General Science

Short Answers

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Power Sector in India

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CHAPTER 6: POWER SECTOR IN INDIA

CONTENTS

6.1 INTRODUCTION TO ENERGY IN INDIA

With the electricity supply in Darjeeling in the year 1897, Power development in India commenced which was followed by commissioning of hydropower station at Shivasamudram in Karnataka.

The Ministry of Power is responsible for the development of electrical energy in India, and it is assisted in this endeavours by the Central Electricity Authority (CEA). Central sector power Corporations are entrusted with the construction and operations of generation and transmission projects under Central Sector that are namely; National Thermal Power Corporations(NTPC), National Hydroelectric Power Corporation Limited (NHPC), North-East Electric Power Corporation Limited (NEECL), Power Grid Corporation of India Limited (PGCIL).

PGCIL is responsible for existing and future transmission projects in the central sector and also for the formation of the National Electricity Grid. Satluj Jal Vidyut Limited and Tehri Hydro Development Corporation are responsible for the execution of Nathpa Jhakri power project in Himachal Pradesh and Tehri Hydroelectric Power project in Uttarakhand while three statutory bodies:- Bhakra Beas Management Board (BBMB), BUREAU OF ENERGY EFFICIENCY, and Damodar Valley Corporation (DVC) are also under the administrative control of Ministry of Power.

The Rural Electrification Corporation (REC) is responsible for the development of electrical energy in rural areas while Power Finance Corporation (PFC), provides term finance to projects in the power sector. The autonomous bodies/societies such as the Central Power Research Institute (CPRI) and National Power Training Institute (NPTI) are also under the control of the Ministry of Power.

6.2 ENERGY POLICY OF INDIA

The energy policy of India is governed by the country's increasing energy deficit. Thus INDIA has increased focus on developing alternative sources of energy, particularly nuclear, solar and wind energy. By the year 2018, the primary energy consumption in India grew by 7.9%, and it is the third biggest after China and USA with 5.8% global share. The figures of net primary energy consumption from coal (452.2 Million Tonnes of oil equivalent), crude oil (239.1 million tonnes of oil equivalent), natural gas (49.9million tonnes of oil equivalent),

nuclear energy (8.8 Mtoe), hydroelectricity (31.6 Mtoe) and renewable power (27.5 Mtoe) is 809.2 Mtoe (excluding traditional biomass use) in the calendar year 2018.

In 2018, the net imports from India were nearly 205.3 million tons of crude oil and its products, 26.3 Mtoe of LNG and 141.7 Mtoe coal totalling to 373.3 Mtoe of primary energy which is equal to 46.13% of total primary energy consumption. By 2030, India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. However, still, India is largely dependent on fossil fuel imports to meet its energy demands as around 80% of India's electricity generation is from fossil fuels. India has a surplus electricity generation capacity and thus is also a marginal exporter of electricity, as recorded in 2017. Since the end of the calendar year 2015, huge power generation capacity has been idling for want of electricity demand. With a production of around 210 Mtoe, India ranks second after China in renewables production.

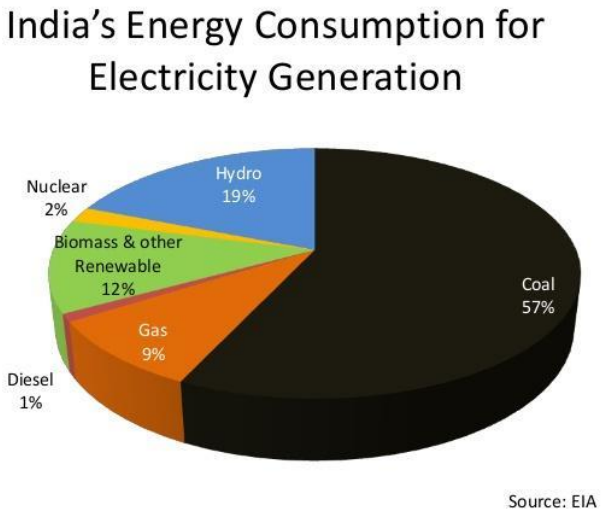


Fig 6.1: India's Energy Use By Sectors

(IMAGE SOURCE: Rockwell industry ltd)

Due to rapid expansion of the energy market and growing demands India is expected to be one of the largest consumers of Energy by the year 2035 accounting for 18% of the rise in global energy consumption. Due to rise in the energy demand in India and Limited availability of fossil fuel resources India endeavours to ramp up its **Non-conventional energy** sources in order to meet energy demand of the country primarily from

- **Solar Energy**: 31 gigawatt (approx.)
- **Wind power**

- **Nuclear power:** India also tries to increase share of Nuclear power to 9% in total in the next 25 years

India has 5 nuclear reactors under construction in the world, the highest in the world while it plans to build additional 25 nuclear reactors.

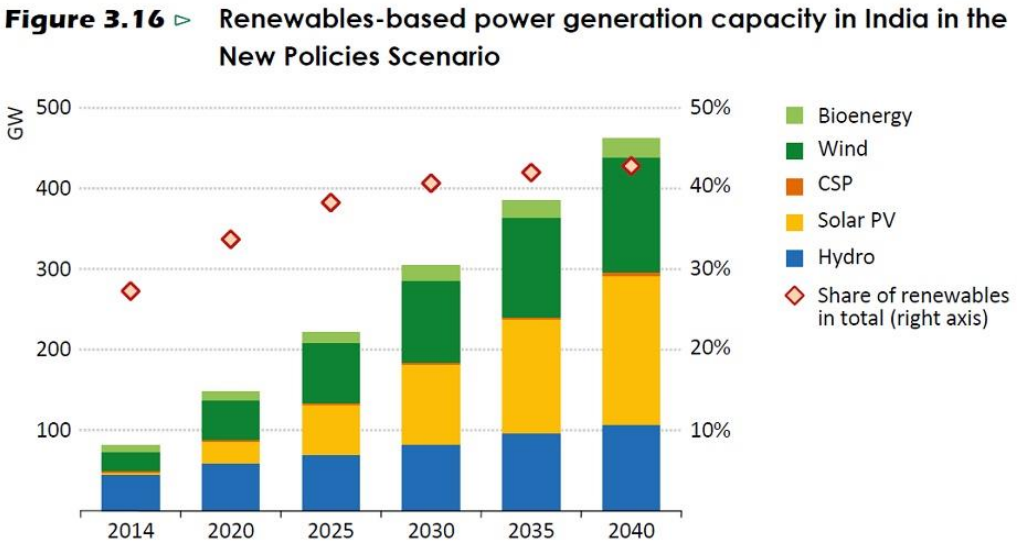


Fig: 6.2 Projected Renewable Energy sector Scenario

(Image source:IEA)

6.3 CLASSIFICATION OF ENERGY SOURCES

Energy Resources are classified as all forms of fuels that can be used for developmental purposes in the modern world, either for heating, generation of electricity or for other forms of energy conversion processes. Energy resources can be roughly classified into three categories: **Renewable, Non-Renewable, and nuclear**.

The energy resources which are obtained from dead plant and animal deposits created over the long history of the planet are called FOSSIL ENERGY SOURCES. These resources are vast, but limited, and are not renewable.

Non-conventional or renewable energy are forms of energy that are naturally replenished on our planet. Hydropower and biomass (e.g., plant fuels such as wood traditionally have been used throughout history, mostly for heating) are some Examples of traditional renewable resources. While examples of Modern renewable resources include wind, wave, tidal, solar, and geothermal. Some forms of fuels created from biomass (plants and animals) also fall under this category.

Nuclear energy resources are used as fuel for nuclear fission-based power plants. The amount of these rare radioactive elements is limited on our planet and cannot be replenished.

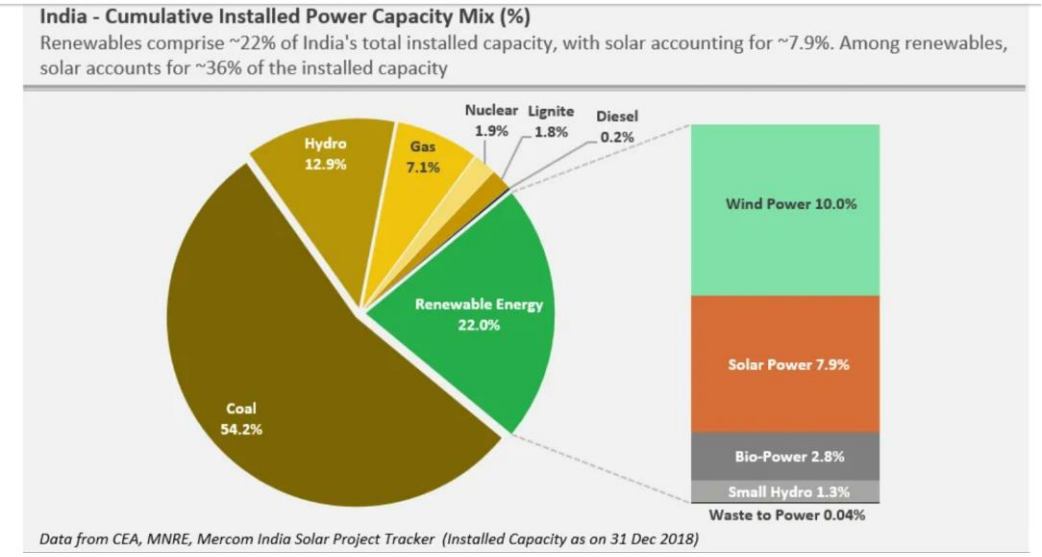


Fig:6.3 Total Installed Capacity (India)

(Image source: CEA)

6.4 INSTITUTIONS AND PROJECTS

1. Central Electricity Authority (CEA)

This organization was originally constituted under Section 3(1) of the Electricity (Supply) Act, 1948, which has been repealed and since substituted by Section 70 of the Electricity Act, 2003. It was established as a part-time body in 1951 and made a full-time body in 1975. The functions, responsibilities and duties of CEA are delineated in Section 73 of the Electricity Act, 2003.

The CEA advises the government on policy matters and formulates plans and reports for the development of electricity systems, projects, and other schemes related to the power sector. CEA prescribes the standards on matters such as the construction of electrical plants, electric lines and connectivity to the grid, installation and operation of meters and safety and grid standards under the Electricity Act 2003. This organization is also responsible for the concurrence of hydropower development schemes of central, state and private sectors and takes into consideration the factors which determine efficient development of the river and its tributaries for power generation, consistent with the requirement of drinking water, irrigation, navigation and flood control.

2. Ultra Mega Power Projects

The Ministry of Power, Government of India has taken steps to set up 9 ULTRA MEGA POWER PROJECT, each of 4000 Megawatt capacity in different states these projects are an initiative of Central electricity authority in Association with Power Finance Limited.

The first UMPP, developed by Tata Power in Gujarat (Mundra) has been commissioned and contributes 4,000 MW in power to the Western grid.

Sasan UMPP	Coal pithead (3600 MW)
Krishnapatnam UMPP	Coastal (4000 MW)
Mundra UMPP	Coastal (4000 MW)
Jharkhand UMPP	Coal pithead (4000 MW)

3. National Thermal Power Corporation (NTPC)

It is India's largest energy conglomerate and has a history dating way back in 1975 to accelerate power development in India. Since then it has established itself as the dominant power major with presence in the entire value chain of the power generation business. it has forayed into generating electricity via hydro, nuclear and renewable energy sources, beginning initially from fossil fuels. This development will play a major role in lowering its carbon footprint by reducing harmful greenhouse gas emissions.

In May 2010 NTPC became a Maharatna company, one of the only four companies to be awarded this status. It is ranked No. 2 Independent Power Producer (IPP) in Platts Top 250 Global Energy Company Rankings.

The total installed capacity of NTPC stands at 62,110 MW (including JVs) own stations including 24 coal-based, 7 gas-based, 1 Hydro 1 Wind 11 Solar and 1 Small hydro plant. Under JV, NTPC has 9 coal-based, 4 gas based and 12 renewable energy projects. The capacity will have a diversified fuel mix and it is projected that by 2032, non-fossil fuel-based generation capacity shall make up nearly 30% of NTPC's portfolio.

In 2019, NTPC was recognized as "Laureate" for consistently ranking among "Top 50 Best Companies to Work for in India" for the last 11 years in the Great Place to Work and Economic Times survey. Besides, NTPC was also recognized as the best among PSUs and in Manufacturing.

6.5 NATIONAL HYDROELECTRIC POWER CORPORATION LIMITED (NHPC)

The NHPC (formerly known as National Hydroelectric Power Corp.) was incorporated on 7th November 1975 as Central Govt. Enterprise for development of Hydro Power in the Central Sector. Since it's inception the NHPC has become the largest central utility for hydropower development in India. It is mandated to plan, promote and organize an integrated and efficient development of power in all aspects deploying Conventional and Non-Conventional Sources in India as well as abroad.it is a Schedule 'A' Enterprise of Govt. of India and has been granted Miniratna status since 2008. It has an authorized share capital of Rs.15,000 crores.

To begin with, NHPC was assigned three most difficult and almost abandoned projects i.e. 180 MW Baira Siul in HP, 105 MW Loktak in Manipur and 345 MW Salal-I in J&K (now Union Territory of Jammu & Kashmir) from the erstwhile Central Hydroelectric Project Control Board. With the commissioning of Baira Siul in 1981, Loktak in 1983 and Salal-I in 1987, NHPC established its strong position in the hydropower sector of the country. Along the journey of over 44 years, NHPC's total installed capacity has reached 7071.2 MW from 24 projects including JV, Solar and Wind. During the financial year 2019-2020, NHPC Power Stations achieved the generation of 26121 MU.

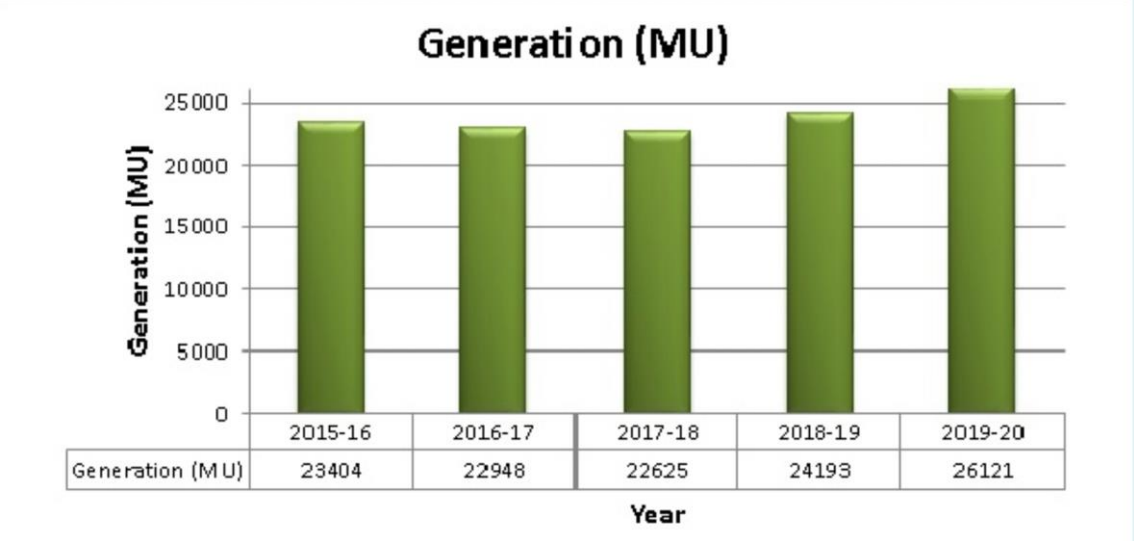


Fig 6.4 Power Generation from NHPC

(Image source: NHPC)

Presently NHPC is engaged in the construction of 6 projects aggregating to a total installed capacity of 4934 MW including 500 MW (Teesta-IV HE Project), 1000 MW (Pakal Dul HE Project) & 624 MW (Kiru HE Project) being executed through Subsidiary/ JV Company and 10 MW Floating Solar power Project in Kerala. Besides, 13 projects with an aggregate

capacity of 8211 MW are under clearance stage which includes 7 Schemes of NHPC own, 4 in JV mode, 1 Wind Project & 1 Solar Project. Further, 2 projects with an aggregate capacity of 1079 MW are in the S&I stage.

1. Rural Electrification Corporation (REC)

Rural Electrification Corporation is a public Infrastructure Finance Company involved in India's power sector. It is a Public Sector enterprise engaged in financing and promotion of electrification projects across Rural India. It provides finances and loans to Central/ State Power Utilities in the country, Electricity Boards, Rural Electrification Cooperatives, NGOs and Private Power Developers.

In the year 2018, the Cabinet Committee of Economic Affairs gave its approval for the sale of 52.63% REC to the state-owned Power Finance Corporation Limited. While it was announced in March 2020 by the PFC that it intends to merge REC with itself.

2. Power Grid Corporation of India Limited (PGCIL)

PGCIL is an Indian state-owned electric utility company that is headquartered in Gurugram, India. About 50% of the total power generated in India on its transmission network is done by POWERGRID.

It is

- A "Maharatna" Central Public Sector Enterprise.
- Central Transmission Utility (CTU) of India
- India's largest Electric Power Transmission Utility
- Listed Company since 2007
- Consistently rated "Excellent" under Memorandum of Understanding with Ministry of Power since 1993-94

3. National Grid and One Nation-One Grid

The Indian Power system is divided into five regional grids for planning and operational purposes. The integration of regional grids, and thereby establishment of National Grid, was conceptualized in the early nineties. The integration of regional grids which began with asynchronous HVDC back-to-back inter-regional links facilitating the limited exchange of regulated power was subsequently graduated to high capacity synchronous links between the regions.

In the beginning, the inter-regional links were planned for the exchange of operational surpluses amongst the regions. But, later on, when the planning philosophy had graduated from Regional self-sufficiency to a National basis, the Inter-regional links were planned associated with the generation projects that had beneficiaries across the regional boundaries.

It is estimated that the country has a total inter-regional transmission capacity of about 75,050 MW, up till the end of the 12th Plan, which is expected to be enhanced to about 1,18,050 MW at the end of XIII plan.

Synchronization of all regional grids into one national grid will help in the optimal utilization of scarce natural resources by transfer of Power from Resource centric regions to Load centric regions. Moreover, this will facilitate the establishment of a vibrant Electricity market facilitating trading of power across regions. **One Nation One Grid shall connect all the regional grids and there will be one national frequency with asynchronous character.**

Grid management on a regional basis started in the sixties.

