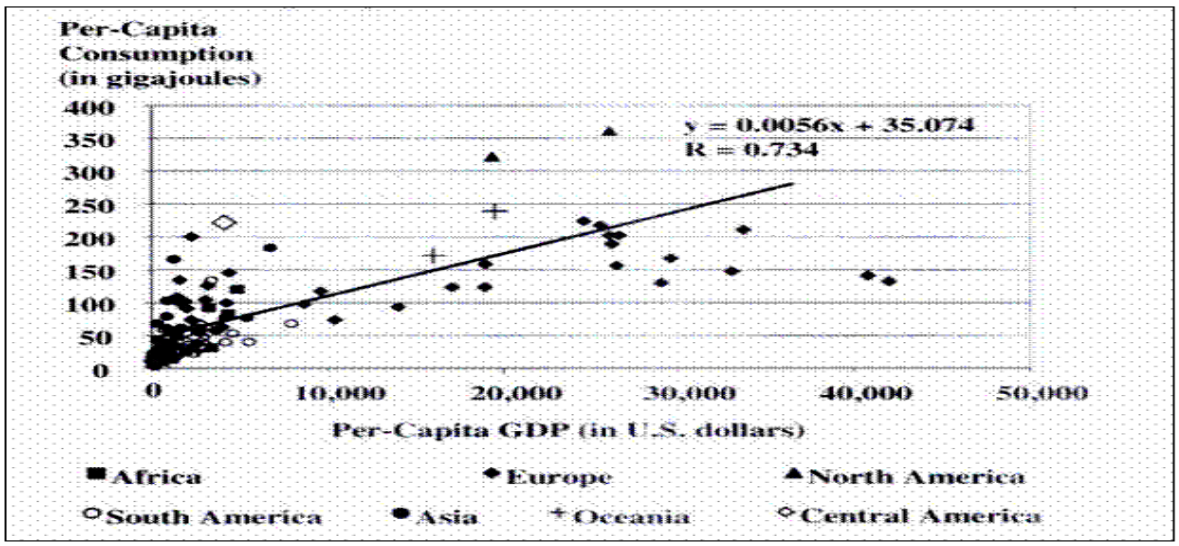



**Figure 4 : The Per-Capita Energy Consumption Versus The Per-Capita Gross Domestic Product (GDP) For All The Countries Considered,**

aR =correlation efficient.

The energy consumption per capita increases as the per-capita GDP increases, until it reaches a threshold. This is illustrated in figure 4 where countries on the left side have higher energy consumption per capita than those on the right side. This indicates higher energy consumption for a lower GDP per capita. The countries seem to spread in figure 4 from the origin (no energy

consumed, no GDP) in almost all the directions like a cone. There does not seem to be any limit on the amount of energy consumed per unit of GDP, and it appears that a minimum amount of energy is needed to produce a certain amount of GDP. That leads to an area on the bottom of the figure where no countries are found. For values of GDP below U.S. $2,000, the relationship between the GDP per capita and the minimum energy consumption seems to be linear. After this value, saturation occurs for an energy consumption of about 125 gigajoules (GJ).

