Gopalan College of Engineering and Management

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DEPARTMENT OF MECHANICAL ENGINEERING

Programme	**Bachelor of Engineering**		**Faculty Name**	**D.Sreenivasa Reddy**	
Academic Year	2023-2024	**Year / SEM**	I/I	**Semester**	ODD
W.E.F.	**01/10/2023**	**Course Name**	**RENEWABLE ENERGY SOURCES (RES/NCE)**	**Course Code**	BETCK105E/205E

NOTES

MODULE –1

Introduction to renewable energy Sources

Introduction: Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE).

CO 1	Describe the environmental aspects of renewable energy resources. In Comparison with various conventional energy systems, their prospects and limitations.
	*********VERY IMPORTANT QUESTIONS*********
01	**Define Energy. Explain the Classification of Energy Sources**
02	**Explain the Importance or Need of Renewable Energy (Non-conventional) energy resources**
03	**Discuss different ways of classification of renewable energy with example in each category.**
04	**What are the Conventional Energy Sources or Non-renewable energy Sources? List the advantages and disadvantages of conventional Energy Sources.**

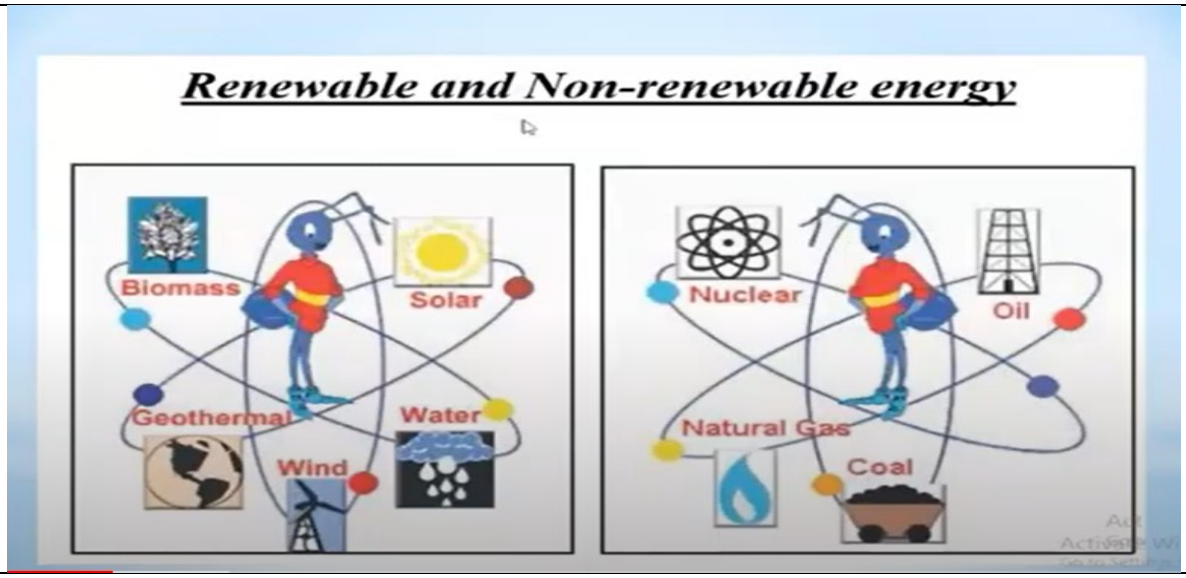
05	**Explain the Advantages &Limitations of use of renewable energy sources (Non-conventional Energy Sources.) & Explain the Importance or Need of renewable energy sources (Non-conventional energy resources).**
06	**Write the Differences between Non-renewable Energy (Conventional) Sources of Energy and renewable Energy (Non-Conventional) Source of Energy.**
07	**Explain the Principles or Scientific principles of renewable energy.**
08	**Write Short notes on Energy and sustainable development.**
09	**Explain the role of Renewable energy in Sustainable development.**
10	**Write Short notes on Fundamental and Social implications of renewable Energy.**
11	**Discuss India and worldwide renewable energy availability**
12	**Explain briefly about Solar Energy, advantages, disadvantages and applications.**
13	**Write a short note on Ocean Energy.**
14	**Explain with a neat sketch construction and working of Geothermal energy power plant.**
15	**What are the advantages, disadvantages and applications of Geothermal Energy?**
16	**Write a short note on Oil shale. (OR)With neat sketch, explain the Production of oil from oil Shale and advantages and Disadvantages (Demerits) of oil Shale.**
17	**Write a short note on Internet of Energy (IOE)**
	IMPORTANT QUESTIONS
01	**What are the needs for alternate sources of Energy?**
02	**Explain briefly about Wind Energy, advantages, disadvantages and applications**
03	**Explain briefly about Tidal Energy, advantages, disadvantages and applications.**
04	**Explain briefly about Wave Energy, advantages, disadvantages and applications.**
05	**Explain briefly about Ocean thermal Energy Conversion, advantages, disadvantages and applications.**
06	**Explain briefly about Biomass Energy, advantages, disadvantages and applications**