- Initially, State grids were interconnected to form regional grids, and India was demarcated into 5 regions namely Northern, Eastern, Western, North Eastern and Southern regions.
- In October 1991 North Eastern and Eastern grids were connected.
- In March 2003 WR and ER-NER were interconnected.
- August 2006 North and East grids were interconnected thereby 4 regional grids Northern, Eastern, Western and North Eastern grids are synchronously connected forming a central grid operating at one frequency.
- **On 31st December 2013, Southern Region was connected to Central Grid in Synchronous mode with the commissioning of 765kV Raichur-Solapur Transmission line thereby achieving 'ONE NATION'-'ONE GRID'-'ONE FREQUENCY'.**

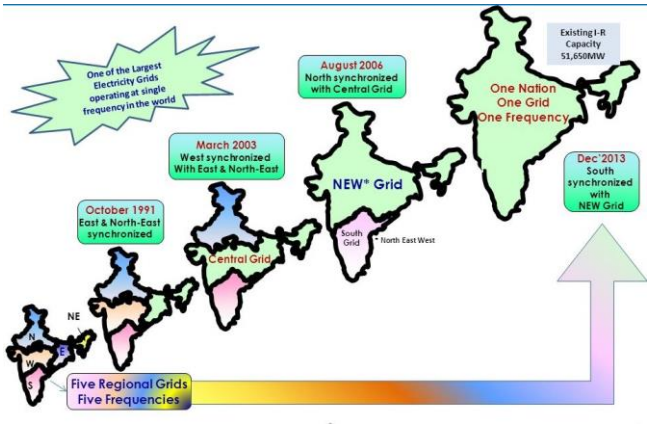


Fig 6.5 One Nation-One Grid

(image source:cevgroup.org)

4. Power Finance Corporation

Incorporated on July 16th, 1986, Power Finance Corporation Ltd. is a Schedule-A Navratna CPSE, and is a leading Non-Banking Financial Corporation in the Country. PFC's registered office is located at New Delhi and regional offices are located at Mumbai and Chennai.PFC is under the administrative control of the Ministry of Power. PFC has conferred the title of a 'Navratna CPSE' in June 2007 and was classified as an Infrastructure Finance Company by the RBI on 28th July 2010.

PFC is the 8th highest profit-making CPSE as per the Department of Public Enterprises Survey for FY 2017-18. PFC is India's largest NBFC and also India's largest Infrastructure Finance Company.

5. Central Power Research Institute (CPRI)

Central Power Research Institute (CPRI) is the powerhouse of the Indian electrical industry. Set up in 1960 by the Government of India, it functions as a center for applied research in electrical power engineering assisting the electrical industry in product development and quality assurance. CPRI also serves as an independent authority for testing and certification of power equipment. CPRI's governing body includes eminent professionals from industries & utilities, prestigious academic and research institutions & the government. It employs over 300 highly qualified and experienced engineers & scientists besides other supporting staff. With its state-of-the-art infrastructure and expertise, CPRI has made significant contributions to the power sector in the country for improved planning, operation and control of power systems. Besides in-house R&D, CPRI also undertakes sponsored research projects from manufacturers and other agencies in different areas of specialization.

6. North East Electric Power Corporation Limited (NEEPCO)

(NEEPCO is a schedule-A 'MINI RATNA' Category-1 and is a central public sector enterprise that is owned by the Government under the MINISTRY OF POWER. The NEEPCO was formed on 2nd April 1976 to plan, investigate, design, construct, generate, operate and maintain power stations in the Northeast East region of the country.

National Thermal Power Corporation Limited overtook the NEEPCO in the year 2019 and now works as its Subsidiary.

7. Bureau of Energy Efficiency (BEE)

The Bureau of Energy Efficiency (BEE) was set up on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. Its mission is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing the energy intensity of the Indian economy.

Role of BEE

BUREAU OF ENERGY EFFICIENCY coordinates with designated consumers, designated agencies and other organizations and recognizes, identifies and utilizes the existing resources and infrastructure, in performing the functions assigned to it under the Energy Conservation Act. BEE has been provided regulatory and promotional functions under the act.

The Major Functions of BEE include

- Creating awareness and dissemination of information on energy efficiency and conservation
- Arranging and organizing training of personnel and specialists in the techniques, to sensitize them on efficient use of energy and its conservation
- Strengthening consultancy services in the field of energy conservation
- To Develop testing and certification procedures and promote testing facilities
- Formulate and facilitate the implementation of pilot projects and demonstration projects
- Promote the use of energy-efficient processes, equipment, devices and systems
- BEE seeks to promote innovative financing of energy efficiency projects
- It provides monetary assistance to institutions for promoting the efficient use of energy and its conservation.
- Preparing educational curriculum on efficient use of energy and its conservation
- Implement international co-operation programs relating to the efficient use of energy and its conservation.

6.6 CONVENTIONAL ENERGY SOURCES (PRODUCTION AND CONSERVATION)

1. Petroleum and Natural Gas

The Ministry of petroleum and natural gas is entrusted with the responsibility of exploration and production of oil and natural gas as well as the import of LNG. It is also involved in refining, production, marketing, distribution, import and export of petroleum products. India is a member of the International Energy Forum which is a platform for dialogue between petroleum producing and consuming countries. It's headquartered in Riyadh, Saudi Arabia.

Petrol Consumption Growth since FY10

Financial Year	Petrol Consumption (000) tonne	Growth (%)
FY10	128,18	--
FY11	141,92	10.71
FY12	149,93	5.64
FY13	157,44	5
FY14	171,28	8.79
FY15	190,75	11.36
FY16	218,47	14.53
FY17	237,65	8.77
FY18	261,74	10.13
FY19	282,84	8.06

Source: PPAC

Petroleum Consumption

Financial Year	Total Gas Production	Change (%)	Offshore Production	Onshore Production
2011-2012	47.55	(8.92)	38.47	9
2012-2013	40.67	(14.46)	31.80	8.87
2013-2014	35.40	(13)	26.39	9.01
2014-2015	33.65	(5)	24.86	8.79
2015-2016	32.24	(4.19)	23.01	9.23
2016-2017	31.89	(1.08)	22.03	9.85
2017-2018	32.64	2.35	22.01	10.63
2018-2019	32.87	0.62	22.11	10.75

All Figures in Billion Cubic Meter (BCM)

Source: Ministry of Petroleum and Natural Gas (MoPNG)

6.7 GAS PRODUCTION IN INDIA

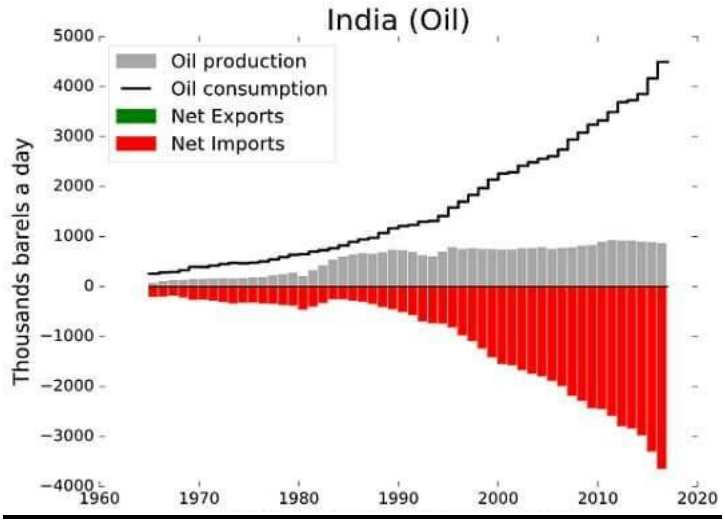


Fig. 6.6 Oil production and consumption over the years

Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL) as well as private and joint venture companies are involved in exploration and production of Oil and Natural Gas in the country.

Oil and Natural Gas Corporation Limited (ONGC)

ONGC is an Indian Crude Oil Gas Corporation involved at national and multinational level. The registered office of ONGC is in New Delhi. It is a state-owned enterprise under the administrative control of the Ministry Of Petroleum and Natural Gas. ONGC is the largest Oil and Gas exploration and production company in the country which produces around 70% of India's Crude oil resources (around 57% of the country's total demand) and upto 84% of its Natural Gas resources. ONGC was given the Maharatna status by the Government In November 2010.

ONGC Videsh Limited is The international Subsidiary of ONGC .ONGC Videsh Limited participates in various exploration and production projects abroad, and currently has projects in 17 countries, which makes it one of the largest multinational Corporation of the world.

6.8 CONVENTIONAL MINERAL RESOURCES OF INDIA

Coal

Coal is the main source of energy in India and accounts for around 2/3rd of the country's requirements for commercial purposes. There are four varieties of coal found in India that is: Anthracite, Bituminous, Lignite and Peat.

Note: Gondwana coal makes up around 98 per cent of the total reserves and 99 per cent of the production of coal in India While lignite comes under the category of Tertiary coal.

Coal is the base of 70% power generation in the country. Indian coal has high ash content and low Sulphur content. India has one of the largest coal reserves, but we are importing large coal for billion dollars because we choose a monopoly that is incapable of domestic demand. To overcome this, we went for captive mining, but this will have a big impact on Coal India and the state which has coal Reserves.

India's Coal Production was reported at 308.044 TOE mn in Dec 2018. This records an increase from the previous number of 286.556 TOE mn for Dec 2017. India's Coal Production data is updated yearly, averaging 149.832 TOE mn from Dec 1981 to 2018.

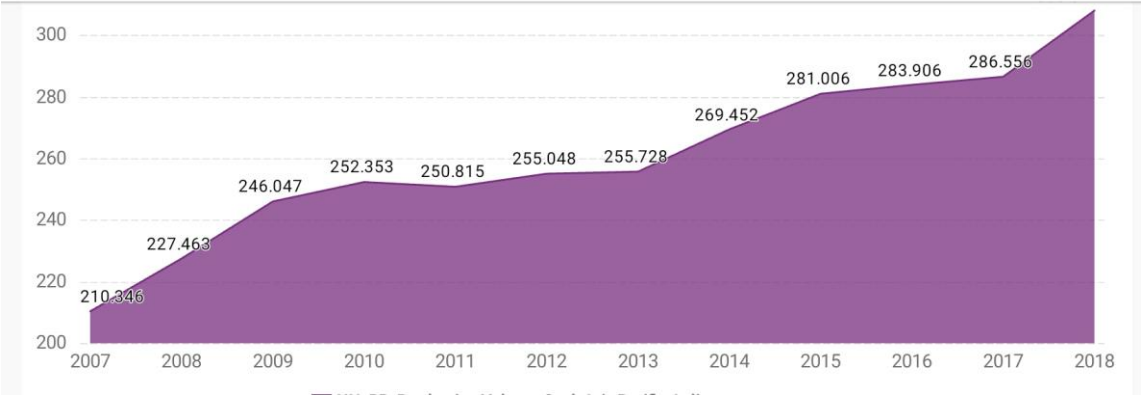


Fig: 6.7 Coal Production over the years

(Image source: CEIC)

Uranium

Uranium is one of the heavy metals that can be utilized as a rich source of concentrated energy. The element exists in many rocks in the concentration of 2 to 4 ppm (parts per

million) and common in Earth's crust as tungsten and tin. It also exists in seawater and can be retrieved from the oceans.

Uranium was formed over 6.6 billion years ago. Though it is not common in the solar system, its slow radioactive decay provides a major source of heat within the Earth, responsible for continental and convection drift. Uranium's high density means it also has applications in the counterweights of aircraft control surfaces and radiation shielding. It is one of the heaviest among all the naturally occurring elements when arranged based on the increasing mass of their nuclei on a scale. The element is 18.7 times denser than water.

Uranium exists in various slightly different forms known as 'isotopes.' These isotopes are distinct in the number of uncharged particles in the nucleus. Natural uranium was found as a mixture of two isotopes. U-238 accounts for 99.3% and U-235 around 0.7%.Pure uranium is silver in colour and readily oxidizes in air.

It is also used to colour glass that glows greenish-yellow in black light, not due to radioactivity because the glass itself is a bit radioactive. The fluorescence is because of the UV light that excites the uranyl compound in the glass and makes it let off photons when it settles down.

Note: India has no significant reserves of uranium. All needs are met through imports. India imports thousands of tonnes of uranium from Russia, Kazakhstan, France.

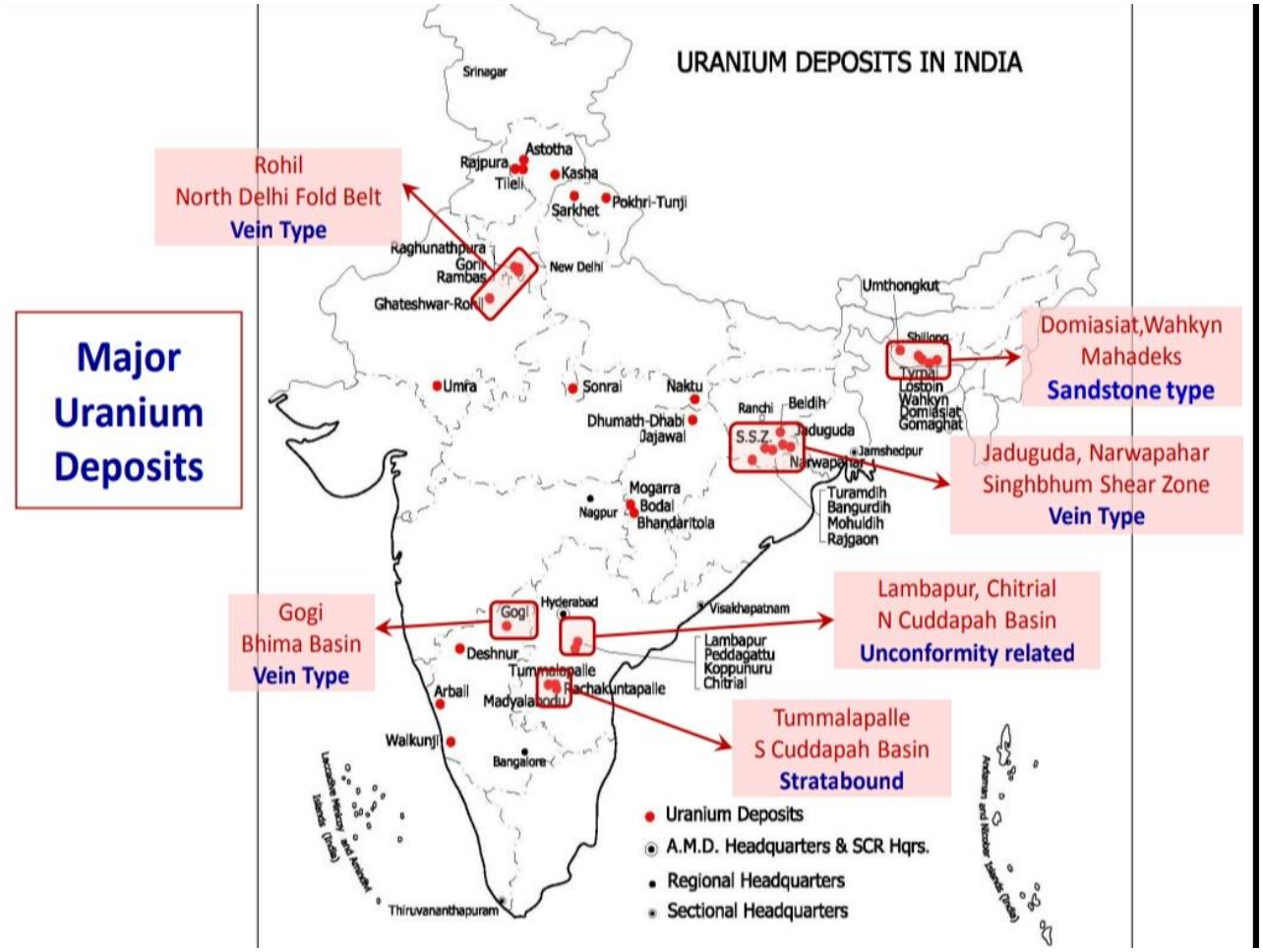


Fig 6.8 Uranium Deposits in India

(Image source: Mines. gov.in)

Thorium

India has the World's Largest Thorium Reserves and has modest uranium reserves. Thorium, despite its greater abundance in nature and a number of superior characteristics, lags behind use of uranium as it does not have any fissile content. The fertile thorium-232 has to be converted into uranium-233 first for use in a nuclear reactor. **Considering the country's vast thorium resources, the long-term nuclear energy policy of India has been focused on utilization of thorium early on.** A three-stage nuclear power program was drafted already in the 1950's.

The known reserves of thorium in India are estimated to be between 457,000 and 508,000 tonnes and mostly located along the **Eastern Coastal Belt**. Kerala, Jharkhand, Bihar, Tamil Nadu and Rajasthan are the main producers.

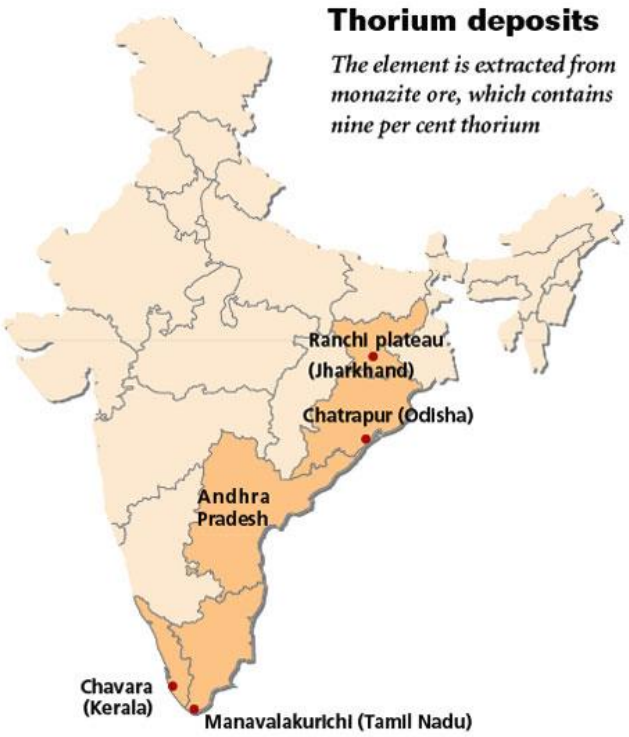


Fig 6.9 Thorium Deposits

(*image source:researchgate)*

Monazite

It is a reddish-brown phosphate mineral that contains rare-earth elements. Due to variability in composition, monazite is considered a group of minerals.Monazite is an important ore for thorium, lanthanum, and cerium. It is often found in place deposits everywhere. Three countries **INDIA MADAGASCAR**, and **SOUTH AFRICA** have large deposits of monazite sands. India has a large number of deposits of MONAZITE.

Atomic Minerals Directorate for Exploration and Research (AMD), under the Department of Atomic Energy (DAE) has estimated the potential of around 11.93 million tonnes of monazite resources in the beach sand mineral placer deposits along the coastal region of India. It is projected that Monazite contains about 55 – 60% total Rare Earth Oxide. The state-wise resources of in situ monazite established by AMD so far are as follows:

State	Monazite (Million tonne)
Odisha	2.41
Andhra Pradesh	3.72
Tamil Nadu	2.46
Kerala	1.90
West Bengal	1.22
Jharkhand	0.22
Total	**11.93**

Fig 6.10 State wise Monazite Deposits

(Source:MINISTRY OF MINES)

It has been found that the quantity of xenotime resources, another rare-earth bearing mineral, are negligible in India. AMD has established about 2000 tonnes of xenotime-bearing heavy mineral concentrate containing 2% xenotime in the riverine heavy mineral placer deposits of Chhattisgarh and Jharkhand.