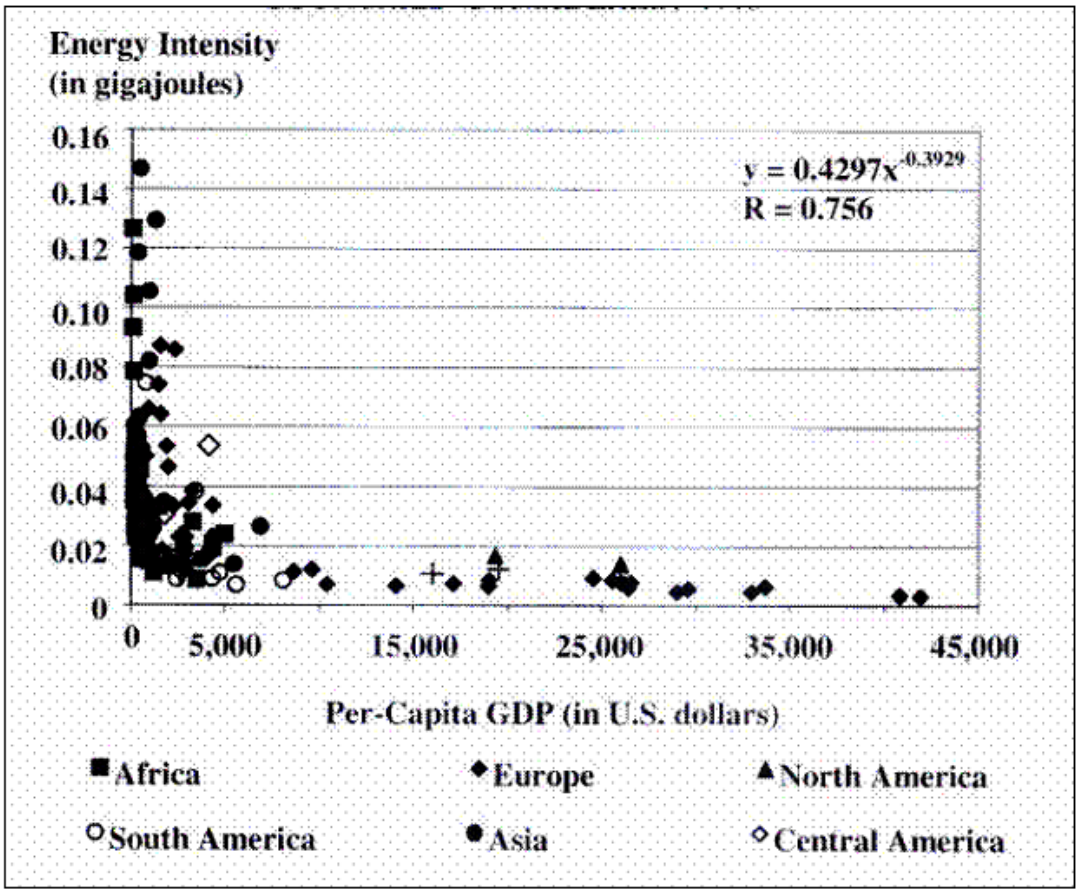



Figure 5 : the energy consumption per gross domestic product(GDP)-energy intensity-versus the per-capita gdp for all the countries considered

aR =correlation efficient.

Three distinct groups emerge from figure 4. The developed countries are spread on the right of that figure. They have high energy consumption per capita, between 100 and 350 GJ, and high GDP per capita, between U.S. $10,000 and $43,000 (consisting of Western European countries and North American countries, Australia, and New Zealand). Second, on the lower left corner the developing (African, some Asian, and Central and South American) countries are found. They have very low energy consumption per capita, up to 75 GJ and low GDP per capita, up to U.S. $6,000. Third, all the countries between the first and the second group form the third group. It is composed of nations that have a GDP per capita between U.S. $6,000 and $10,000 and countries that have a GDP per capita of less than U.S. $6,000 but energy consumption per capita higher than 75 GJ (composed of North African, East European, and Middle East countries, plus some countries of Asia and South and Central America).

Variability is observed in per-capita energy consumption for similar GDP per capita, for both developed and developing countries. It can be explained partially by the fact that not all the energy consumed is taken into account in the GDP. Transport and home heating or cooling, for instance, need energy to be performed. Therefore, the energy consumption of a country does not depend only on the outcome but also on the climate and the way people live. It is possible to evaluate the efficiency of energy consumption in a country. In a region (state), apart from the industry, agriculture, and service sectors, which participate in the GDP and consume energy, people of the country use energy for cooking, heating, and for different tasks in their

day-to-daylife. A country very efficient in all the domains will have very low energy consumption per GDP. That does not mean that the energy consumption per capita is low. On the contrary, high efficiency is generally associated with high technology and a high standard of living, leading to lower energy consumption per capita. Countries with high energy consumption per GDP and low energy consumption per capita are poor and inefficient. Most of the energy is used by industry and the GDP is low, indicating low efficiencies. Industrial composition and end-use efficiencies have to be taken into account in order to make a good comparison. Sectors like cement or paper, for example, are highenergy industries. Nevertheless, high energy consumption per GDP is generally associated with inefficient countries, especially ifthe energy consumption per capita is low. Figure 5 clearly shows that countries with a high GDP per capita also have low energy consumption per GDP. On the other hand, having low energy consumption per GDP does not imply a high GDP per capita. In order to have more disposable energy, two paths can be followed. The first is to increase the energy production. Supposing that the GDP will increase if the energy production expands; the country will then have an energy-intensive path. The second possibility is to increase the efficiency or to minimize the loss. That also leads to a situation where more energy is available. Regarding figure5, the second possibility is certainly the best. If a country wants to increase its GDP per capita, it will have to reach high efficiencies. Improving efficiency can save vast amounts of energy.

**A REVIEW OF ENERGY INTENSITY STUDIES**

The concept of **energy intensity(the ratio of energy consumption to gross domestic product**), and energy elasticity (the ratio of the percentage change in energy consumption to that of GDP), have been used frequently in predicting energy needs, in comparing energy use efficiency, and in assessing the impact of energy on the economy. Energy intensity, as defined above, also represents the amount of energy required to produce one unit of income. It has been considered a global indicator of the link between energy consumption and income. Damstadler, Dunkerly,andAlterman (1977), applied this concept of energy intensity to a comparative analysis of how industrialized societies use energy. They found that there existed complex methodological issues indispensable in making international comparisons. In addition, the task of going beyond the energy consumption GDP ratio, which revealed differences but masked the reasons, proved difficult.

**DETERMINANTS OF ENERGY INTENSITY**

Energy intensity is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP.