Q.No	Questions and Answers	
01	**Define Energy. Explain the Classification of Energy Sources**	
	The word energy 'itself is derived from the Greek word "en-ergon", which means in-work'or work content. The work output depends on the energy input.	
	Energy can be defined as the Ability to do Work. Energy is measured in the same unit as Work: Joules (J) or Kilo Joules (KJ).	
	Energy is all around us. We can hear energy as Sound. We can see energy as Light. We can Feel it as Wind.	
	Energy is the most basic infra-structure input required for economic growth & development of a country. Thus, with an increase in the living standard of human beings,the energy consumption also accelerated.	
	Classification of energy resources: **1)Based on Usability of Energy:-** **a)Primary resources:** Resources available in nature in raw form are called primary energy resources. Primary Resources consists of unconverted or Natural Fuels. They provide High Energy Yield Ratio. Energy Yield Ratio=$\frac{\text{Energy received from raw Energy Source}}{\text{Energy Spent to Obtain Raw energy Source}}$ **Ex: Fossil fuels (coal, oil & gas), uranium, hydro energy.** These are also known as raw energy resources.	
	b) Intermediate resources: This is obtained from primary energy resources by one or more steps of transformation & is used as a vehicle of energy. **c) Secondary resources:** The form of energy, which is finally supplied to consume for utilization. (The energy Resources Supplied directly to Consumer for Utilization after one or more steps of Transformation are known as Secondary or Usable Energy) Ex: electrical energy, thermal energy (in the form of steam or hot water), chemical energy (in the form of hydrogen or fossil fuels). Some form of energies may be classified as both intermediate as well as secondary sources. **Ex: electricity, hydrogen**.	
	2)Based on traditional use: **a)Conventional:** Energy resources which have been traditionally used for many decades. Ex: fossil fuels, nuclear & hydro resources **b) Non-conventional:** Energy resources, considered for large scale use over past few years & renewable are referred as Non-Conventional Energy Sources. Ex : solar, wind & bio-mass	
	3)Based on term availability: **a)Non-renewable resources:** Resources which are finite and do not get replenished (Replaced) after their	

consumption.
Ex : fossil fuels, uranium

b)Renewable resources:

Resources which are renewed by nature again & again & their supply are not affected by the rate of their consumption.
Renewable energy is Energy obtained from Sources that are essentially inexhaustible**.**
These resources are inexhaustible.
Ex: solar, wind, bio-mass, ocean (thermal, tidal& wave), geothermal, hydroelectric Power.



4.Based on commercial application:

a)Commercial energy resources:

The Energy Sources are available in the market for a definite price is known as commercial Energy.
The secondary usable energy forms such as electricity, petrol, and diesel are essential for commercial activities.
The economy of a country depends on its ability to convert natural raw energy into commercial energy.
Ex: coal, oil, gas, uranium, & hydro