Monazite is a mineral mainly containing rare earths and thorium-a prescribed substance to be handled by the Department of Atomic Energy (DAE). Accordingly, Indian Rare Earths Ltd. (IREL) which is under the administrative control of the Dept. of Atomic Energy (DAE) and wholly owned subsidiary of GOVERNMENT, utilises monazite mainly for production of rare earth compounds, and thorium, as needed in the Department of Atomic Energy.

6.9 RARE EARTH MINERAL

As defined by IUPAC, rare earth minerals are a set of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides, as well as scandium and yttrium. Scandium and yttrium are considered rare earth elements because they tend to occur in the same ore deposits as the lanthanides and exhibit similar chemical properties. They are not especially rare, but they tend to occur together in nature and are difficult to separate from one another.

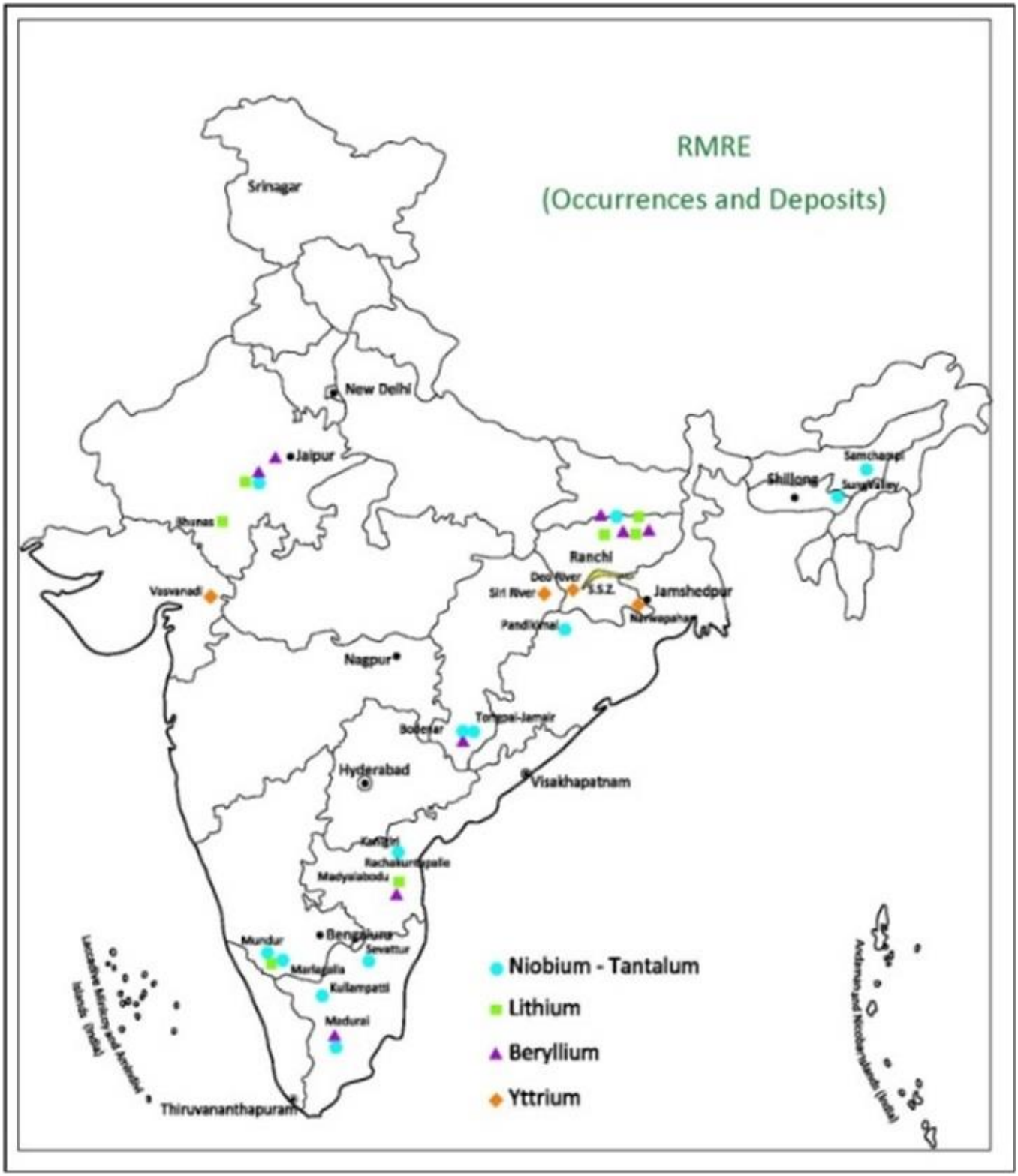


Fig 6.11: Rare earth minerals deposits (India)

(Image source: Atomic Energy Directorate)

India has the third-largest reserves of rare earth minerals in the world. Indian Rare Earths Ltd under the Department of Atomic Energy is the sole producer of rare earth compounds.

Globally, China has a monopoly over rare earths, after USA's recede in this industry due to serious environmental and health concerns. China had once almost shivered the Japanese economy by halting the export of rare earth elements. India is also blessed with some crucial rare earth minerals like zirconium, neodymium etc., available in plenty in monazite sands. This could contribute to Indian export markets if utilized properly.

However, Owing to various reasons such as cost reduction due to high production (economies of scale) in China, lack of demand in the domestic market, lack of domestic processing technologies, the production of rare earth minerals has depleted over the years. Most of the products that use rare earth minerals as raw materials are imported. Despite rare earth minerals having high value add the potential for export growth, inadequate processing technologies have made India suffer.

Rare earth minerals are very crucial for India to reduce the energy burden. It is an important component in the manufacture of hybrid vehicles, fuel cells and LEDs.

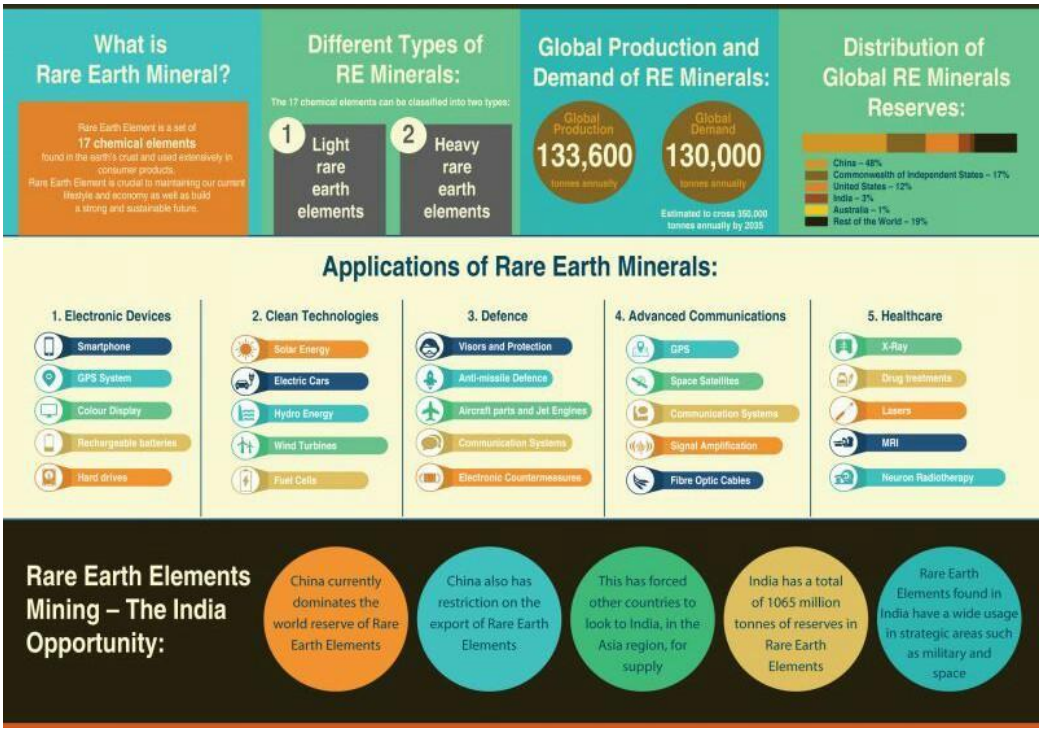


Fig: 6.12 Rare Earth Minerals

(Image source: Deccan Chronicle)

6.10 RENEWABLE ENERGY (NON CONVENTIONAL ENERGY SOURCES)

India is blessed with plenty of responsible energy sources like solar wind hydro and Biomass the importance of renewable energy was recognised in the country as early as 1970 the

ministry of non conventional energy sources is the nodal Ministry of the government for all matters relating to new and renewable energy systems and devices marketing outlets namely **Akshay Urja shops** have been set up in a number of major cities and towns with a view to promote sales servicing and repair of these systems and devices Prime Minister of India release the national Action Plan on climate change(NAPCC) in 2008 which proposes to start 8 missions which are as follows :

Fig 6.13 Missions Under NAPCC

(Image source: http://ndias-national-action-plan-on-climate.html?m=1)

Subsequently many States had also formulated their own State Action Plan on climate change. According to a report in 2016 by REN21, the global energy consumption by the use of renewable energy resources contributed to 19.2% in 2014 and 23.7% in 2015. Many countries have started to invest in these renewable energy resources as these resources will

help in maintaining a sustainable development. The amount of investment in 2015 was about 286 billion dollars and major sectors were biofuel, solar power, wind, and hydroelectricity.

The existence of renewable energy resources is spread over a wide geographical area in comparison to the conventional energy resources which are often concentrated to a limited number of countries like oil and gas are mostly concentrated in the Middle East countries. The use of renewable energy resources in energy generation is resulting in less pollution and has a significant effect on economic benefits and energy security.

We can define renewable energy as those energies which can never be depleted. The importance of renewable energy is invaluable. These types of energy sources are different from fossil fuels, such as oil, coal, and natural gas. Some examples of renewable energy sources are:

- **Wind energy**
- **Solar energy**
- **Geothermal energy**
- **Hydropower**
- **Biomass energy**
- **Tidal Energy**
- **Hydrogen and Fuel cells**

The sources could sustain for a longer period of time and can easily be renewed often. Sustainable sources are biomass, nuclear power, geothermal, wind energy, solar power, tidal power, and wave power. The sources of renewable energy are known to be less polluting and therefore the whole world is looking forward to new carbon emission norms, where carbon will play a major role in developing new factories and industries. They will be rated according to the carbon emission and the products that they are producing will be rated accordingly.

India has outlined its Intended Nationally Determined Contributions as per the Paris Accord on Climate Change, and made a pledge that by 2030, around **40% of its installed power generation capacity shall be from non-fossil fuel sources and also by 2030, reduce emission intensity of GDP by 33-35 % from 2005 level**. Economic growth, increasing prosperity, a growing rate of urbanisation and rising per capita energy consumption has increased the energy demand of the country.

Keeping in view the above and our commitment for a healthy planet with less carbon intensive economy, we decided in 2015 that **175 GW of renewable energy capacity will be installed by the year 2022. This includes 100 GW from solar, 60 GW from wind, 10 GW from biomass and 5 GW from small hydro power**. The substantial higher capacity target will ensure greater energy security, improved energy access and enhanced employment opportunities, India will become one of the largest Green Energy producers in the world. With the accomplishment of these ambitious targets, and would even surpass several developed countries.

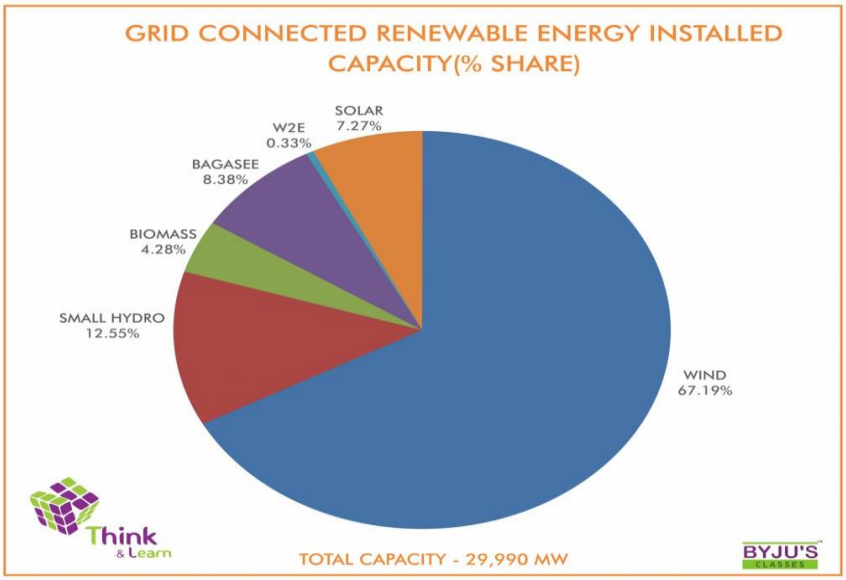


Fig 6.14 Installed Capacity of Renewables

(Image source: Byjus)

The Prime Minister in his address atto Climate Action Summit stated that "India's renewable energy capacity would be increased to much beyond 175 GW, and later till 450 GW".In line with the objective of expanding renewable energy sector, several important initiatives were taken during year 2019.

6.11 SOLAR ENERGY

The radiant light and heat energy from the sun is harnessed with the use of solar collectors. These solar collectors are of various types such as the photovoltaics, concentrator photovoltaics, Solar heating (CSP) concentrated solar power, artificial photosynthesis, and solar architecture. This collected solar energy is then used to provide light, heat and different other forms of electricity. India, is a tropical country, thus It experiences about 300 sunny days in a year (approximately).

The total solar energy received by India in a year = 5000 trillion kilowatt-hours (kWh)- that is equal to 4-7 kWh per square meter per day. According to the **Ministry of New and Renewable Energy**,India has a potential of generating more than 750 GW of solar power (close to 68 % of its renewable energy potential).

The technology that is generally utilised for Solar Energy generation are:

Solar Thermal Technology(Solar Thermal Energy Programme)	Solar Photovoltaics
These technologies utilise sunlight reflectors and concentrators in order to either convert the solar heat into electricity or use the heat energy for domestic and commercial heating purposes. Water is turned into steam by the solar heat, which can be used to run the turbines, producing alternating current (AC) power.	Photovoltaic cells (PV) convert the incident sunlight into electricity which is called the photoelectric effect. The Solar Photovoltaics cells are made of semiconducting materials like silicon, cadmium telluride,carbon-rich polymers etc. Among these, silicon-based and cadmium telluride based cells are the most used as PV cells. These cells convert solar energy into direct current (DC)

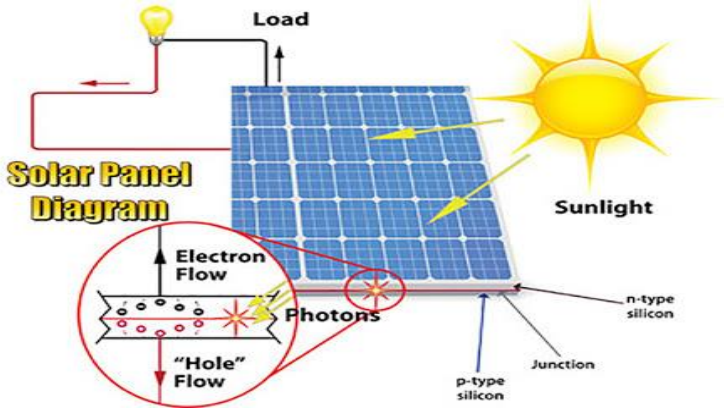


Fig 6.15 Solar Panel

(Image source: byjus.com)

The Government of India has set a national target of installing 1,00,000 MW grid connected solar power capacity in the country by December, 2022. As on 31.10.2019, a total grid connected solar power generation capacity of 31,696 MW has been set up in the Country, projects of 17998 MW capacity are at various stages of installations and tenders for 36278 MW capacity projects have been issued. With new tenders of around 15000 MW planned in the remaining period of 2019-20 and 2020-21, we are on course for achieving the target.

The Union Government has been implementing the National Solar Mission under which various Schemes have been launched for promoting the generation and use of solar power in

the country. This apart, the Ministry of New and Renewable Energy makes publicity for effective implementation of all schemes including Solar Schemes through print, social, electronic and other media. The Ministry has also launched a Mobile App for solar rooftop systems.

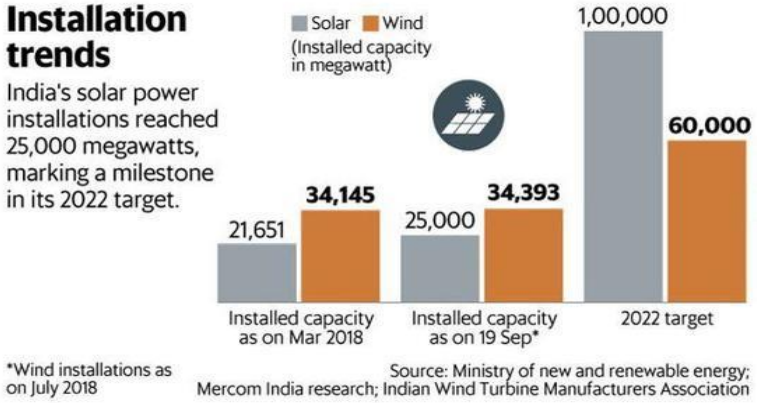


Fig: 6.16 Installed Solar Capacity

(Image source: Mercom india and MNRE)

National Solar Mission
Initially in India, the focus on solar technologies was bordered on the social and rural segment. Some institutes like IIT, National Physical Laboratory focused on developing solar, thermal and photovoltaic (PV) technologies. PV technology was being promoted extensively to meet the challenge of providing electricity for rural telecom networks, village electrification and electrification of the unmanned railway crossing. Jawaharlal Nehru National Solar Mission is also known as the National Solar Mission. The mission was launched in Jan 2010 by the Government. **The Target for National Solar Mission:** ● It had set a target of 20,000 MW of grid-connected solar power by 2022. It was revised in June 2015 to 1,00,000 MW by 2022. ● The 100 GW solar power capacity has been divided into: ○ Rooftop solar electricity generation – 40 GW ○ Large and Medium Scale grid-connected solar projects – 60 GW **Funding**: ● The total cost for up-gradation to 100 GW solar power capacity would be $ 94 Billion. ● The Central Government is also planning to leverage bilateral and international donors, including green climate funds under the United Nations Framework Convention on Climate Change (UNFCCC). ● Using the bundling mechanism with thermal power. ● Investments would come from large Public Sector undertakings. ● Funds would be generated from Independent Power Producers. ● The Government of India is providing Rs 15,050 crore as capital subsidy to promote solar capacity addition. ● This capital subsidy is for rooftop solar projects in various cities and towns, for

viability gap funding based projects to be developed through the Solar Energy Corporation of India (SECI) and for decentralised generation through smaller projects.

The mission is made up of 3 phases:

- Phase 1 – 2012 – 13
- Phase 2 – 2013 – 17
- Phase 3 – 2017 – 22

Targets are given Below:

- Install 1,00,000 MW of solar power by 2022.
- 40 GW rooftop and 60 GW through large and medium scale grid-connected solar power projects.
- To achieve 15 million sq metres of solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022.