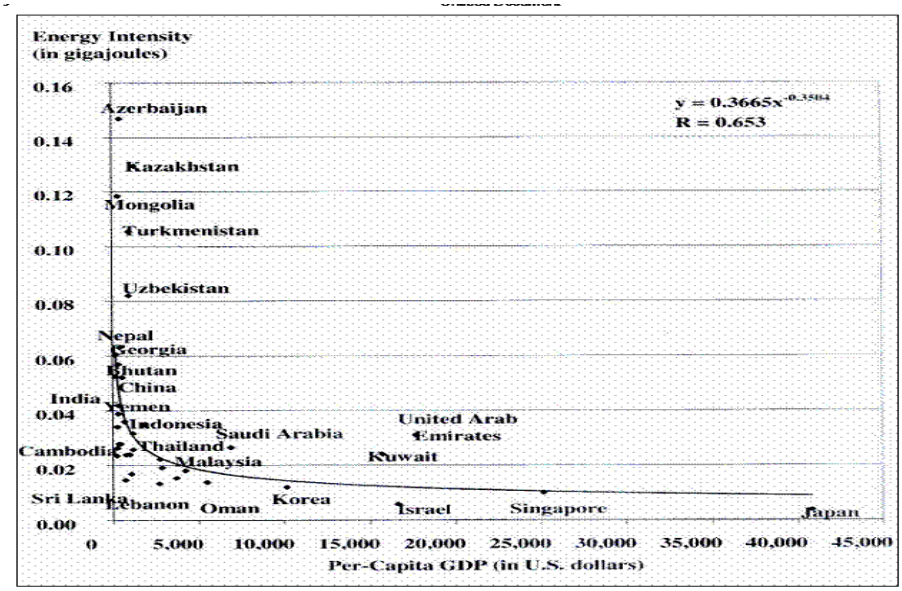
1. High energy intensities indicate a high price or cost of converting energy into GDP.
2. Low energy intensity indicates a lower price or cost of converting energy into GDP.

The following factors are presented from the literature review laid out above. These factors influence the intensity of energy use over time.

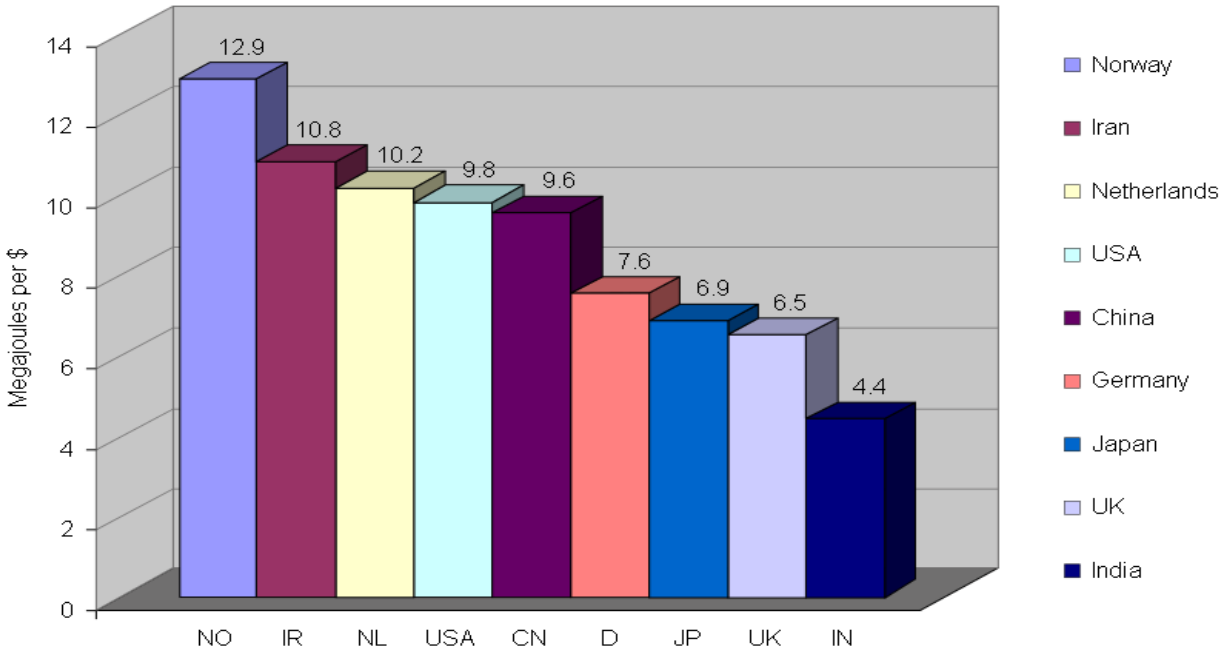
1. Technological change in the economy (Tabti and Mandi, 1985)
2. Increasing industrialization
3. Efficiency in the use of energy
4. Energy conservation
5. Energy price(s)
6. Stages of economic development (Elias and Grabik, 1980)
7. Structure of energy consumption pattern
8. Climatic conditions
9. Energy supply
10. Political structure
11. Energy substitution - commercial for noncommercial fuels (Ang, 1987)
12. Strong demand for transportation energy use
13. Rise in electricity demand in the household and commercial sectors

14. Expansion of energy conversion industries
15. Extent of urbanization (Jones, 1991)
16. Extent of capital formation (Miketa, 2001)
17. Structural changes in the economy (Murtishaw and Schipper, 2001)
18. Foreign direct investments (Michnik and Goldemberg, 2002)
19. Research and development expenditures (Fisher Vanden et al, 2003)
20. Ownership structure in the enterprise sector

Energy availability and consumption are important for economic progress. Because energy inputs are scarce, they must be used wisely and efficiently. Understanding the interactions between energy consumption and economy growth will be very helpful in planning to meet the demand for energy in each country. Increased use of energy inputs contribute to improvements in the quality of life. Energy intensity has declined in the U.S.A. over the last fifty years.