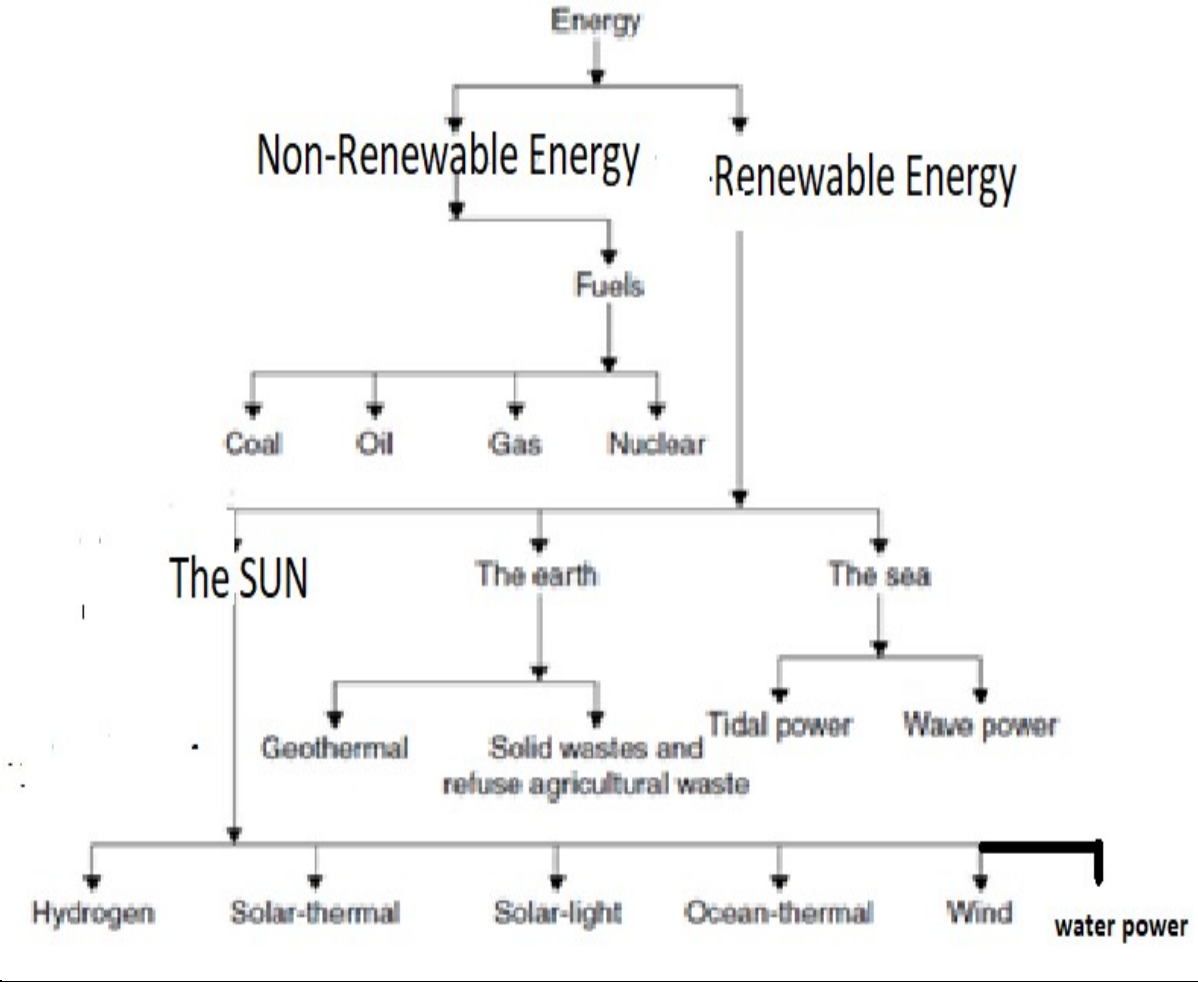
b)Non-commercial energy resources:

The Energy Sources are not available in the commercial market for a price is known as Non-commercial Energy Sources.
The energy derived from nature & used–directly without passing through commercial outlet.
Ex: wood, animal dung cake, crop residue. Agricultural Waste

5.Based on origin :

a)Fossil fuels energy
b)Nuclear energy
c)Hydro energy
d)Solar energy
e)Wind energy
f) bio-mass energy
g) geothermal energy
h) tidal energy
i) ocean thermal energy
j) ocean wave energy