Implementation model:

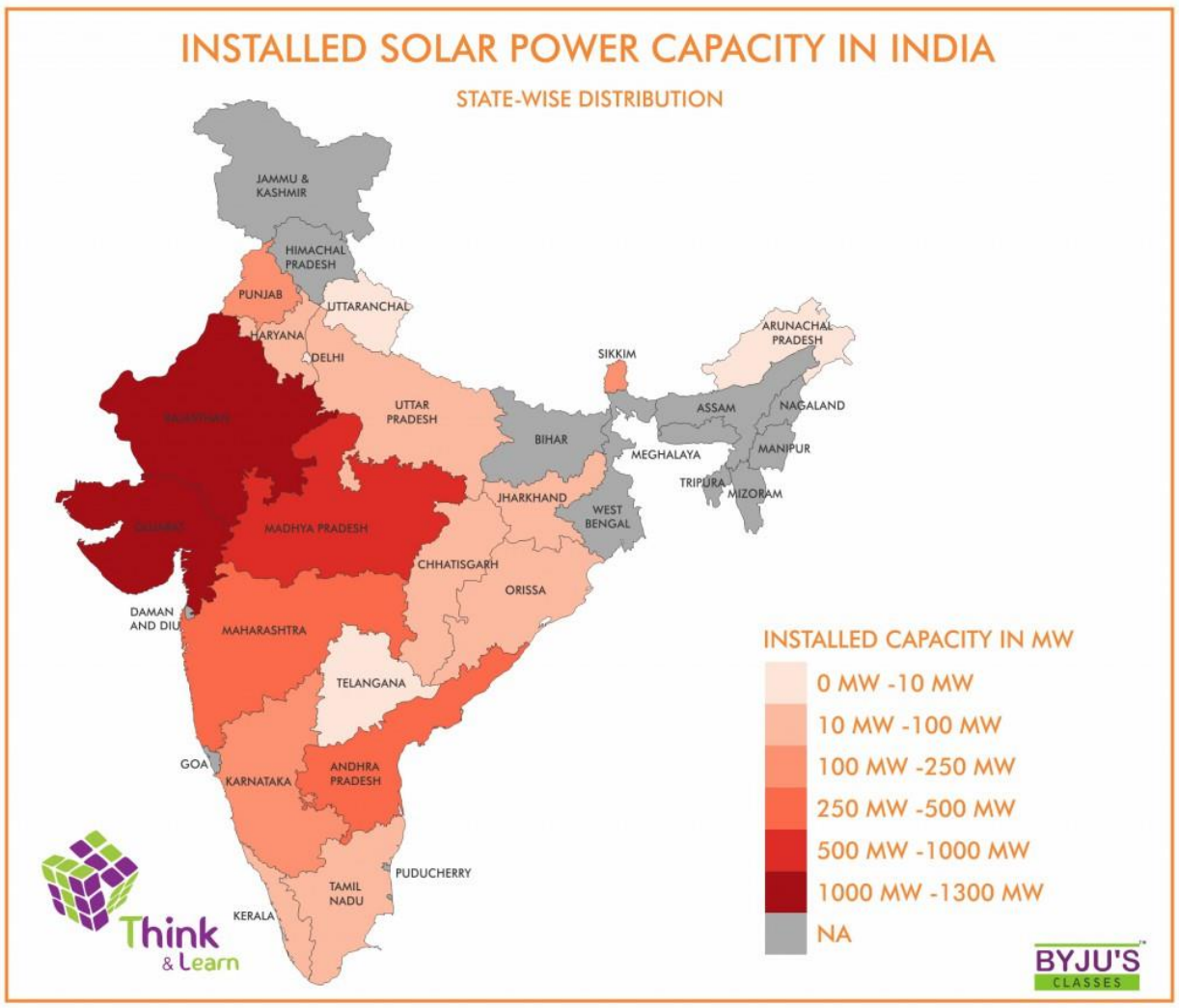
- Bundling scheme
- Generation Based Incentive (GBI) Scheme
- Viability Gap funding scheme

The mission also aims to reduce the cost of Solar Power Generation in the country through

- Long term policy
- Large Scale deployment goals
- Aggressive R&D
- Domestic production of critical raw materials, components and products, as a result, to achieve grid tariff by 2022.

Achievements of the National Solar Mission:

- To reduce the risks of solar power producers, Solar Energy Corporation of India (SECI) was established as a major procurement agency.
- Creation of larger projects to bring down capital investments in solar power generation projects through the development of integrated solar parks so as to provide infrastructure for solar power plants.
- Renewable energy corridor was also launched to develop a dedicated transmission grid for areas with an abundance of sunlight or wind to create solar and wind energy.
- Solar radiation monitoring stations were set up across India.



Major Positive Developments since 2014

The new Government as per its ambition to provide electricity for all, the target was revised for establishing grid-connected solar power was revised from 20 GW to 100 GW under the NSM.

The huge quantum jump in targets generated huge demands for solar energy projects and equipment.

100 GW is divided into two major segments –

a) 60 GW of grid-connected ground-mounted large solar power plants, typically above 1 MW capacity.

b) 40 GW of rooftop solar power plants for generation of electricity.

The emphasis is on roping in Central and State Public Sector companies, defence establishments and others who started establishing projects on their unutilized land. The problem of limited land availability can be avoided using innovative ideas such as floating solar power plants, solar power plants over canals, and use of barren land for solar power plants are being promoted. Revised targets for Renewable Purchase Obligations (RPO), to ease

the purchase of solar power, net metering, interstate power purchase by bulk consumers such as Delhi Metro. Focus on skill development and indigenous manufacturing through the establishment of Skill council for green jobs.

Advantages of Solar Energy:

Advantages of solar energy are:

1. **Clean**: It is considered to be the cleanest form of energy as there is no emission of carbon dioxide like in case of fossil fuels which is one of the causes of global warming.
2. **Renewable**: There is an ample amount of energy available on earth as long as the sun exists.
3. **Reliable**: The energy can be stored in the batteries and so there is no question of unreliability.
4. **Reduction in utility costs**.
5. **Free energy** because it can be trapped easily.

Disadvantages of Solar Energy:

1. The production is low during winters and on cloudy days.
2. Installation and the initial cost of the materials are expensive.
3. Space consumption is more.

Due to several efforts made by the Government, a report of 2018 by the International Renewable Energy Agency, stated that India is now the lowest-cost producer of solar power globally.

Some Initiative to Promote Solar Power Generation in India

(a) Solar Cities Programme:

The Ministry of New and Renewable Energy is implementing a programme on 'Development of Solar Cities' which aims to reduce a minimum of 10% of the projected demand of conventional energy of the city through renewable energy installations and energy efficiency measures. Around 60 cities will be developed under this.

(b) Solar Energy scheme for Small powerloom Units:

Government has approved a new scheme to provide financial assistance/capital subsidy to small powerloom units, for installation of Solar PhotoVoltaic (SPV) plant, in order to alleviate the problem of power cut/ shortage faced by decentralized powerloom units in the country.

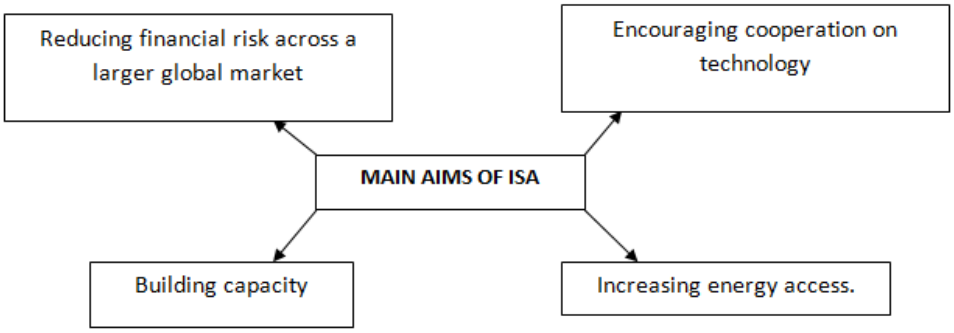
Under the Solar Energy Scheme, the plants have two options:

- On-Grid Solar Power Plant where power cut/shortage is negligible and power tariff is high
- Off-Grid Solar Power Plant in areas where there is power shortage & on-grid power is not continuously available.

(c)International Solar Alliance (ISA):

The International Solar Alliance is a group of nations that lies within the Tropics (Tropic of Cancer and Tropic of Capricorn) and receive sunshine for more than 300 days.

- It is a platform for the collective collaboration of sunshine countries in the domain of energy security.
- The energy that comes from the Sun in a day is enough for the entire globe to use for a whole year, however, we are not able to capture the entire energy that comes.
- Most of the sunshine countries are poor and the least developing. Hence, solar power becomes critical for their energy security.
- The underlying rationale for ISA is to "ensure access to affordable, reliable, sustainable and modern energy for all",
- It also plans to increase the share of renewable energy substantially by 2030. By 2030, it envisages enhancing international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology.
- Developing solar projects in silos is not financially viable, despite the involvement of prominent financial institutions such as AIIB, World Bank, NDB and private and public investments towards this.
- Absence of established renewable energy policy.
- There is no ecosystem that creates a willingness to buy and set up renewable energy; there is no proper integration method with conventional energy.
- Hence, the focus of ISA will be on policy, ecosystem and integration with regard to solar energy.



(d) KUSUM Scheme:

Kusum Scheme is being implemented by- The Ministry of New and Renewable Energy	Initially, the government will distribute 1.75 million off-grid agricultural solar pumps	10000 MegaWatts Solar plants will be put up on lands that are barren.
The state electricity distribution companies, also called, DISCOMS will buy the additional solar power produced by the farmers on barren lands. DISCOMS will get sops to buy this electricity.	Tube wells and existing pumps of the government will be converted to run on solar power	Farmers will get a subsidy of 60% on solar pumps. It shall be deposited to their bank accounts directly. This subsidy is going to be shared by the central and the state governments. 30% of the cost will be obtained as a bank loan. Hence, only the 10% will have to be borne by the farmers themselves.

(e) Grid-Connected Rooftop Solar (RTS) Programme:

Phase II of the Grid connected rooftop solar programme was approved with a target for achieving cumulative capacity of 40,000 MW from Rooftop Solar (RTS) Projects by the year 2022 in February 2019.

(f) Government Producer Scheme for setting up Solar PV Power plants using domestically manufactured SPV cells & modules:

Government have approved a Scheme [CPSU Scheme Phase-II (Government Producer Scheme)] for setting up of solar PV power plants by Government Producers [Central Public Sector Undertakings (CPSUs)/ State Public Sector Undertakings (SPSUs)/ Government Organisations, etc.], as per extant Guidelines, in a World Trade Organization (WTO)

compliant manner, using domestically manufactured solar PV cells and modules to encourage 'Make in India' in Solar PV Manufacturing sector.

(g) Wind-Solar Hybrid:

- The main objective of the **National Wind-Solar Hybrid Policy** is to provide a framework for promotion of large grid connected wind-solar PV hybrid systems for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land.
- The wind - solar PV hybrid systems will help in reducing the variability in renewable power generation and achieving better grid stability.
- The policy also aims to encourage new technologies, methods and way-outs involving combined operation of wind and solar PV plants.
- So far, Solar Energy Corporation of India (SECI) has awarded 1440 MW capacity of wind solar hybrid projects after e- reverse auction.
- In addition, Hero Future Energies has commissioned a wind solar hybrid project by adding 28.8 MW of solar project to an existing 50 MW wind project (Total 78.8 MW hybrid project) in Raichur district, Karnataka.

(h) Solar Parks Scheme:

The Ministry of New and Renewable Energy (MNRE) has launched a scheme to set up several solar parks across various states in the country, each with a capacity of Solar Projects generally above 500 MW.

The Scheme proposes to provide financial support by the Government of India to establish solar parks to facilitate the creation of infrastructure necessary for setting up new solar power projects in terms of allocation of land, transmission and evacuation lines, access roads, availability of water and others, in a focused manner.

Solar Energy Corporation of India (SECI), a central public sector enterprise under MNRE, has been implementing various schemes to develop the solar sector in the country. As per the policy, these solar parks will be developed in collaboration with the State Governments.

Some of the biggest solar power projects in INDIA include:-

- Pavagada solar park(Karnataka), it is the largest

- Kamuthi solar park (Tamil Nadu)
- Bhadla solar park(Rajasthan)
- Rewa ultra mega solar park (MP)

The implementation agency would be the Solar Energy Corporation of India (SECI) on behalf of the Government of India (GOI). SECI handles funds that are made available under the scheme on behalf of the Government Of India. Under the scheme, the states designate a nodal agency for the implementation of the solar park.

Issues with the Solar Parks:

Several concerns have been rising out of the establishment and working of Solar Parks, primary among which is the generation of Waste out of the plants which have been flagged by Farmers and communities living in the vicinity of these parks

One Stark example of this is the issues arising due to the Pavagada solar park in Karnataka, where farmers and Civil Society have raised problems of waste generation and unprecedented dumping of unused parts from the plant.

Also, the acquisition of land from farmers on lease has not only resulted in irrational land-use changes to the fertile lands but the majority of greenery and tree cover has been cleared off the lands instead of setting up parks. There have been claims that Solar Parks has only helped big farmers as small and marginal farmers only get a meager amount in return for the lease entered into.

Moreover, a large amount of polluting gases released due to the burning of waste is causing a lot of problems for the people in the surrounding areas. So also studies are highlighting that the temperature of villages where the solar parks are being established is comparatively higher due to the reflection of light by the solar panels.

Atal Jyoti Yojana (AJAY) Phase-II

- A scheme for installation of Solar Street Lights.
- Financial support: 75% of the cost by MNRE and balance 25% through MPLAD.
- Targets: A total of 3,04,500 Solar Street Lights (SSLs) will be installed

6.12 WIND ENERGY

The energy we get from winds is known as wind energy. For this, windmills have been used for hundreds of years to pump out water from the ground. We use large tall wind turbines that allow winds to generate electricity. The natural airflow on the surface of the Earth is used to run the wind turbines.

The modern-day wind turbines range from about 600 Kilowatt to 5 Megawatt, for commercial purposes; these are rated with an output power of 1.5 to 3 Megawatt. The most preferred locations for these wind turbines to be installed are the areas which are strong and have constant airflows on offshore and sites that are at high altitudes.

Development of wind power in India began in December 1952, when Maneklal S Thacker, a distinguished power engineer, initiated a project with the Indian CSIR(Council of Scientific and Industrial Research) to find out the probability of harnessing wind power in the country. A Wind Power Sub-Committee was set up by CSIR, under P. Nilakantan, which was assigned the task of investigating the available resources that could be practically utilized, along with researching the economic possibilities of wind energy. Assistance was provided by the IMD(Indian Meteorological Department), the Sub-Committee extensively reviewed available data on surface winds in India and their velocity duration, and began detailed surveys of promising sites for harnessing the optimum amount of wind energy; it also successfully developed and tested large wood-and-bamboo windmills.

CSIR established a Wind Power Division In 1960, as part of the new National Aeronautical Laboratory (NAL) in Bangalore, which was founded that year. From the 1960s to the 1980s, the NAL and other groups continued to carry out wind velocity surveys and develop improved estimates of India's wind energy capacity. With the setting up of the first wind project in Veraval, Gujarat, in 1985, wind power development began, it was a 40-kW Dutch machine connected to the grid. Subsequently, the government launched several demonstration wind projects.

In 2015, the Government had set the target for Wind Power generation capacity by the year 2022 at 60,000 MW (60GW). The estimated potential of generating wind energy in India, at a mast height of 100 meters above the ground, is 302 GW (ACCORDING TO MINISTRY OF NEW AND RENEWABLE ENERGY). India had become the country with the fourth-largest installed capacity of wind power, behind China, USA, and Germany.

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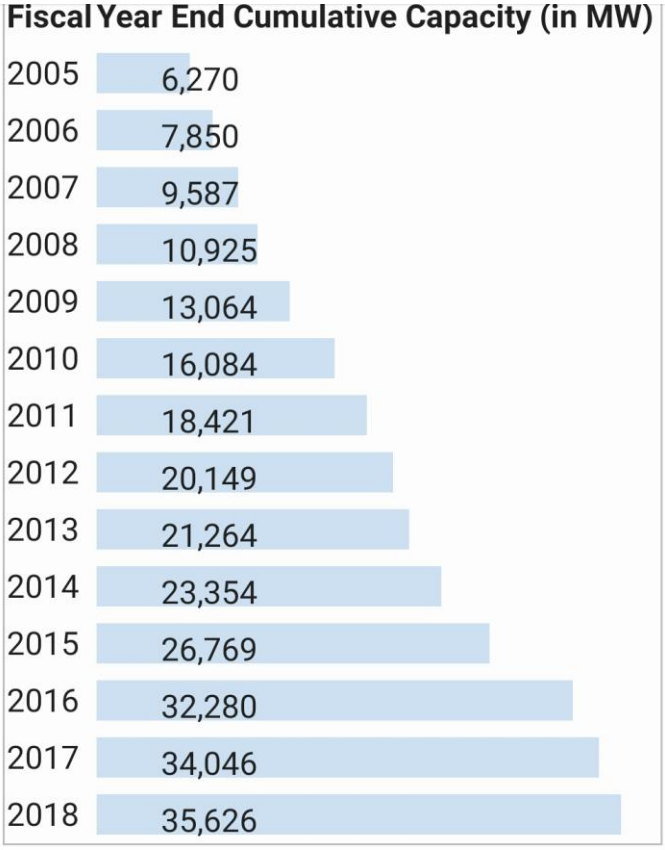


Fig 6.17: Cumulative capacity of Installed wind power

(Image source:MNRE)

Several Wind power projects are established in the country, including in Rajasthan, Gujarat, Madhya Pradesh among others, on commercial lines taking into account wind resource, land availability, transmission infrastructure, etc.

So far, bids for 15,100 MW of wind power projects have been issued, out of which projects of 12,162.50 MW capacity have been awarded.

The cumulative installed capacity of wind power (as on 31.10.2019) in the country is 37,090.03 MW.[source :*Ministry of New and Renewable Energy*]

MINISTRY OF NEW AND RENEWABLE ENERGY, has issued 'Guidelines for Development of Onshore Wind Power Projects' on 22 October 2016 intending to develop wind power projects in an efficient, cost-effective and environmentally sustainable manner taking into account the requirements of project developers, States and national imperatives. The Guidelines have provisions for the requirement of site feasibility, type and quality certified wind turbines, micrositing criteria, compliance of grid regulations, real-time

monitoring, online registry and performance reporting, health and safety provisions, decommissioning plan, etc.

The government has also issued 'Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Wind Power Projects', on 8 December 2017, to provide a framework for procurement of wind power through a transparent process of bidding including standardization of the process and defining of roles and responsibilities of various stakeholders.