The same two indicators have been plotted with the countries that save a per-capita GDP of less than U.S. $10,000 (figures 5 and 6). It is then possible to see the countries falling between the developing and the developed countries: Saudi Arabia, Lebanon, Oman, Malaysia, Turkey, and Thailand. With some former Soviet Union countries (Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan) and Iran, they form the Asia 3 group. Other countries comprise the Asia 2 group. Low-income countries of the Asia 2 group are Sri Lanka, Laos, Cambodia. and Vietnam, with very low energy consumption per capita and very low energy consumption per GDP.



The analysis and results of this study indicate that we can produce more income while being more energy efficient through energy conservation policies, and policies that promote improvements in technology for energy use plus the ability to substitute amongst various forms of energy inputs.

**Comparison of various Conventional energy sources with renewable resources. Nov 2015**

INTRODUCTION:

The conventional sources of energy are generally non-renewable sources of energy, which are being used since a long time. These sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent. The coal, petroleum, natural gas etc., are conventional sources of energy.

With the rising cost and decreasing availability of non renewable fossil fuels, renewable resources are receiving increasing attention and also these are pollution free. We can regenerate or replenish them. Biomass, water, geothermal, wind and solar are the Renewable Energy sources

ELECTRICITY GENERATION USING COAL (Conventional Energy Source):

Thermal power station turns the chemical energy in coal into electrical energy that can be used in homes and businesses.

COAL: Coal is one of the most important sources of energy and is being used for various proposes such as heating of housed, as fuel for boilers and steam engines and for generation of electricity by thermal plants.

a. Coal burning: First the coal is ground to a fine powder and sent into the boiler, where it is burned, converting its chemical energy into heat energy. As well as heat, burning coal produces ash and exhaust gases. The ash falls to the bottom of the boiler and is removed by the ash systems. The gases enter the exhaust stack, which contains equipment that filters out any dust and ash, before venting into the atmosphere.

b. Mechanical Energy: Burning the coal heats water in pipes coiled around the boiler, turning it into steam. The hot steam expands in the pipes, so when it emerges it is under high pressure. The pressure drives the steam over the blades of the steam turbine, causing it to spin, converting the heat energy released in the boiler into mechanical energy.

c. Electrical Energy: A shaft connects the steam turbine to the turbine generator, so when the turbine spins, so does the generator. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy. After passing through the turbine, the steam comes into contact with pipes full of cold water. The cold pipes cool the steam so that it condenses back into water. It is then piped back to the boiler, where it can be heated up again, turn into steam again, and keep the turbine turning.

d. Finally, a transformer converts the electrical energy from the generator to a high voltage. The national grid uses high voltages to transmit electricity efficiently through the power lines, homes and businesses that need it. Here, other transformers reduce the voltage back down to a usable level.

We can generate electricity using oil and natural gas but from the past decades we are generating 50% of electricity using coal and remaining by the other sources due to the advantages of coal and disadvantages of natural gas and oil.

DISADVANTAGES OF NATURAL GAS FOR GENERATING ELECTRICITY:

- Natural gas is pollution free but when it burns, carbon dioxide, monoxide, and other carbon compounds are emitted in the atmosphere contributing to the greenhouse effect.
- Natural gas is cheap in cost but the transportation cost is high.
- During the transportation or in any another situation. Natural gas is extremely dangerous. Such leaks may be the cause of fire or explosions. The gas itself is extremely toxic when inhaled. The main risk comes from the fact that it is naturally odorless and cannot be detected by smell, unless an odorant has been added to the gas mixture. In the case of an underground leak, the odorant may gradually become weaker and the gas may go undetected.
- It is a finite source of energy and cannot be considered a long-term solution to our energy supply problem.
- The whole pipe installation may be very expensive to construct since long pipes, specialized tanks, and separate plumbing systems need to be used. Pipe leakage may also be very expensive to detect and fix.

DISADVANTAGES OF OIL FOR GENERATING ELECTRICITY:

The cost of oil is low but disadvantages are more for oil for producing electricity. And the disadvantages are as follows:

1. Not sustainable.
2. Produces carbon dioxide, which causes greenhouse effect.
3. Requires sustainable amount of cooling water.
4. The world's oil reserves are limited.
5. If the oil spills while transporting, causes severe pollution and affects the marine species.
6. Some oils contain high levels of sulphur.

When compared to the use of natural gas and oil for generating electricity use of coal is more convenient. Some of the advantages of coal for generating electricity are as follow:

ADVANTAGES OF COAL FOR GENERATING ELECTRICITY:

1. Burning of coil is currently one of the cheapest ways to generate power comparing with energy sources of energy.
2. Power stations can built anywhere with good transport links or access to gas pipelines and a plentiful supply of cooling water.
3. The world has many coal reserves.
4. For cooling purpose Gas can be easily transported by pipeline as it is light in weight.

Not only are these advantages but there some disadvantages of using coal to produce electricity.

DISADVANTAGES OF COAL FOR GENERATING ELECTRICITY:

- Coal is not a Renewable energy source. So, we may lose the coal reserves.
- Thermal Power stations require large amounts of fuel to produce the less amount of electricity which results in wastage of fuel.
- Causes pollution when compared to another sources. Coal emits less percentage of harmful gases into atmosphere.
- Requires more water for the thermal power plant.

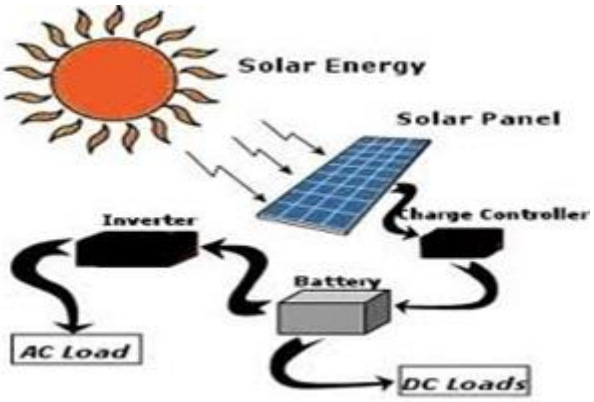
- Very large quantities of ash have to be disposed of and a lot of smoke is produced.
- The methods of mining coal can be very destructive; although responsible coal miners do a remarkably good job of restoring the land after the coal has been mined off.
- These coal mines are getting reduced day by day because of the extensive use of the coal for generating electricity in large amounts for development in all the fields. Also electricity produced by coal causes the environmental pollution and In future these coal mines may completely vanished. It cannot be renewed or reused again so, there is need to develop the Renewable methods of generating electricity such as solar energy, tidal energy, wind energy etc.

Hence it was proved that we have disadvantages if we consider coal as a usage of generating electricity. So let us discuss about the Renewable energy sources.

**ELECTRICITY GENERATION BY SOLAR ENERGY (Renewable Energy Source):**

Photovoltaic devices, or solar cells, directly convert solar energy into electricity. Individual solar cells grouped into panels range from small applications that charge calculator and watch batteries, to large systems that power residential dwellings. Photovoltaic power plants and concentrating solar power plants are the largest solar applications, covering acres.

Sun: The sun has been producing energy in the form of heat and light since the Earth is formed. Solar energy systems do not produce emissions and are often not harmful to the environment. Thermal solar energy can heat water or buildings.

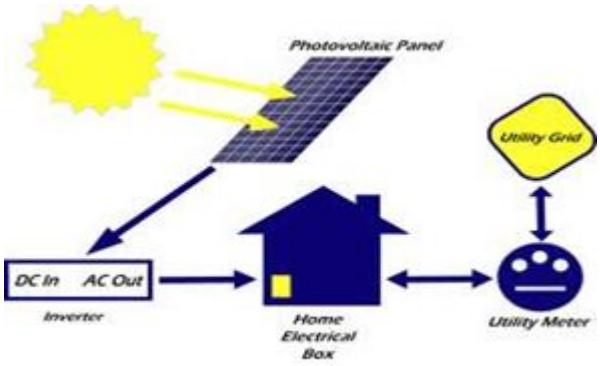



Solar panels turn energy from the sun's rays directly into useful energy that can be used in homes and businesses. There are two main types: solar thermal and photovoltaic, or PV. Solar thermal panels use the sun's energy to heat water that can be used in washing and heating. PV panels use the photovoltaic effect to turn the sun's energy directly into electricity, which can supplement or replace a building's usual supply.

Working of photovoltaic cell: PV panel is made up of a semiconducting material, usually silicon-based, sandwiched between two electrical contacts. To generate as much electricity as possible, PV panels need to spend as much time as possible in direct sunlight. A sheet of glass protects the semiconductor sandwich from hail, grit blown by the wind, and wildlife. The semiconductor is also coated in an antireflective substance, which makes sure that it absorbs the sunlight it needs instead of scattering it uselessly away.

Getting Electrical energy: When sunlight strikes the panel and is absorbed, it knocks loose electrons from some of the atoms that make up the semiconductor. The semiconductor is positively charged on one side and negatively charged on the other side, which encourages all these loose electrons to travel in the same direction, creating an electric current. The contacts capture this current in an electrical circuit.

Converting DC to AC: The electricity PV panels generate is direct current (DC). Before it can be used in homes and businesses, it has to be changed into alternating current (AC) electricity using an Inverter. The inverted current then travels from the inverter to the building's fuse box and from there to the appliances that need it.




PV systems installed in homes and businesses can include a dedicated metering box that measures how much electricity the panels are generating.