The government is promoting capacity addition of wind power projects through private sector investment by providing various fiscal and financial incentives such as Accelerated Depreciation benefit; concessional custom duty exemption on certain components of electric wind generators. Wind projects commissioned before 31 March 2017 are eligible for Generation Based Incentive (GBI). Technical support, including wind resource assessment and identification of potential sites, is being provided, In addition to fiscal and other incentives as stated above, through the National Institute of Wind Energy, Chennai.

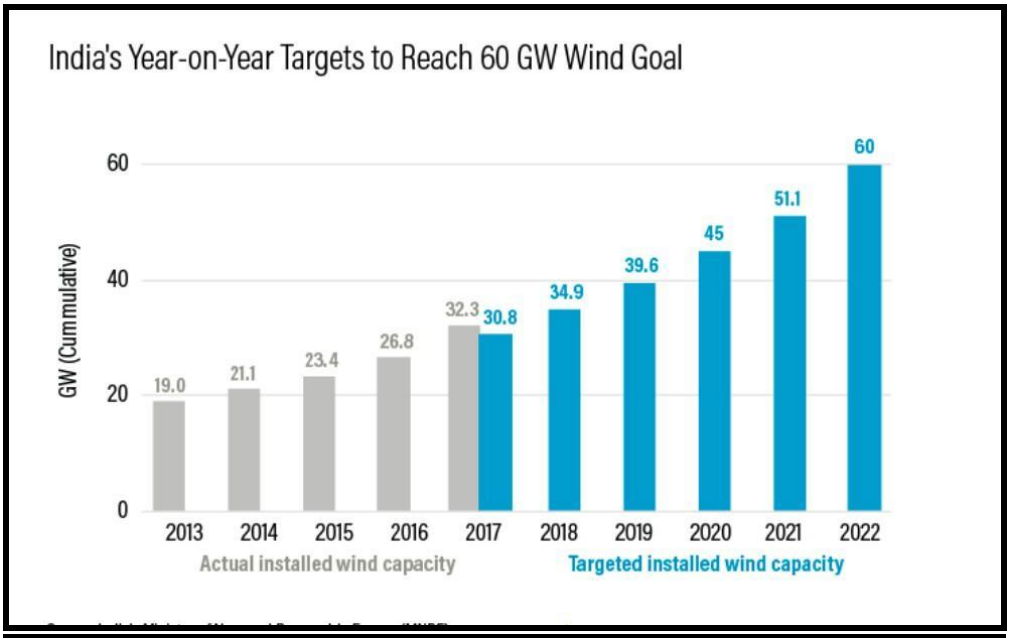


Fig 6.18 Year on Year Wind power Status in India

(Image source: World Resources Institutions)

National Institute of Wind Energy (NIWE)

Set up in the year 1998 in Chennai, It is an institution working under the Ministry of New and Renewable aims at developing wind energy and to help India achieve self-reliance in the power sector supplementing the core conventional resources. MNRE has been planning and developing the basic infrastructure, institutions, and resources for carrying out research and development, large scale demonstration and diffusion of the non-conventional energy sources.

It has a Wind turbines test station at Kayathar, which works with technical support from the Government of Denmark.

Advantages of Wind Energy:

- Onshore wind farms have a lesser cost than conventional energy generation and thus allow for mass farms of wind turbines to be set up.
- The shorter distance between the windmill and the consumer allows for less voltage drop off on the cabling.
- Wind turbines can be installed in a short period; hence unlike a nuclear power station, which can take over twenty years, a windmill can be built in a few months.
- Environmentally sustainable and provide economy of scale for the owners
- In the case of offshore wind farms, large scale windmills can be installed along with suitable conditions for installation and functioning.

Limitations of wind energy:

- Their efficiencies are limited to some 50-70% of the Betz limit.
- Wind turbine towers are at most a few hundred feet tall, winds at higher elevations from the ground are not utilized.
- It assumes almost certainly incorrect that there will be no further developments or improvements in wind turbine technology.
- The Wind Fluctuates. Wind energy has a similar drawback to solar energy in that it is not constant.
- Wind Turbines Pose a Threat to Wildlife

Recent Initiatives by the Government:

- India has a strong manufacturing base of wind power equipment in the country. There are a number of wind turbine manufacturers in INDIA. Wind turbines being manufactured in India are of international quality standards and cost-wise amongst the lowest in the world being exported to Europe, USA and other countries.
- **Online wind atlas** is available on NIWE website. This will create a new dimension to the wind power development in the country.
- **National Offshore Wind Energy Policy, notified in 2015, has an objective of developing the offshore wind energy in the Indian Exclusive Economic Zone (EEZ) along the Indian coastline.**

- **National Wind-Solar Hybrid Policy:-**
    - The main objective of the Policy is to provide a framework for the promotion of large grid connected wind-solar PV hybrid systems for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land.
    - The wind-solar PV hybrid systems will help in reducing the variability in renewable power generation and achieving better grid stability. The policy also aims to encourage new technologies, methods and way-outs involving combined operation of wind and solar PV plants.
- Potential renewable energy zones (66.5 GW – Solar 50 GW and Wind 16.5 GW) have been identified in the states of Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, Rajasthan & Madhya Pradesh and a comprehensive transmission scheme was evolved integrating these renewable energy zones.
- **Indian Wind Turbines Certification Scheme:** Ministry of New and Renewable Energy, in consultation with National Institute of Wind Energy Chennai, has prepared a draft of new Scheme called Indian Wind Turbine Certification Scheme (IWTCS) incorporating various guidelines Turbine Certification Scheme (IWTCS).The draft Scheme enlists the guidelines for the benefit of all the stakeholders from concept to lifetime of wind turbine, including Indian Type Approved Model (ITAM), Indian Type Certification Scheme (ITCS), Wind Farm Project Certification Scheme (WFPS) and Wind Turbine Safety & Performance Certification Scheme (WTSPCS).The WITCH is envisaged to assist and facilitate the following stakeholders; (i.) Original Equipment Manufacturers (OEMs) (ii.) End Users -Utilities, SNAs, Developers, IPPs, Owners, Authorities, Investors and Insurers (iii.) Certification Bodies (iv.) Testing Laboratories.

- National Institute of Wind Energy (NIWE), is an autonomous institution under the Ministryof New and Renewable Energy which has installed a remote sensing instrument- LiDAR for assessment of offshore wind resources in the Gulf of Khambhat, off the Gujarat Coast.

Over the decades,wind energy has matured enough to be the mainstream source of renewable power generation in India. The steady growth of the sector has seen different types of wind turbines with diverse performance and safety criteria. The Ministry of New and Renewable Energy (MNRE), Government of India through various policies and schemes has facilitated the healthy and orderly growth of the wind energy sector.

6.13 HYDROPOWER IN INDIA

Hydroelectricity is the conversion of mechanical energy in flowing water into electricity. Hydroelectricity is generated when the force of falling water from dams, rivers or waterfalls is used to turn turbines, which then drives generators that produce electricity. The energy produced is directed to a substation, where transformers "step up" the voltage before its transmission to the electricity grid.The first step in the generation of energy in a hydropower plant is the collection of run-off of seasonal rain and snow in lakes, streams and rivers, during the hydrological cycle. The run-off flows to dams downstream. The waterfalls through a dam, into the hydropower plant and turns a large wheel called a turbine. The turbine converts the energy of falling water into mechanical energy to drive the generator After this process has taken place electricity is transferred to the communities through transmission lines and the water is released back into the lakes, streams or rivers

The conversion of the mechanical energy in flowing water into electricity is called hydroelectricity. When a force of falling water from dams, rivers or waterfalls is used to turn turbines, it drives generators that produce electricity, and this is the process of its generation. The energy produced is directed to a substation, where transformers "step up" the voltage before its transmission to the electricity grid.The first step involved in the generation of energy in a hydroelectric power plant is the collection of run-off of seasonal rain and snow in lakes, streams and rivers, during the hydrological cycle. The run-off flows to dams downstream. The waterfalls through a dam, into the hydropower plant and turns a large wheel called a turbine. The turbine converts the energy of falling water into mechanical energy to drive the generator After this process has taken place electricity is transferred to the communities through transmission lines and the water is released back into the lakes, streams or rivers.

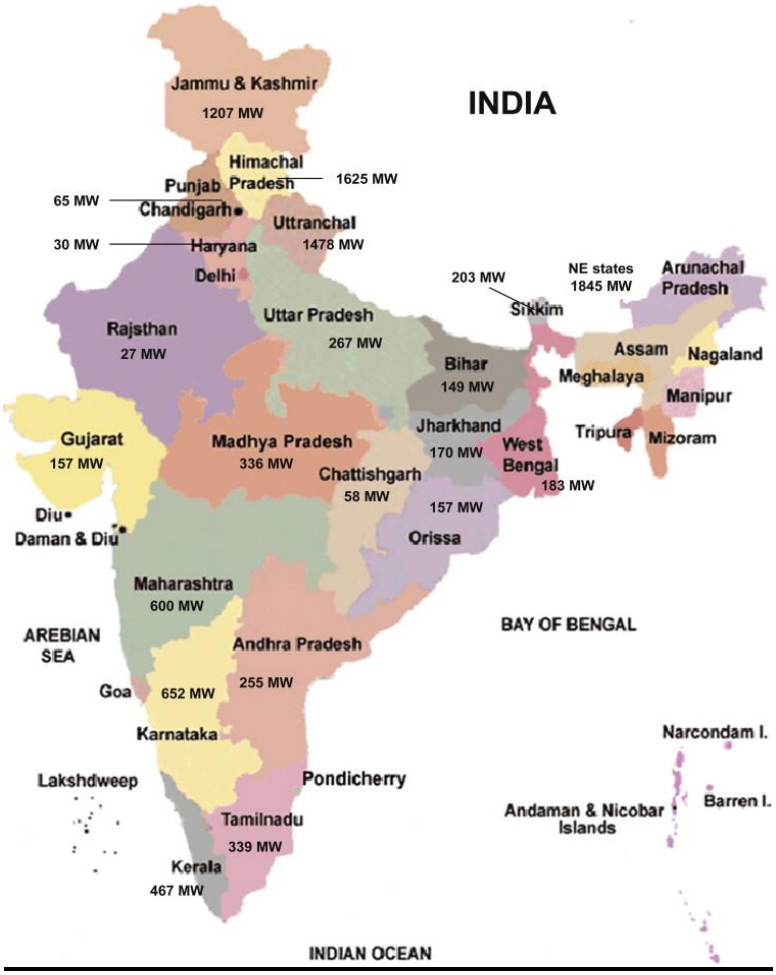


Fig :6.19 Small Hydro Projects

(imagesource: Science direct.com)

Classification of Hydro Projects based on Installed Capacity:

Hydropower projects are mainly classified into two segments, i.e. small and large hydro. In India, hydro projects that have up to 25 MW capacities are categorized as Small Hydro Power (SHP) projects.

- Micro: up to 100 KW
- Mini: 101KW to 2 MW
- Small: 2 MW to 25 MW
- Mega: Hydro projects with installed capacity >= 500 MW
- Thermal Projects with installed capacity >=1500 MW

For large hydro projects, the Ministry of Power, Government of India is responsible. In contrast, for the small hydropower projects (up to 25 MW) the Ministry of New and Renewable Energy is responsible.

India is bestowed with a large hydropower potential of 1,45,320 MW of which only about 45,400 MW has been utilized till now. Only Around 10,000 MW of hydropower has been added in the last ten years. The hydropower sector is presently under a challenging phase, and the share of hydropower in the total capacity has declined from 50.36% in the 1960s to around 13% in 2018-19. As the country has targeted to add 160 GW of intermittent Solar and Wind power by 2022 and 40% of the total capacity from non-fossil fuel sources by 2030 to honour its Nationally Determined Contribution for Climate Change, the importance of hydropower is increasing even more.

Note: India is 7th largest producer of Hydroelectric Power in the world.

River System	Potential (MW)	% to total potential
East flowing rivers of South India	8,626	21.0
West flowing rivers of South India	4,346	10.6
Rivers of CentralIndia	4,287	10.4
GangaBasin (minus Nepal)	4,828	11.7
BrahmaputraBasin	12,486	30.3
IndusBasin	6,583	16.0
India (Total)	41,156	100.0

Fig 6.20 Potential of Hydropower

(image source: researchgate)

Advantages of Hydropower:

As Hydropower only utilises and not consumes water,it is a renewable source of energy because for generation of electricity, and the hydropower leaves this vital resource	These stations are a preferred solution for meeting peak loads in grids because they have unique capabilities of quick starting and closing.

available for other uses.	
It is a renewable source of energy with no consumables involved; hence it has a little recurring cost and no high long term expenditure. As compared to electricity generated from coal and gas-fired plants, this energy is cheaper. It decreases the financial losses due to frequency fluctuations.	The operational needs of hydro & thermal stations are complimentary, and the balanced mix helps in optimal utilization of the capacity. Seasonal load curves of regional grids match with the pattern of hydropower generation. During the summer/monsoon season, when the generation at hydropower plants is high, the load factor of the system is high due to heavy agricultural load. During winter, the thermal stations operating at base load and hydro stations working as peak load stations will take care of weather beating loads.

Disadvantages of Hydropower

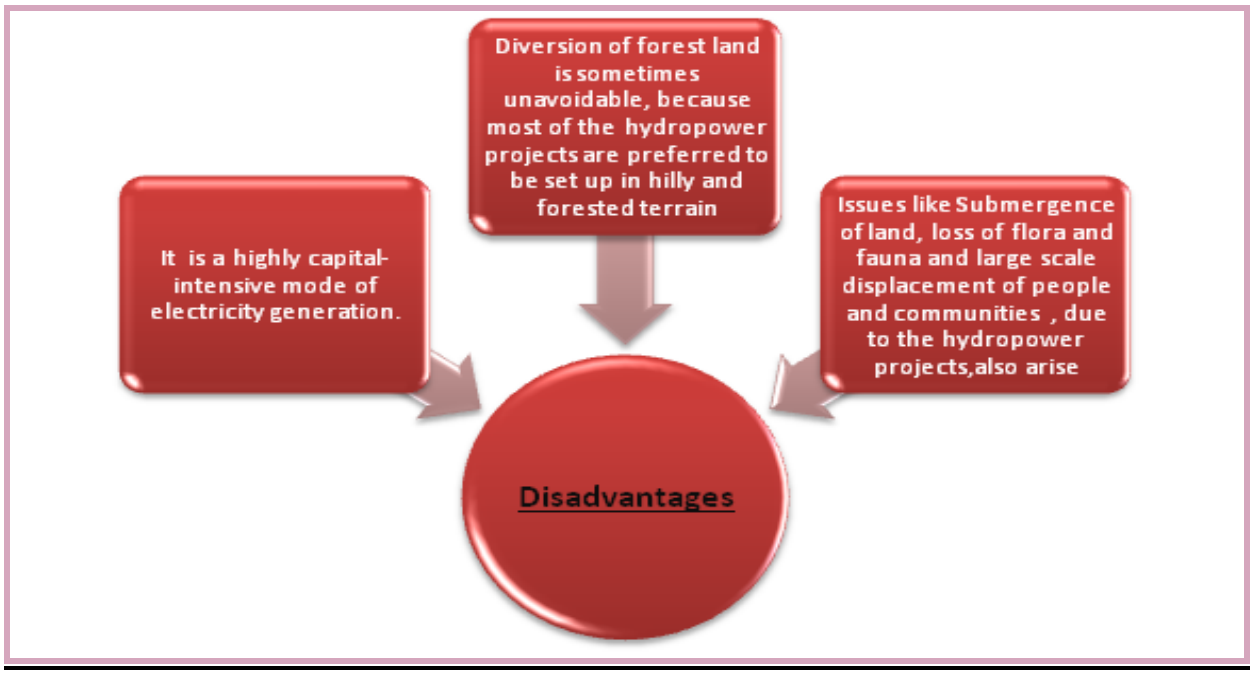


Fig. 6.21 Disadvantage of Hydropower

Initiatives for Hydropower Development:

- As per approval of the Cabinet,Large Hydropower Projects will now be declared as Renewable Energy source (as per existing practice, only hydropower projects less than 25MW are categorized as Renewable Energy).
- The Government has declared Hydropower Projects as a separate entity within non-solar Renewable Purchase Obligation in order to cover large hydro projects commissioned after notification of these measures (SHPs are already covered under Non-Solar Renewable Purchase Obligation).
- To expedite development of hydropower projects, a Hydropower policy has been formulated. Many States have followed the kinetic and adopted the hydropower policy
- The Centre and many states have initiated hydro projects in PPP mode to attract investors for the development of water resources in an environment-friendly manner and to generate revenue while ensuring project viability.

6.14 GEOTHERMAL ENERGY

Geothermal energy is the thermal energy generated and stored inside the Earth's crust. The centre of the Earth remains at the same temperature as the Sun, which is nearly constant due to the continuous process of nuclear fusion. Due to such high temperature and pressure, some rocks melt, which results in the upward motion of the mantle (as they become lighter with the heat). These molten rocks formed in the Earth's crust are pushed upward where they get trapped in certain regions called 'hot spots'.If underground water comes in touch or proximity with the hot spot, steam is generated. Sometimes this hot water formed region finds outlets at the surface. When this hot water gushes out of one of these outlets, it is called hot springs. To harness the geothermal energy, a hydrothermal convection system is used. In this process, a hole is drilled deep under the Earth, through which a pipe is inserted. The steam trapped in the rocks is routed through this pipe to the surface of the Earth. This steam is then used to turn the blades of a turbine of an electric generator. In another method, the steam is used to heat water from an external source which is then used to rotate the turbine.

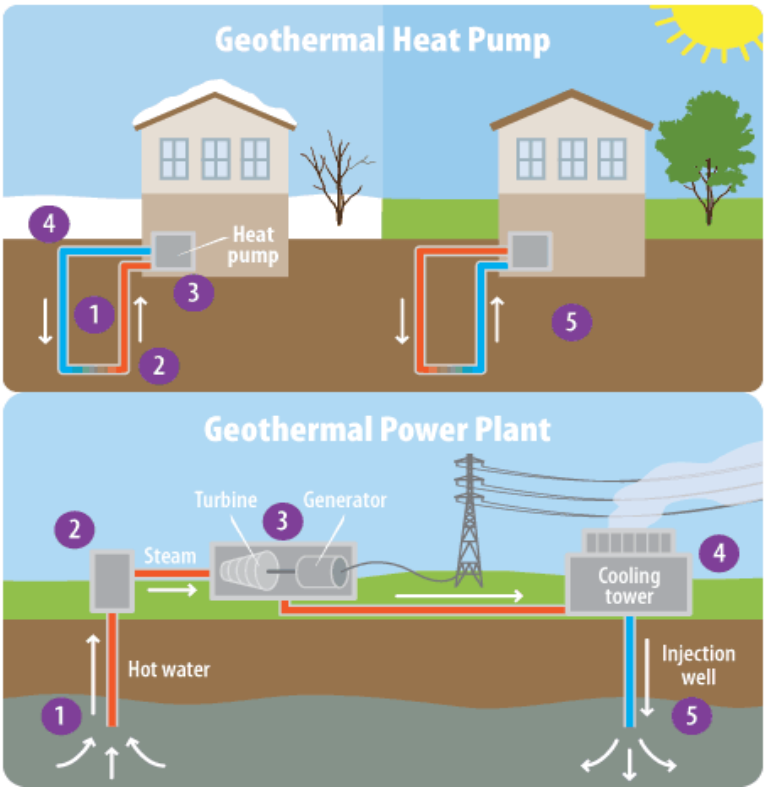


Fig 6.22 Geothermal Energy

(*Image source: byjus.com)*

In India, exploration and study of geothermal fields started in 1970. The GSI (Geological Survey of India) has identified 350 geothermal energy locations in the country. The most promising of these is in Puga valley of Ladakh. The estimated potential for geothermal energy in India is about 10000 MW.