- Solar panels can be arranged at the roof or terrace of our Homes and Industries or more number of the solar panels can be arranged in a large area like a power plant for huge amount of electricity. For reducing the use of large space we can place them on roofs or terrace.
- We can generate the electricity using biomass, wind, tidal, etc renewable energy sources but we will get only less amount electricity compared to these all we get the maximum electricity from solar energy. It is the purest and cleanest form of energy we get freely every day by the sun we can make a best use of it by converting into Electricity for our development. And solar energy is pollution free, does not emit any harmful gases.

ADVANTAGES OF SOLAR ENERGY:

1. Non-polluting, no carbon dioxide like fossil fuels
2. Free except for capital expenses.
3. Longevity – solar panels can last over thirty years
4. Environmental friendly because the conversion of energy does not produce any carbon dioxide.
5. It is renewable. It comes from the sun, which is unlimited.
6. Solar power costs less and is better for the environment, compared to burning fossil fuels and other electrical power
7. It doesn't have to be dug up from the ground like coal, oil, natural gas, or uranium
8. It doesn't have to be cut down, like wood from forests.
9. We are using a renewable energy source like the sun, instead of non-renewable energy sources such as Gas, oil, fossil fuels etc…
10. We can save power of electricity. Solar energy is not as much danger as electricity

DISADVANTAGES OF SOLAR ENERGY:

1. It doesn't produce much electricity for one single panel.
2. If u were to build it on the ground, the cost will be higher [ for massive area of land]
3. Only areas of the world with lots of sunlight are suitable for solar power generation
4. The major disadvantage of solar power or solar energy is the cost of the photovoltaic panels
5. You need a lot of money to the installation of the solar power plant.
6. Least power energy at night time is another disadvantage of solar energy.
7. There is no solar energy to be collected which means you'll have to have adequate battery backup to get you through the nights
8. Solar energy is not available 24 hours a day. It can only be harnessed well when it is the strongest, that is, excluding morning, evening and night.
9. There is no guarantee of sunlight in stormy climate or during rain.
10. Limited by environmental factors (like latitude and weather)

APPLICATIONS OF SOLAR ENERGY:

Water heating and pumping-Heating water using electricity can be an expensive undertaking. Using applications of solar energy can help people to reduce their water heating and pumping costs.

Rural vacation homes-cottages and cabins may not have access to traditional power grids. If this is the case, these vacation homes can be designed to use solar energy so that vacationers can enjoy all the creature comforts of a hidden getaway.

Industrial uses-Most industries operate in environments where traditional power supplies are readily available.

CONCLUSION:

- Solar energy has great potential for the future. It does not pollute or otherwise damage the environment. It cannot be controlled by any one nation or industry. If we can improve the technology to harness the sun's enormous power, we may never face energy shortages again.
- By using renewable energy sources for generating electricity is a best way and we can save our non-renewable energy sources for future. And also we can save our environment.
- So, in our view if we find out the solutions which can reduce some of the disadvantages of solar energy, we can eradicate pollution to some extent and we can also use the natural source which is not at all harmful in anyway
- In Abroad solar energy is successful, like they are placing the solar panels on street lights and on roofs or terrace of buildings to avoid the using large power plants and free land which is not useful for constructing and agriculture.
- In our India we can see Gujarat; It is also successfully generating the electricity using solar energy. In the same way we can make the best use of Solar Energy

# Top 5 Countries in all the Energy Resources Based on Production (2018)

| Coal&Lignite | | |
|---|---|---|
| Rank | Name | Production rate in Mtoe/Yr |
| 1 | China | 3349 |
| **2** | **India** | **717** |
| 3 | USA | 701 |
| 4 | Australia | 478 |
| 5 | Indonesia | 461 |

| Oil | | |
|---|---|---|
| Rank | Name | Production rate in Million tonnes/Yr |
| 1 | USA | 893 |
| 2 | China | 564 |
| 3 | Russia | 278 |
| **4** | **India** | **266** |
| 5 | Japan | 158 |

| Gas | | |
|---|---|---|
| Rank | Name | Production rate in Million tonnes/Yr |
| 1 | USA | 767 |
| 2 | Russia | 694 |
| 3 | Iran | 209 |
| 4 | Canada | 184 |
| 5 | Qatar | 166 |
| **35** | **India** | **32** |

| Hydro Power | | |
|---|---|---|
| Rank | Name | Production rate in Million tonnes/Yr |
| 1 | China | 96.9 |
| 2 | Brazil | 32.9 |
| 3 | Canada | 32.3 |
| 4 | USA | 21.5 |
| 5 | Russia | 13.8 |
| **7** | **India** | **11.1** |

| HydroPower | | |
|---|---|---|
| Rank | Name | Production rate in Million tonnes/Yr |
| 1 | China | 4.18 |
| 2 | USA | 3.26 |
| 3 | Turkey | 1.28 |
| 4 | Sweden | 1.24 |
| 5 | Iceland | 1.09 |

| Wind Energy | | |
|---|---|---|
| Rank | Name | Production rate in Million tonnes/Yr |
| 1 | USA | 15.8 |
| 2 | China | 13.6 |
| 3 | Germany | 4.93 |
| 4 | Spain | 4.47 |
| **5** | **India** | **2.88** |

| Solar Energy | | |
|---|---|---|
| Rank | Name | Capacity (MW) |
| 1 | China | 43530 |
| 2 | Germany | 39700 |
| 3 | Japan | 34410 |
| 4 | USA | 25620 |
| 5 | Italy | 18920 |
| **10** | **India** | **5050** |