There are seven geothermal provinces in India

- Himalayas, Sohana, West coast, Cambay, Son-Narmada-Tapi (SONATA), Godavari, and Mahanadi.

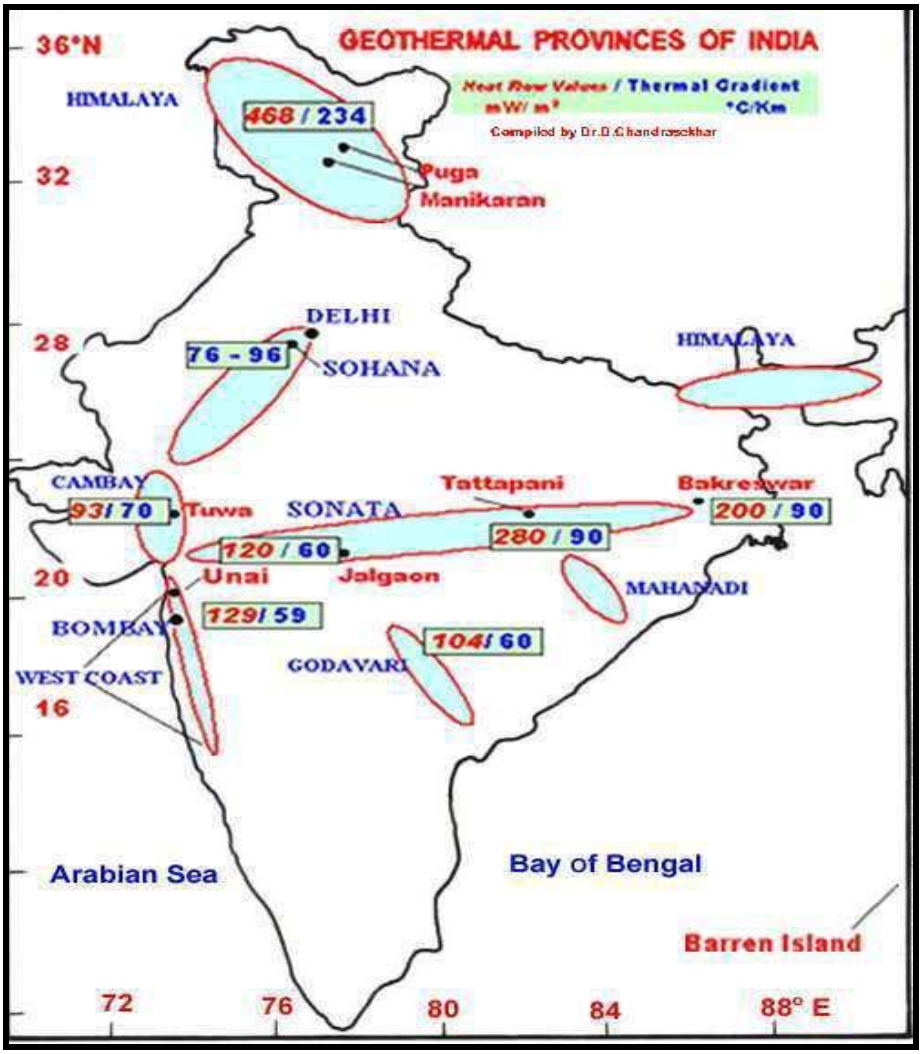


Fig 6.23: Geothermal Provinces in India

(Image source: India energy portal)

In its quest to increase its renewable energy portfolio, India proposes to harness 10,000 MW (10 GW) of geothermal energy by 2030 through active international collaboration with countries such as the US, Philippines, Mexico and New Zealand. India is at a nascent stage in terms of exploitation of geothermal energy, primarily because coal is cheaper. But with increasing environmental problems associated with coal-based projects, India is now also looking at developing clean and eco-friendly energy sources.

Though India has been one of the earliest countries to begin geothermal projects way back in the 1970s, at present, there are no operational geothermal plants in India.

However, in Dholera, Gujarat 20 MW capacity Geothermal plant is being proposed to be run as soon as possible.

There is also no installed geothermal electricity generating capacity as of now, and only direct uses (eg.Drying) have been detailed.

Thermax, a capital goods manufacturer, based in Pune, has entered an agreement with Icelandic firm Reykjavík Geothermal.

Thermax is planning to set up a 3 MW pilot project in Puga Valley, Ladakh (Jammu & Kashmir). Reykjavík Geothermal will assist Thermax in exploration and drilling of the site.

Technology for electricity generation:

Flash Steam Plants	Binary Plants
When the geothermal energy is available at 150 °C and above temperature, the fluids can be used directly to generate electricity. In some cases, direct steam is available from the geothermal reservoir; otherwise the steam is separated and turbines are used for power generation.	These plants are used when geothermal temperature is between 100 °C and 150 °C. The fluid is extracted and circulated through a heat exchanger where the heat is transferred to the low boiling point organic liquid. This gets converted into high pressure vapour, which drives organic fluid turbines.

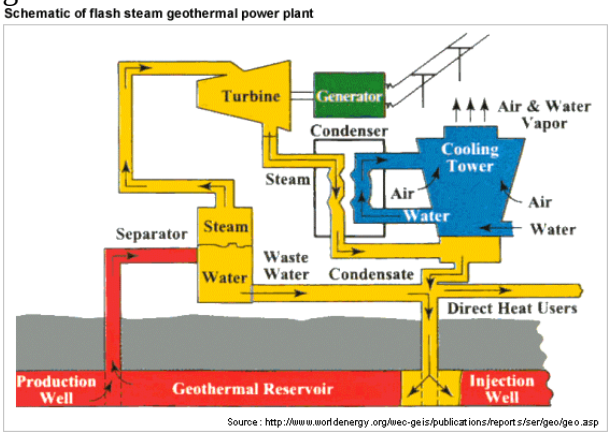


Fig 6.24 Flash Steam process

(Image source: http://www.indiaenergyportal.org/subthemes_link.php?text=geothermal&themeid=13)

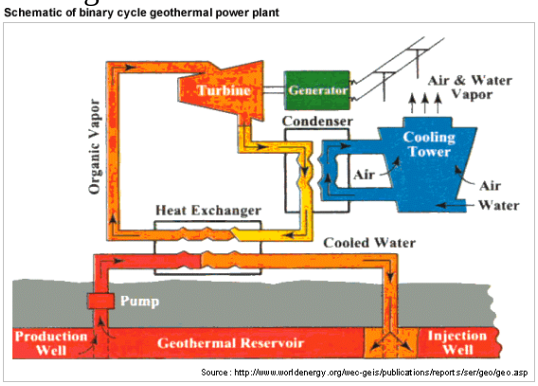


Fig 6.25 Binary Use of Geothermal energy

(Image source: http://www.indiaenergyportal.org/subthemes_link.php?text=geothermal&themeid=13)

Indian organisations working in geothermal energy:

- Central Electricity Authority
- Geological Survey of India
- Indian Institute of Technology, Mumbai
- Regional Research Laboratory, Jammu
- National Geophysical Research Institute, Hyderabad
- Oil and Natural Gas Corporation, Dehradun

Note: Several projects have been Ongoing in **India**: **Magneto-telluric investigations in Tattapani, Geothermal area in Madhya Pradesh, Magneto-telluric investigations in Puga, Geothermal area in Ladakh region, Jammu & Kashmir.**

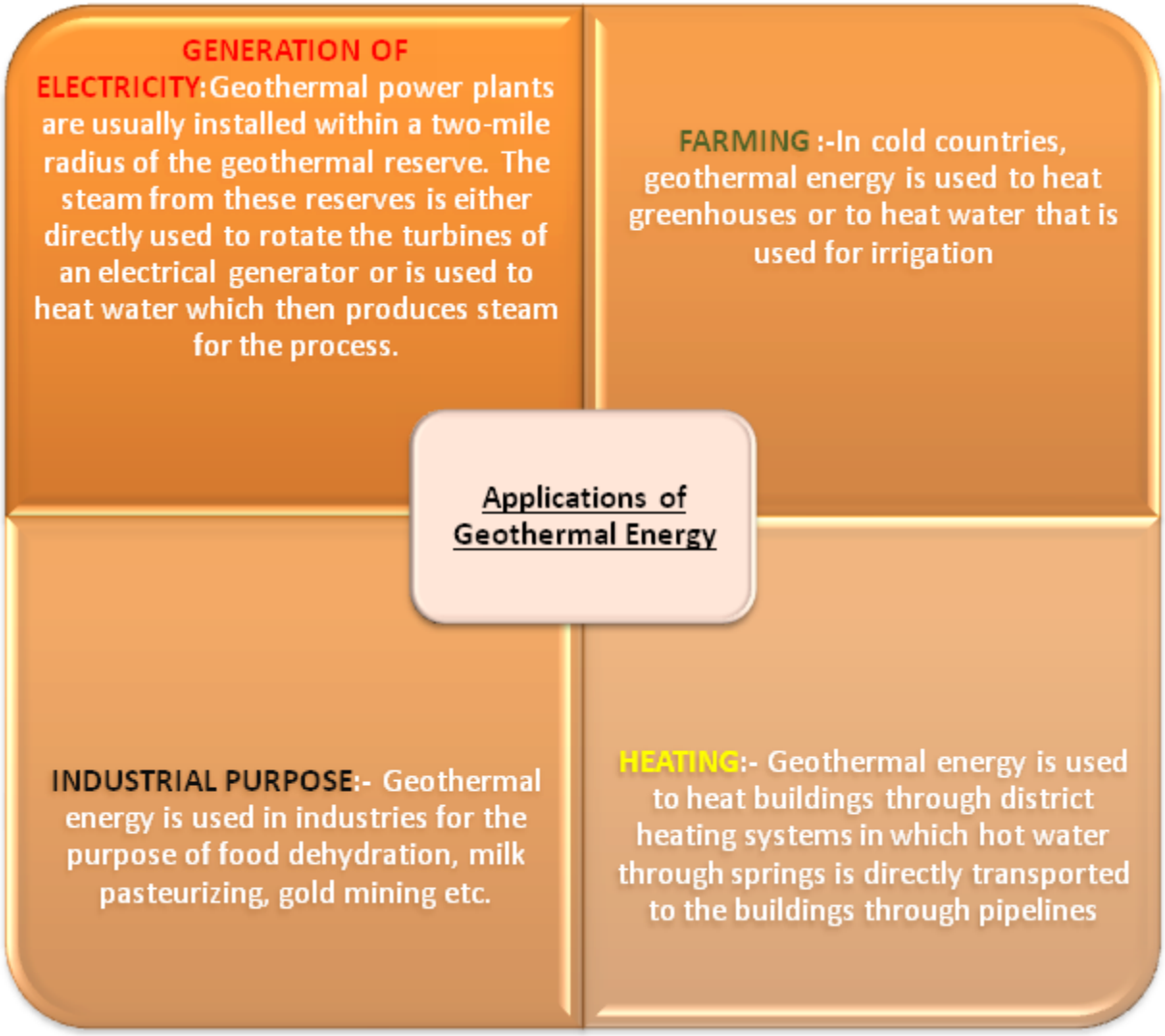


Fig 6.26 Application of Geothermanl Energy

Advantages Of Geothermal Energy	● Renewable resource: Geothermal energy is free and abundant. The constant flow of heat from the Earth makes this resource inexhaustible and limitless to an estimated time span of 4 billion years. ● Green energy: Geothermal energy is non-polluting and environment-friendly as no harmful gases are evolved with the use of geothermal energy unlike the use of fossil fuels. Also, no residue or by-product is generated. ● Generation of employment: Geothermal power plants are highly sophisticated and involve large scale research before installation. This generates employment for skilled and unskilled labours at a very large scale at each stage of production and management. ● Can be used directly: In cold countries, the geothermal energy is used directly for melting of ice on the roads, heating houses in winters, greenhouses, public baths etc. Although the initial cost of installation is very high, the cost for maintenance and repair is negligible.
Disadvantages of Geothermal Energy	● Transportation and transmission: Unlike fossil fuels, geothermal energy cannot be transported easily. Once the tapped energy is harnessed it can only be used efficiently in the nearby areas. Also, with the transmission, there are chances of emission of toxic gases getting released into the atmosphere. ● High installation cost: The installation of geothermal power plants to get steam from deep under the Earth requires a huge investment in terms of material and human resource. ● Intensive research required: Before setting up a plant, extensive research is required, as the sites can run out of steam over a period of time due to a drop in the temperature as a result of excessive or irregular supply of inlet water. ● Limited to particular regions: The source of geothermal energy is available in limited regions, some of which are highly inaccessible such as high rise mountains and rocky terrains, which renders the process economically infeasible in many of the cases. ● Impact to the environment: Geothermal sites are present deep under the earth, so the process of drilling may result in the release of highly toxic gases into the environment near these sites, which

	sometimes prove fatal to the workforce involved in the process.

Recent Initiatives By Government to Promote Geothermal Energy:

- Geothermal Atlas of India, prepared by the Geological Survey of India(GSI) gives information/data for more than 300 geothermal potential sites. This Atlas is being updated by GSI with the support from MNES.
- Applications of geothermal energy for small-scale power generation and thermal applications are being explored.
- Gujarat has become the first state and is planning to implement its geothermal energy policy
- India proposes to harness 1,000 MW of geothermal energy till 2022 and 10,000 MW by 2030.
- **Draft Geothermal Energy Policy:**
    - The geothermal policy envisages to make a substantial contribution to India's long-term energy supply and reduce our national greenhouse gas emissions by developing a sustainable, safe, secure, socially and environmentally responsible geothermal energy industry.
    - It seeks to create new employment opportunities in Geothermal Sector
    - Promotion of environmentally sound sustainable development by the means of deployment of 1,000 MW(therm) and 20 MW(elect) Geothermal Energy Capacity in the initial phase till 2022 and 10,000 MW(therm) & 100 MW(elect) by 2030.
    - The policy seeks to mitigate electricity demand by deploying Ground Source Heat Pumps (GSHP'S) and retrofitting the existing HVAC systems with Geo-exchange based systems.
- Ministry of New and Renewable Energy is planning to encourage the International Collaboration with the world leaders in Geothermal Energy like USA, Philippines, Indonesia, Mexico and New Zealand for support to accelerate deployment of geothermal energy by international investment promotion (100% FDI in RE Sector), Customized capacity building and technical assistance to key stakeholders, help in mitigating the exploratory risk, technological support etc.

6.15 OCEAN THERMAL ENERGY

Oceans are a source of two major types of **Renewable energy source**

- **Thermal energy** - Which is produced by the heat of the Sun
- **Mechanical energy** - Which is produced from wave action and tides namely,
    - Tidal Energy
    - Wave Energy Ocean Thermal Energy is also called as Ocean Thermal Energy Conversion (OTEC) is a **method of using the temperature difference between the deep parts of the sea which are cold and the shallow parts of the sea which are cold to run a heat engine and produce useful work.**

Ocean thermal energy conversion is an electricity generation system. The deeper parts of the ocean are cooler since the heat of sunlight cannot penetrate very deep into the water. Here the efficiency of the system depends on the temperature difference: greater the temperature difference, greater the efficiency.

The temperature difference in the oceans between the deep and shallow parts is maximum in the tropics, 20 to 25-degree C. Tropics receive a lot of sunlight which warms the surface of the oceans, increasing the temperature gradient.

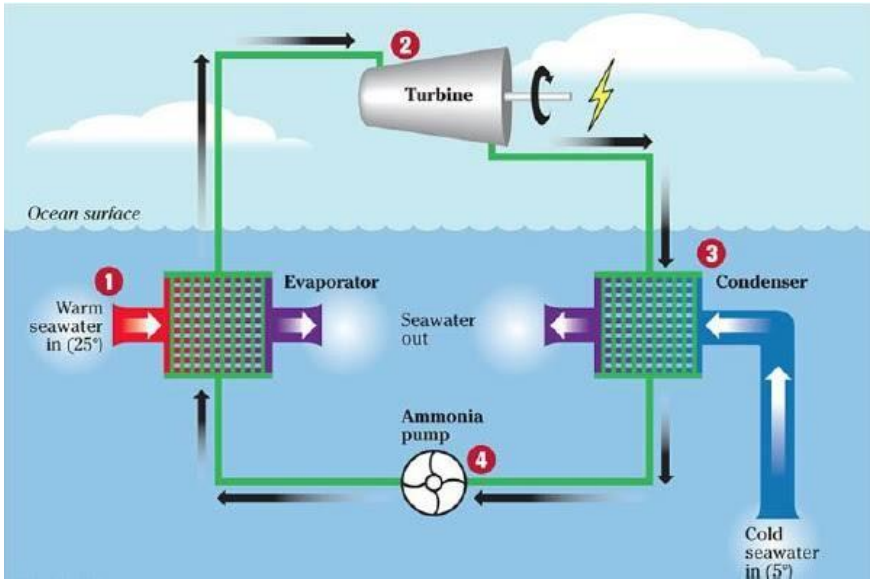


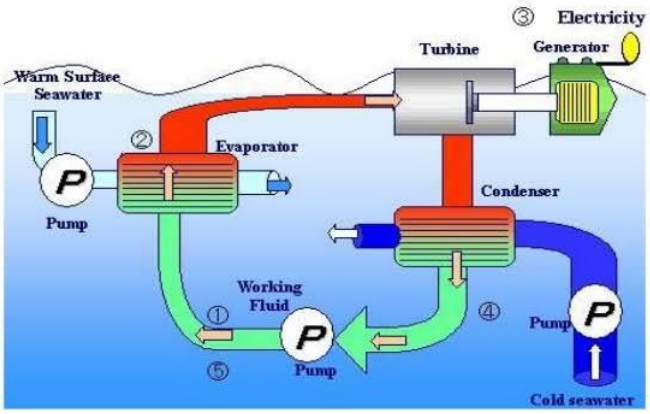
Fig 6.27 OTEC -process

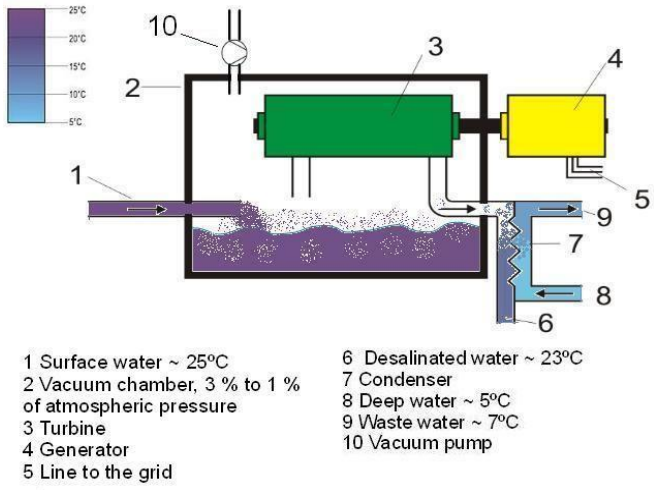
(Image source: byjus.com)

The energy source of OTEC is abundantly available, free and will be so for as long as the sun shines and ocean currents exist. Estimates suggest that ocean thermal energy could contain

more than twice the world's electricity demand. This makes it necessary for us to give it a closer look.

Types of Ocean Thermal Energy Conversion (OTEC):

	Types of Ocean Thermal Energy Conversion (OTEC):
Closed Cycle	Closed cycle Ocean Thermal Energy Conversion systems use a working fluid with a low boiling point, Ammonia for example, and use it to power a turbine to generate electricity. Warm seawater is taken in from the surface of the oceans and cold water from the deep. The warm seawater evaporates the fluid in the heat exchanger which then turns the turbines of the generator. The fluid now in the vapour state is brought in contact with cold water which turns it back into a liquid. The fluid is recycled in the system which is why it is called a closed system. **CLOSED (ANDERSON) CYCLE** 
Open Cycle	Open cycle OTEC directly uses the warm water from the surface to make electricity. The warm seawater is first pumped in a low-pressure chamber where due to the drop in pressure, it undergoes a drop in boiling point as well. This causes the water to boil. This steam drives a low-pressure turbine which is attached to an electrical generator. The advantage this system has over a closed system is that, in open cycle, desalinated water in the form of steam is obtained. Since it is steam, it is free from all impurities. This water can be used for domestic, industrial or agricultural purposes.



Ocean Thermal Energy (OTEC) is a real candidate as one of the future sources of energy. Its environmental impact is negligible, in fact, the mixing of deep and shallow seawater brings up nutrients from the seafloor. The deepwater is rich in nitrates and this can also be used in agriculture.

Types of Ocean Thermal Energy Conversion:

THERMAL ENERGY

Thermal energy is the energy that comes from the temperature of matter. The hotter the substance, the more is the vibration of molecules and hence the higher is the thermal energy.

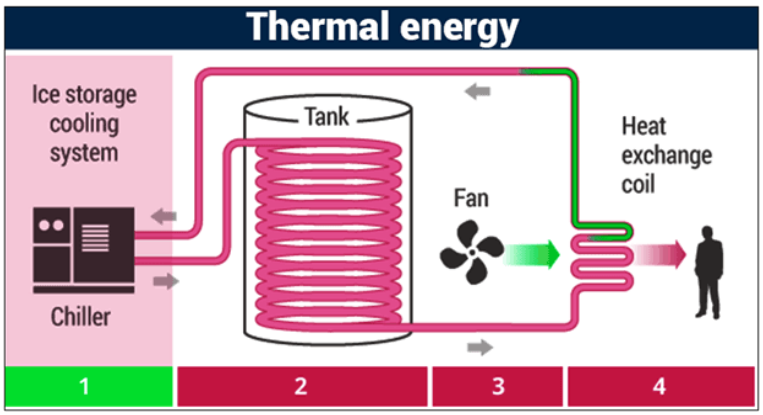


Fig 6.28 Thermal Energy Mechanism

(Image source:byjus)

The water at the surface of the sea or ocean is heated by the Sun while the water in deeper sections is relatively cold. This difference in temperature is exploited to obtain energy in

ocean-thermal-energy conversion plants. These plants can operate if the temperature difference between the water at the surface and water at depths up to 2 km is 20 K (20°C) or more. The warm surface-water is used to boil a volatile liquid like ammonia. The vapours of the liquid are then used to run the turbine of the generator. The cold water from the depth of the ocean is pumped up and condenses vapour again to liquid.

6.16 TIDAL ENERGY

Tides are a regular phenomenon. They can be predicted over months and years in advance. This is why the energy from this massive movement of water can be harnessed and converted into a usable form of energy.

The gravitational forces of the sun and the moon combined with the rotation of the earth result in an alternate rise and fall of the sea levels. At one particular place, it usually occurs twice on a lunar day. The rise of the sea level is called the high tide, whereas the fall is called the low tide. When the earth and moon's gravitational fields are in a straight line, the influences of these two fields become very strong and cause millions of gallons of water flow towards the shore resulting in the high tide condition. Likewise, when the moon and earth's gravitational fields are perpendicular to each other, the influences of these fields become weak causing the water to flow away from the shore resulting in a low tide condition.

When the moon is perfectly aligned with the earth and the sun, the gravitational pull of the sun and the moon on the earth becomes much stronger and the high tides much higher and the low tides much lower during each tidal cycle. This condition occurs during the full or new moon phase. Such tides are known as spring tides. Similarly, another tidal situation emerges when the gravitational pull of the moon and sun are against each other cancelling their effects. This results in a smaller difference between the low and high tides due to the smaller pulling action on the sea water, thereby resulting in weak tides. These weak tides are known as neap tides. Neap tides occur during the quarter moon phase.

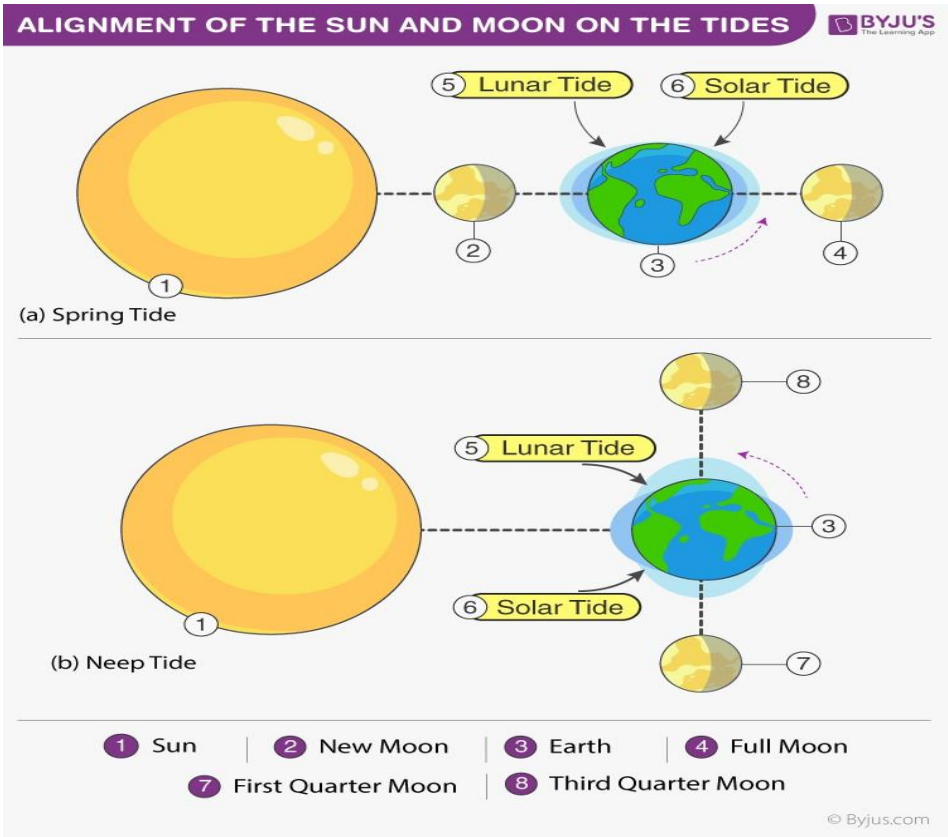


Fig 6.29 Mechanism for Tides

(Image source: byjus.com)

The energy obtained from the rise and fall of tides is called the tidal energy.

Tidal barrages or dams are constructed across a narrow opening to the sea. Water rushes into the dam when the sea level rises. This moves the blades of the turbines which are attached at the opening of the dam. This results in the generation of electricity.

6.17 ENERGY FROM WAVE AND CURRENTS

You may have noticed that there is a certain kind of air force when you go near any seashore. This is due to a type of energy which gets transported by wind waves. This energy is also known as wave power. When the wind passes on the water surface, it leads to the pressure difference between the upper and bottom wind which results in the generation of waves. This wave energy which is captured can be used for several useful works namely water distillation, electric generator, and WEC. The motion of waves contains a different degree of energy. The electromagnetic waves from the wave energy give us energy for sustaining life on earth. Water desalination or the pumping of water into reservoirs are some of the uses of the wave power, electricity generation, etc. Some of the main properties of waves include

speed, frequency, period, amplitude and wavelength. Ocean wave energy is a natural source of energy which is directly captured from the pressure fluctuations below the surface or from the surface area itself. They are therefore of two types namely:

- **Ocean Thermal Energy**
- **Ocean Mechanical Energy**

In Ocean Mechanical Energy, electricity is produced by taking energy from the ocean in three main types:

1. The channel systems, which are used to funnel the waves into reservoirs.
2. Float systems are used to run the hydraulic pumps.
3. The column system is used to compress the air present within the containers.

Ocean wave power is then used to rotate the turbine or the generator and the electricity is produced. Ocean Thermal Energy uses the temperature of the surface sea waters to run a heat engine and produce electricity. Ocean water moving in one direction is called marine current. This ocean current is known as the Gulf Stream. Currents are also by tides. Kinetic energy can be captured from the Gulf Stream and other tidal currents with submerged turbines that are very similar in appearance to miniature wind turbines. Similar to wind turbines, the movement of the marine current moves the rotor blades to generate electric power.

Developments in the field of Ocean Thermal Energy Systems:

In order to increase its efforts to reach the objectives of Renewable Energy generation and climate change objectives post-2022, it is a necessity to explore all possible avenues to stimulate innovation, create economic growth and new jobs as well as to reduce our carbon footprint. India has a long coastline with the estuaries and gulfs. The Ministry of New and Renewable Energy (MNRE) looks over the horizon at the development of new technology and considers the various options available to support its deployment. Most types of technologies are currently at pre-R&D / demonstration stage or the initial stage of commercialization. Basic R&D is being looked after by the Ministry of Earth Sciences (example: National Institute of Ocean Technology, Chennai). MNRE intends to support demonstration projects of proven technologies and as approved by an expert committee constituted by MNRE.

- The estimated potential of Tidal Energy is about 12455 MW, with potential locations identified at Khambhat & Kutch regions, and large backwaters, where barrage technology could be used.

- The total potential of wave energy in India along the coast is around 40,000 MW – while these are preliminary estimates, this energy is, however, less intensive as compared to that which is available in more northern and southern latitudes.
- Ocean thermal energy conversion has a theoretical potential of 180,000 MW in India, but it is highly dependent on technological evolution.

In case of Tidal Energy Total identified potential is about 12455 MW, with potential locations identified at Gulf of Khambhat & Kutch regions, and large backwaters, where barrage technology could be used.

BIOMASS ENERGY:

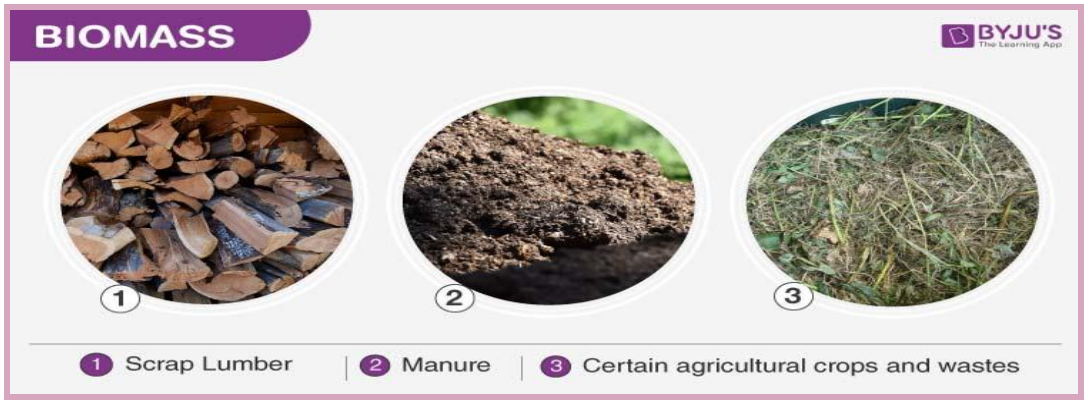


Fig 6.30 Biomass

(Image source: Byjus.com)

The fuel developed from natural and organic materials or wastes, which are a renewable and sustainable source of energy is known as Biomass.

Few types of fuels used to generate biomass are:

a) Scrap Lumber

b) **Woody construction and Forest debris** (Wood waste, sawmill waste, green waste from landfills and other vegetative)

c) **Certain agricultural crops and wastes**

d) **Manure**

e) Animal waste

f) Ethanol waste

g) Municipal solid waste (sewage sludge or other landfill organics)

h) Landfill gas

i) Other industrial waste (i.e. paper sludge from paper recycling processes)

For generating biomass, often the energy sources are thought to be limited to plant wastes but that's not the case. Even animal-derived materials are used for biomass generation. Biomass is the prime building block of biofuels, highly used for electricity production to produce heat in the context of energy, as an alternative to fossil fuels.

The chemical composition of Biomass comprises – Carbon, Hydrogen, and Oxygen along with nitrogen and alkali atoms, heavy metals and alkaline earth.

Difference between Biomass and Other Fossil Fuels:

The first, foremost and major difference is the 'Time Difference', i.e. the time required for it to be generated. Biomass takes carbon out of the atmosphere while it is developing, and returns as it is burned. Biomass can be converted into ethanol by a thermal process and into methanol by fermentation and digestion. Fuels have a high energy density, and burning and utilizing them releases carbon dioxide into the atmosphere.

Disadvantages of Biomass:

If crops are no longer grown then there wouldn't be any agricultural wastes found. If there's a demand for biomass then harvesting methods need to be developed. Another major disadvantage is that the land used for growing crops for biomass, is occupied for the long term and which may be in need for other purposes like housing, conservation, farming, resort or agricultural use.

6.18 BIOFUEL

A biofuel is a fuel that is produced through contemporary processes from biomass, rather than a fuel produced by the very slow geological processes involved in the formation of fossil fuels, such as oil. Since biomass technically can be used as a fuel directly (e.g. wood logs), some people use the terms biomass and biofuel interchangeably.

Biofuels are of 3 types: a) Ethanol b) Biodiesel c) Biojet fuel

- **Ethanol:** is used in engines that burn gasoline most cars.
- **Biodiesel** is used in engines that burn diesel fuel like large trucks and tractors.
- **Biojet** fuel is used in planes.
- Theoretically, biofuel can be produced through any carbon source, with plants being the most commonly used material. But, ethanol is produced in a different way from Biodiesel.

- What they have in common is the need to grow the plant that will eventually be used to make the fuel. For ethanol, corn or sugarcane is first harvested and then bacteria are allowed to digest it.
- This is done under special conditions where oxygen levels are low. This process is called fermentation that produces ethanol. For Biodiesel, the process requires chemical reactions- the most common is called trans-esterification, which is the process of breaking down fats catalysed by methanol.
- Biofuel can be made from various sources like feedstock. Ethanol can be made from
    - a) Corn b) Sugarcane c) Sugar beet d) Wheat e) Grass f) Inedible parts of most plants
    - Biodiesel can be made from a cactus-like plant called Jatropha, flowering plants like Camelina, Soybeans, Rapeseed, Canola Oil, Palm Oil, Peanut Oil, Vegetable Oil, Animal Fat, and Algae Oil (Algae Oil is made by Algae that lives in water).

Today, Biomass is used to produce Biofuels that are used together with biofuels or even replace them.About 25 billion gallons of ethanol are made each year as fuel, and each year, about 1 billion gallons of biodiesel are produced.
Biofuel is a source of renewable energy, unlike fossil fuels like petrol, coal and natural gas. Further, it is cost-effective and also environmentally friendly. This makes it well suited in an age where the cost of petroleum products are rising and there is a growing concern of fossil fuels in global warming. Biofuels are subdivided into generations.

Biofuel is grouped by categories and further classified into different types.

Categories of Biofuels:

FIRST GENERATION BIOFUELS	SECOND GENERATION BIOFUELS	THIRD GENERATION BIOFUELS	FOURTH GENERATION BIOFUELS
These are the conventional biofuels that are produced	The 2nd Generation Biofuels are more advanced Biofuels.	They entered the mainstream recently, and they refer to biofuel that is derived from Algae	The 4th Generation biofuels don't require the destruction of biomass. This includes electrofuels

directly from food crops. They are derived from starch, sugar, animal, fats, and vegetable oil. Corn, wheat and sugarcane are the most common first-generation biofuel feedstock.	They are made from various types of non-food biomass, which are plant materials and animal waste		and photobiological solar fuels. Some of these fuels are carbon-neutral.

Different types of fuels can be produced using 1st, 2nd, 3rd and 4th generation biofuels production procedures.

Biodiesel:

- Biodiesel is a renewable resource made from vegetable oil, recycled cooking oil, soybean, palm oil, peanut oil, canola oil, animal fat and fatty acids.

Bio-ethanol:

- Bio-ethanol is made from the fermentation of plant starch.
- This is also a by-product of the chemical reaction with ethylene and other types of petroleum products.
- One of the latest techniques to produce ethanol is eugenol which is done with the help of algae. Bio-ethanol is a clean gas with no toxins. It reduces greenhouse gas emissions as well (GHG's).

Biogas:

- Biogas is a renewable source of energy that is produced by the anaerobic digestion of biomass.
- It is obtained when organic matter is broken down in the absence of oxygen.
- The raw materials used are manure, food waste, municipal waste, agricultural waste and sewage used as raw materials.
- A major portion of biogas is methane and CO2. It also has small proportions of hydrogen sulfide, hydrogen carbon-monoxide.

- It is used for heating, electricity and automobiles.

Butanol:

- Butanol is similar to ethanol. It is a type of alcohol that can be produced from the petrochemical process or by the fermentation of sugar from crops.
- Its energy content is the highest when compared to other gasoline alternatives.
- It has zero toxic emissions that minimize air pollution.
- Butanol is added to diesel to reduce emissions.

It serves as a solvent in textile industries and is used as a base in perfumes.

Bio-hydrogen:

- It is similar to biogas and is produced with the help of bacteria, algae, and archaea biologically. The common methods used in its production are photo-fermentation, dark fermentation, direct photolysis, and indirect photolysis.

This year, the government approved the National Policy on Biofuels not only to help farmers economically dispose of surplus stock but also to reduce India's oil import dependence. Rajasthan became the first state to implement it.

With the first Indian airplane being flown with biofuel, there has been little doubt that biofuel can be used to run vehicles as well.

But, the truth is that biofuel can replace all human energy needs from home-heating to vehicle fuel to electricity generation. The basic concept of biofuel is that if we use as much product as is grown, then our net impact on the environment is negligible if not zero.