## 2- MARKS

1. **What are the sources of energy?**

Electrical energy is produced from energy available in various forms in nature. The sources of energy are

- The Sun
- The wind
- Water
- Fuels
- Nuclear energy

2. **Define primary energy sources.** **(Nov 2011) (April 2015)**

Primary energy is an energy form found in nature. This is the energy found in raw form is called raw energy .It cannot be used as such.

Eg: Coal, oil, sunlight, wind, running rivers, uranium, etc.

3. **What are the available energy sources for various power plants?**

i. Conventional energy sources or Non-renewable energy sources
ii. Non-conventional energy sources or Renewable energy sources

4. **What are the major power limitations of conventional energy sources?**

i. Resources for power generation i.e, coal, gas etc., are limited.
ii. The hydro power is seasonal and varies depending upon the rainfall in the catchment areas.
iii. Submersion of land area due to raise in water level.
iv. Centralized power generation and distribution of the same to long distances will result in high losses.
v. The energy conversion process from thermal power projects results in emission of greenhouse gases.

5. **List out the various conventional and non-conventional power plant.** **(April/May 2012) (April/May 2014)**

**Types of conventional power plant:**

1. Hydro power plant
2. Steam power plant
3. Nuclear power plant
4. Gas turbine power plant

**Types of non-conventional power plant:**

1. Tidal power plant
2. Wind power plant
3. Geothermal power plant
4. Solar power plant
5. Wave power plant

6. **What is conventional energy Sources?**

The conventional sources of energy are generally non-renewable sources of energy, which are being used since a long time. These sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent.

Eg: Nuclear, hydro and fossil fuel

7. **What is nonconventional energy Sources?**

Non-conventional energy sources are the energy sources which gives non-renewable energy. The energy which never gets depleted is called non-conventional energy .Non-conventional sources of energy are those which are abundantly available in nature,

Eg: Solar, wind, biomass, etc.

8. **What is mean by Intermediate resources?**

It is obtained from primary energy by one or more steps of transformation.

Eg: energy used in vehicle

**9. What are the Secondary energy Sources? (April/May 2014)**

The form of energy which is finally supplied to a consumer for utilization is known as secondary or usable energy, e.g, electrical energy, thermal energy (in the form of steam or hot water), chemical energy (in the form of hydrogen or fossil fuels), etc. some form of energy may be categorized both in intermediate as well as secondary resources, e.g., electricity and hydrogen

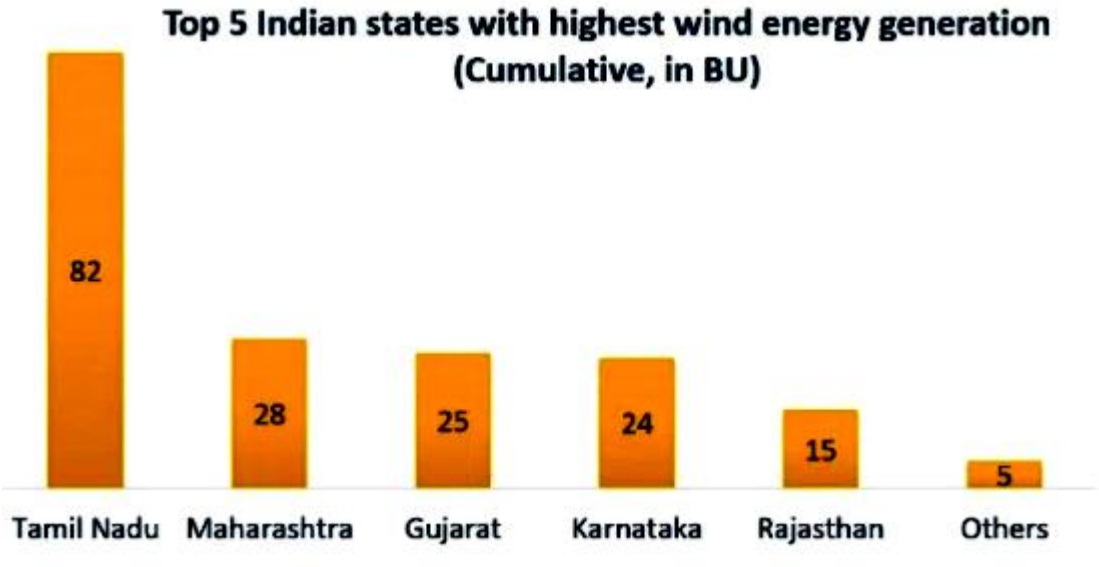
**10. What are the advantages of renewable energy? (April/May 2014)**