Uses of Biofuel and their impact on the environment:

Biofuels are as old as cars. At the beginning of the 20th Century, when Henry Ford built his first automobile, he also had plans to fuel it with ethanol. Considering that this happened over a century ago and that ethanol is still not a popular fuel, the plan did not take off.

The discovery of huge petroleum deposits kept petrol cheap for decades, and by then biofuels were largely forgotten. But a recent rise in the price of Oil and the rise and the concern about Global warming has reignited the interest in Biofuels. Estimates suggest that we have nearly hit peak-oil and that it is only a matter of time when we will run out of it. So, the need to find an alternative is clear. It is strategically very important for India that she develops her indigenous capabilities in fuels to cater to different needs. Thus, when we move towards biofuels, it is natural that we would be developing our farming industries, our rural areas, our energy security, etc. Petroleum products are in any case subject to a lot of ups and downs in the international market. Thus if we produce biofuels internally in India, then this would be a very good addition.

Many of the alternatives like wind and solar energy are non-practical as transporting them is very difficult. Thus, the solution seems to be algal-based biofuels. Algae has lipid and lipids can be converted into several fuels, including diesel, ethanol, butanol and methanol.

With this renewed interest, it is important to examine the uses of biofuels, the first being transportation. Globally, transportation accounts for 25% of all energy needs and nearly 62% of all Oil consumed. Most of this energy is burnt to operate vehicles, while the rest goes towards maintenance, manufacturing, infrastructure, and raw material harvesting.

Further, more than 70% of energy consumption in transportation is used in private cars. Thus, it is being used in the least efficient means. The other use is in the area of power generation. Electricity generation is the single largest user of fuel in the world. In 2008, the world produced over 20,261 TWh of electricity and about 41% of that came from coal, 21% came from natural gas, and the rest 16% from hydropower, 13% from nuclear, and 5% from Oil. Of the fuel burnt, only 39% went into producing energy, and the rest was lost as heat.

The third major use of biofuel is generating heat. The majority of biofuel used in heating is used as solid. The renewed interest has led to a surge of innovation in the industry with research focussing on improved efficiency, reduced emissions, and enhanced convenience.

Recently, a fuel cell was developed with cooking Oil and sugar to generate electricity. This could soon become a common method to do that.

Consumers may be able to use fuel cells in place of batteries to charge anything from computers to mobiles. Biofuels can help to clean up oil spills and grease as well. It has been tested as a potential cleaning agent in areas where Oil has contaminated waters. Biofuel can also be used for cooking; the other uses are as a motor lubricant, and to remove paint and adhesives.

The biggest advantage of biofuels is that it is biodegradable. However, developing biofuels require huge investments for water and fertilizer. In other words, more energy is put into the system than taken out; thus, it leads to a net loss. Until the input of energy is lower than what the system produces, the system cannot be viable.

NATIONAL POLICY ON BIOFUELS

- Biofuels are classified as "Basic Biofuels" viz. First Generation (1G) ethanol & biodiesel and "Advanced Biofuels" - Second Generation (2G) ethanol, Municipal Solid Waste (MSW) to drop-in fuels, Third Generation (3G) biofuels, bio-CNG etc. in order to provide adequate financial and fiscal incentives to each category.
- Under the NATIONAL POLICY, the scope of usage of raw material for ethanol production has been expanded, by allowing the use of Sugarcane Juice, Sugar containing materials like Sugar Beet, Sweet Sorghum, Starch containing materials like Corn, Cassava, Damaged food grains like wheat, broken rice, Rotten Potatoes
- Farmers are at risk of not getting appropriate prices for their produce during the surplus production phase. Taking this into account, the policy allows the use of surplus food grains for production of ethanol for blending with petrol with the approval of the National Biofuel Coordination Committee.
- The National Policy Advocates a viability gap funding scheme for 2G ethanol Bio refineries of Rs.5000 crore in 6 years, for advanced Biofuels, as well as additional tax incentives, higher purchase price as compared to 1G biofuels.
- It encourages establishing supply chain mechanisms for biodiesel production from non-edible oilseeds, Used Cooking Oil, short gestation crops.
- In order to synergize efforts roles and responsibilities of all the concerned Ministries/Departments with respect to biofuels has been captured.

Expected Benefits of the Policy:

Reduce Import Dependency: One crore lit of E10 saves Rs.28 crore of forex at current rates. The ethanol supply year 2017-18 is likely to see a supply of around 150 crore litres of ethanol which will result in savings of over Rs.4000 crore of forex.

Cleaner Environment: One crore lit of E-10 saves around 20,000 ton of CO2 emissions. For the ethanol supply year 2017-18, there will be lesser emissions of CO2 to the tune of 30 lakh

ton. By reducing crop burning & conversion of agricultural residues/wastes to biofuels, there will be a further reduction in GreenHouse Gas emissions.

Health benefits: Prolonged reuse of Cooking Oil for preparing food, particularly in deep-frying, is a potential health hazard and can lead to many diseases. Used Cooking Oil is a potential feedstock for biodiesel, and its use for making biodiesel will prevent diversion of used cooking oil in the food industry.

MSW Management: It is estimated that annually 62 MMT of Municipal Solid Waste gets generated in India. There are technologies available which can convert waste/plastic, MSW to drop-in fuels. One ton of such waste has the potential to provide around 20% of the drop-in fuels.

Infrastructural Investment in Rural Areas: It is estimated that one 100klpd biorefinery will require around Rs.800 crore capital investment. At present Oil Marketing Companies are in the process of setting up twelve 2G bio refineries with an investment of around Rs.10,000 crore. Further addition of 2G biorefineries across the country will spur infrastructural investment in rural areas.

Employment Generation: One 100klpd 2G bio refinery can contribute 1200 jobs in Plant Operations, Village Level Entrepreneurs and Supply Chain Management.
Additional Income to Farmers: By adopting 2G technologies, agricultural residues/waste which otherwise are burnt by the farmers can be converted to ethanol and can fetch a price for these waste if a market is developed for the same. Also, farmers are at risk of not getting an appropriate price for their produce during the surplus production phase. Thus conversion of surplus grains and agricultural biomass can help in price stabilization

MISCELLANEOUS

6.19 GREEN FUEL

Green fuel, also known as biofuel, is a type of fuel distilled from plants and animal materials, it is generally considered as environmentally friendly and sustainable. Green fuel has evolved as a possible fueling option and an alternative for fossils.

Generally, crops are broken down into two types: sugar producing and Oil producing, while making biofuels. These sugar and starch producing crops, like sugar cane or corn, are put through a fermentation process to create ethanol. The Oil producing plants, such as the one's used in vegetable oils, can be utilized much like fossil sources of Oil; they create diesel that can be burned by cars or further processed to become biodiesel.

Recent innovations, in the field of technology, have opened new possibilities in the fields of advanced biofuels, which focus on non-food sources and waste renewal as energy. The conversion of landfill material, as well as wood and inedible plant parts, into a form called green fuel, not only the use of fossil fuels is reduced but also effectively a large amount of waste is reduced.

A new form of fuel can be called green, as it derives from green algae. Algae, often seen growing on bodies of water, is a tiny plant with a rapid growth rate. Its utility as fuel is because it has an extremely high oil content that can be processed like other oil-producing crops. Many countries have been involved in extensive research on algae, which is easy to cultivate and grows extremely quickly. One acre of algae can produce 200 times as much oil as one acre of corn.as per estimates by start-up algae oil companies,

Some critics allege that green fuel is not free from pollution-causing attributes. The processing of sugar and starch plants into ethanol has come under heavy criticism in recent years; not only do these plants take away food-growing space, but the fermentation process also releases considerable pollution into the air. Moreover, green fuel is not necessarily clean and may emit formaldehyde, ozone, and other carcinogenic substances when used or burnt.

It is not yet clear whether the green fuel currently available is the wave of the future or merely an interim step on the journey away from fossil fuel use. Governments around the world are devoting enormous resources to the research of clean, sustainable fuels to replace the pollutant and quickly disappearing oil reserves used today. Green fuel may not be a perfect solution to the problems of oil need and global protection, but it remains an important innovation that may pave the way for a better future.

6.20 ENERGY AUDIT

Today Energy has become a key determinant of production cost at the micro-level as well as in dictating the inflation and the debt burden at the macro level. Energy cost is a significant factor in economic activity at par with factors of production like capital, land and labor.due to a situation of energy shortage and need for conservation there are requirements for energy conservation measures, which essentially mean using less energy for the same level of activity.

An Energy Audit is an inspection survey, and an analysis of energy flows for energy conservation in a building. It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output. It helps in the optimization of energy costs, pollution control, safety aspects and suggests the methods to improve the operating & maintenance practices of the system. It is useful in the situation of variation in energy cost availability, reliability of supply, the decision on appropriate energy mix, decision on using improved energy conservation equipment and technology.

Objectives of Energy Audit

The Energy Audit provides the vital information base for the overall energy conservation program covering essentially energy utilization analysis and evaluation of energy conservation measures. Its objectives include:-

- Identify the quality and cost of various energy inputs.
- Relating energy inputs and production output.
- Identifying potential areas of the thermal and electrical energy economy.
- It highlights wastage in major areas.
- Fixing of energy saving potential targets for individual cost centers.
- Implementation of measures for energy conservation & realization of savings

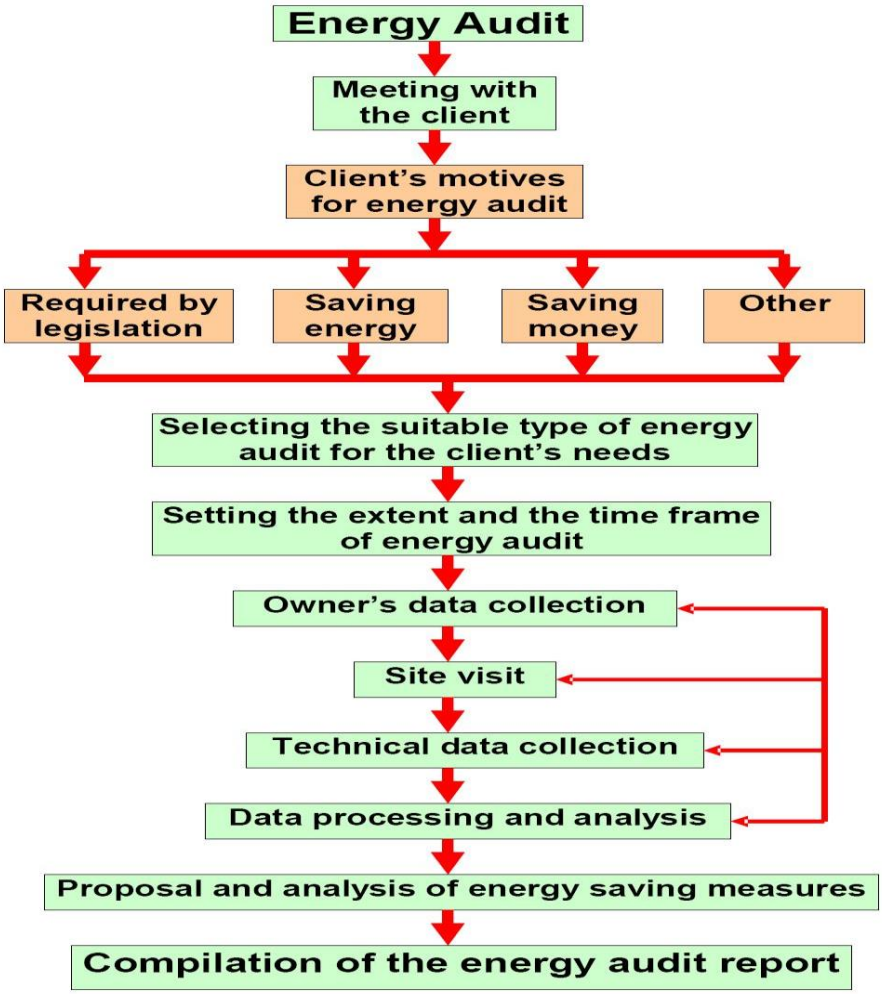


Fig: 6.31 Steps in Energy Audit

(Image source: Petroleum Conservation Research Association)

6.21 HYDROCARBON VISION-2025

The Hydrocarbon vision 2025 visualises Indian hydrocarbon sector to be a globally competitive industry benchmarked with the best in the world and promoting healthy competition in the market.

- By the year 2025, petroleum product demand would go up 4 times to about 370 million tons per annum.
- Refining capacity would go up from 112 to about 360 million tonnes at a cost of Rs 2500 billion.
- Pipeline capacity requirement would go up from 30-170 million tonnes at the cost of Rs 210 billion for transportation of about 45 percent of petroleum fuels.
- Storage capacity requirement would go up from 9-27 million tonnes, at the cost of over Rs 160 billion.

- The investment needed to set up retail outlets for the sale of about 133 million tonnes per annum of motor gasoline and diesel is estimated at Rs 930 billion.

NATIONAL ELECTRIC MOBILITY MISSION PLAN:

The National Electric Mobility Mission Plan (NEMMP) 2020 was launched by the Government of India in 2013 with the objective of achieving national fuel security by promoting electric and hybrid vehicles. The target is to achieve sales of 6 – 7 million in the hybrid and electric vehicles sector from 2020. The government will provide fiscal and monetary incentives for this industry. The expectation is that crude oil worth Rs.62000 crore will be saved due to this.

Under the NEMMP, the government has launched the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME India) scheme.

- This scheme had an initial outlay of Rs. 75 crore.
- This scheme is expected to provide a major thrust towards early adoption of electric and hybrid technologies.
- The government hopes that such vehicles will become the first and natural choice of consumers thereby slowly replacing conventional vehicles, thus helping India inch towards a pollution-free environment.
- The government envisions that by 2020, early market development via demand incentive, domestic production and in-house technology development will help this industry reach self-sufficient economies of scale.
- In 2012-13, around 42000 electric vehicles and close to 20000 hybrid vehicles were sold in India. Most of the electric vehicles were low-speed scooters. It is expected that with the government push for this sector, the market can be extended for 2 Wheeler, 3 Wheeler, 4 Wheeler, LCVs and buses.
- The government has plans to incentivise buyers buying hybrid and electric vehicles by offering monetary support. The incentive will be disbursed through an electronic mechanism or portal.
- Under this scheme, the producer of the vehicle will reduce the price of the vehicle while selling to the consumer and the same amount will be reimbursed to the manufacturer by the government.

Note: The latest update on the scheme: the government has withdrawn the subsidy given to mild-hybrid vehicles.

Four focus areas of FAME India:

Technology development	Pilot projects
Demand creation	Charging infrastructure

The NEMMP 2020 is an important scheme under the Government of India.

ENERGY STORAGE SYSTEMS:

It is a well-known fact that the intermittent nature of power supply which is provided by renewable energy sources like wind or solar create a necessity for efficient and scalable ways to store and supply electricity so that when the wind stops flowing and the sun stops glowing, even then the operators are able to provide a steady stream of power for uninterrupted use.
In this light it is necessary technologies that are being developed for storing electricity at a large scale;

Batteries

Large scale batteries are the most common example of energy storage systems. the recent ongoing innovations have improved the scalability , reliability and capacity of batteries ,thus, there has been improved longevity of the batteries for storage of energy.

Lithium-ion batteries are the most widely used form of batteries. The flexibility and the reliability of the technology is a huge benefit that makes these batteries superior in many ways to other forms of rechargeable batteries, and for that reason its developers - Dr. M. Stanley Wittingham, Dr. John Goodenough and Dr. Akira Yoshino - were awarded this year's Nobel Prize in Chemistry.

These batteries have flexibility of Technology which makes them an important component of vehicle industry system, where they can be adapted as small high-power batteries for hybrid power buffering, to medium power batteries that can provide both electric power and buffering in plug-in hybrids, to the increasingly effective high-energy batteries in electric-only vehicles.
There are several advantages of lithium-ion batteries, which is why in a 2016 study it was found that this technology accounted for 95% of deployed systems in the grid-scale battery market. But there are certain demerits as well which driving demand for other kinds of storage systems is. Some of the issues associated with these batteries are; significant cost of

production, laser efficiency for long term storage, also they can have robustness issues, with batteries liable to explode if damaged. Over time they will also degrade and require replenishment.
Lithium itself is a relatively rare mineral that must be mined at increasing costs, so also, there are sustainability issues with the disposal of batteries.

Hence, for these reasons there has been an increased push in the development of alternative batteries, with a rise in other forms in grid-scale developments over the last two to three years.

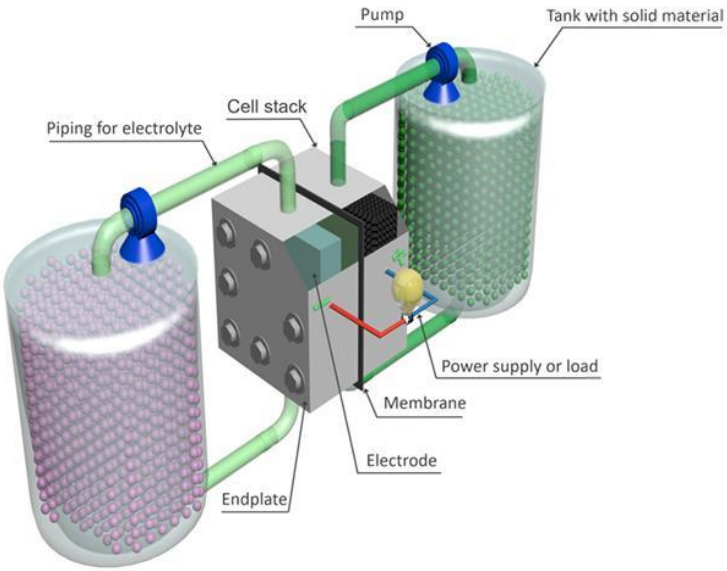


Fig. 32: Battery for energy

(Image source: Singapore university)

Thermal Energy Storage

Thermal energy storage converts energy into heat that can be reused at a later time. The basic process that it undergoes is relatively simple compared to the complex chemical processes that make up batteries, but the solutions at scale can require huge construction projects.

There are three main forms of thermal energy storage systems

Fig.6.33 Forms of thermal energy storage

Mechanical Heat Storage

Mechanical energy storage systems use kinetic or gravitational forces to store energy. Since generators use the movement of a turbine to generate electricity, these systems harness the potential force to drive that turbine for a later date.

Like thermal energy storage, it's based on a relatively simple theory, but produces some complex and imaginative results. In its simplest form it can take the shape of a weight and pulley, with the energy required to lift the weight stored as gravitational potential until it is released again. But more ambitious ideas are required in order to store grid-scale energy.

Hydrogen Energy Storage

Energy can be stored through the electrolysis of water, which separates hydrogen and oxygen molecules. Hydrogen can then be stored and then used to generate electricity in much the same way as fossil fuels - but without any emissions. It's also used effectively in fuel cells for the automotive sector.

When used in a small scale, hydrogen can be stored in pressurised vessels. But for large scale projects it is stored in underground salt caverns of up to 500,000 cubic meters, at pressures of 2,900 psi. A cavern at this size and pressure would deliver a capacity of around 100 GWh of stored electricity.