- No Global Warming Emissions
- Improved Public Health and Environmental Quality
- A Vast and Inexhaustible Energy Supply
- Jobs and Other Economic Benefits
- Stable Energy Prices
- A More Reliable and Resilient Energy System

**11. What is the difference between renewable and non-renewable energy resources?**

| Sl.no | Renewable energy | Nonrenewable energy |
|---|---|---|
| 1. | Renewable energy is energy which is generated from natural sources i.e. sun, wind, rain, tides and can be generated again and again as and when required. | Non-Renewable energy is energy which is taken from the sources that are available on the earth in limited quantity and will vanish fifty-sixty years from now. |
| 2. | They are available in plenty and by far most the cleanest sources of energy available on this planet. | Non-renewable sources are not environmental friendly and can have serious effect on our health. |
| 3. | wind, geothermal, biomass ,solar | Fossil fuels, natural gas, oil and coal. |

**12. Which region in India producing more wind power?**




**13. State the world wide status of India in coal energy. (April/May 2012)**

Indiais ranked 3rd in the world coal production. The production of coal was 600 million metric tons in the year2013 – 14. The Indian coal has on an average of about 18 to 22% ash content. The coal availability in India will last for 50 to 60 years.

**14. List out the availability of nuclear fuel in India. (April 2013)**

In India it is available as inland resources in the Ranchi plateau. Apart from there they are available as scattered deposits in the Gujarat region, Bihar and inner Tamil Nadu.

**15. Write the renewable energy sources utilized in India. (Nov/Dec 2014)**

1. Solar power plant
2. Wind power plant
3. Hydro power plant
4. Geothermal power plant

**16. Name any two types of nuclear fuels used as conventional energy sources. (Nov 2011)**

U238, P234 and U235.

**17. What is mean energy intensity?**

Energy intensity is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP. 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.

**18. What is GDP?**

Gross Domestic Product (**GDP**) is the broadest quantitative measure of a nation's total economic activity. More specifically, **GDP** represents the monetary value of all goods and services produced within a nation's geographic borders over a specified period of time.

**19. What is real GDP?**

Real gross domestic product, or real GDP, is the total market value of goods and services produced, measured in constant dollars. It represents 'current quantities at past prices.'

**20. What is mean by nominal GDP?**

Nominal gross domestic product, or nominal GDP, is the total market value of goods and services produced, measured in current dollars. It represents 'current quantities at current prices.'

**21. How GDP can be calculated?**

GDP = (quantity of A X price of A) + (quantity of B X price of B) + (quantity of whatever X price of whatever) for every good and service produced within the country.

**22. What are the limitations to the implementation of renewable energy systems? April 2015**

1. Solar panels and wind turbines need to become cheaper than raw fossil fuels. This is the challenge posed by the diffuse nature of renewables.
2. Storage solutions need to become cheaper than fossil fuel refineries (e.g. power plants). This is the challenge posed by the intermittent nature of renewables.

**23. What is the need of energy storage Nov'2015**

Wind and solar power installations generate power only intermittently and with a highly variable output. When the wind is blowing or the sun is shining, excess power should be stored and made available during suboptimal generating conditions or during peak demand. This requirement has led to greater demand for alternative energy storage facilities to support the grid. Such a fundamental changes in the architecture and controllability of the grid calls for smart, efficient power transmission and distribution networks. These require the storage of energy at appropriate times and locations, both to balance generation with consumption and to maintain grid stability.

## PONDICHERRY UNIVERSITY QUESTIONS

### 2 MARKS

1. Define primary energy sources. **(Nov 2011) (April 2015)**
2. List out the various conventional and non-conventional power plant. **(April/May 2012) (April/May 2014)**
3. What are the Secondary energy Sources? **(April/May 2014)**
4. What are the advantages of renewable energy? **(April/May 2014)**
5. State the world wide status of India in coal energy. **(April/May 2012)**
6. List out the availability of nuclear fuel in India. **(April 2013)**
7. Write the renewable energy sources utilized in India. **(Nov/Dec 2014)**
8. Name any two types of nuclear fuels used as conventional energy sources. **(Nov 2011)**
9. What are the primary energy Sources? (**April 2015)**
10. What are the limitations to the implementation of renewable energy systems? (**April 2015)**
11. List out the renewable energy sources available (**Nov' 2015)**
12. What is the need of energy storage (**Nov'2015)**

### 11 MARKS

1. What are the prospects of renewable energy sources? **(April/May 2014) (April 2013)**
2. Explain about the various conventional energy sources and their availability? **(April/May 2012)**
3. Explain the energy sources and their availability **April 2015**
4. Explain in detail about the availability of oil, hydro, natural gas and coal power. **(Nov 2012) (April 2015) (April 2013)**
5. Explain any three different forms of energy and sources of India **(May 2016)**
6. Explain the present scenario of regional energy production and consumption in India. **(May 2016)**
7. Explain in brief about the energy sources with special reference to Indian content. **(April/ May 2014)(April 2013)**
8. Explain in detail about resources for power generation in India. **(April/May 2014)**
9. Compare various conventional energy sources with renewable resources**.** **Nov 2015**