02	**Explain the relationship between Energy Consumption and Standard of Living**	
	Energy Consumption and Standard of Living • The energy consumption of a nation can be broadly divided into the following areas or sectors depending on energy-related activities. ➢ Domestic sector :-(houses and offices including commercial buildings). ➢ Transportation sector ➢ Agriculture sector ➢ Industry sector • Consumption of a large amount of energy in a country indicates increased activities in these sectors. • This may imply better comforts at home due to use of various appliances, better transport facilities and more agricultural and industrial production. • All of this amount to a better quality of life. • Therefore, the per capita energy consumption of a country is an index of the standard of living or prosperity (i.e. income) of the people of the country. • Energy is the most basic infrastructure input required for economic growth & development of a country. • Thus, with an increase in the living standard of human beings, the energy consumption also accelerated. • Energy Consumption Will increasethe GDP of Country	
03	**Explain the Importance or Need of Renewable Energy (Non-conventional) energy resources**	
	1) Non-Renewable sources are finite assets, with present rate of Consumption their availability is rapidly decreasing. 2)The demand of energy is increasing by leaps & bounds due to rapid industrialization &population growth, the Non-Renewable Energy resources of energy will not be sufficient to meet the growing demand. 3)Non-Renewable Energy sources (fossil fuels, nuclear fules) also cause pollution leading to degradation of the environment.Ultimately,their use has to be restricted within accetable limits. (a)Fossil fuels generate pollutants like CO, CO_2, NO_X, SO_X. Particulate matter & heat. The pollutants degrade the environment, pose health hazards & cause various other problems. (b) **Safety of nuclear plants is difficult:** (i) The waste material generated in nuclear plants has radioactivity of dangerous level. (ii) Possibility of accidental Leakage of radioactive material from reactor. (4) Use of Non-Renewable Energy sources (fossil fuels, nuclear fuels) is mainly responsible for Global Warming. (5) Use of Non-Renewable Energy sources (fossil fuels, nuclear) is mainly responsible for ozone layer Depletion. (6)Non-Renewable Energy sources are bound to finish one day. (7)Fossil fuels are also used as raw materials in the chemical industry (for chemicals, medicines, etc) & need to be conserved for future generations. (8)Renewable Energy Resources are Inexhaustauble,Environmental Friendy,Freely	

	and abundantly availble in Nature. Due to these reasons it has become important to explore & develop Renewable Energy resources (non-conventional energy resources) to reduce too much dependence on Non-Renewable Energy resources. However, the present trend development of Renewable Energy resources indicates that these will serve as supplements rather than substitute for Non-Renewable Energy resources for some more time to time.	
04	**Discuss different ways of classification of renewable energy with example in each category.**	
		
	Energy Resources From Sun:	
	Solar energy or Solar Thermal Energy- It is the Heat energy radiated form Sun. Example:Solar water Heaters. **Solar-Light Energy: It is the Light energy radiated from Sun is used for photosynthesis of plants to make food.** **Hydel Energy or Water Power-Energy obtained from water.** **Example :Hydro Electrical Power Plants.** **Wind Energy-Energy from the flow of Wind.Examples :Wind Turbines/Wind Mills.** **Ocean Thermal Energy-It is the Heat energy obtained from the surface of water in oceans. Ocean Thermal Energy Conversion Power Plants**	

	Green Energy or Hydrogen Energy:-It is the energy obtained from Hydrogen in Atmosphere.Examples :-Hydrogen Cars and Busses.	
	Energy Resources From Earth:	
	Geothermal Energy-It is the heat energy stored deep inside the earth. **Examples:Geothermal Power Plants,Geothermal Heating/Cooling of Buildings.** **Biomass Energy-Energy obtained from the organic matter of plants and Animals.** **Example:Bio Diesel Plants,Bio gas Generation. Ethanol/&Methane gas production.**	
	Energy Resources From Sea or Oceans:	
	Tidal Energy-It is the energy obtained from the Tides in oceans. **Example:Tidal Power Plants.** **Ocean Wave Energy-It is the energy obtained from the Waves in oceans** **Example:Wave Energy Power Plants,Wave Energy Converting Devices.**	
05	**What are the needs for alternate sources of Energy?**	
	The need for alternatives: **1**. The average rate of increase of oil production in the world is declining & a peak in production may be reached around 2021. There after the production will decline gradually & most of the oil reserves of the world are likely to be consumed by the end of the present century. The serious nature of this observation is apparent when one notes that oil provides about 30% of the world's need for energy from commercial sources & that oil is the fuel used in most of the world's transportation systems. **2.** The production of natural gas is continuing to increase at a rate of about 3.5% every year. Unlike oil, there has been no significant slowdown in the rate of increase of production. Present indications are that a peak in gas production may occur between 2022 and 2046. 3. As oil & natural gas becomes scarcer, a great burden will fall on coal. It is likely that the production of coal will touch a maximum somewhere between 2040 and 2060. 4. Finally, it should be noted that in addition to supplying energy, fossil fuels are used extensively as feed stock material for the manufacture of organic chemicals. As resources deplete, the need for using fossil fuels exclusively for such purposes may become greater.	
06	**What are the Non-Renewable (Conventional Energy) Sources? List the advantages and disadvantages of Non-Renewable(conventional) Energy Sources.**	**10M**
	Fossil Fuels, Nuclear Fuels and Oil Shale are Considered as **Non-Renewable** Energy Sources Fossil Fuels:- Coal, Crude oils (Oil), Natural gas,Oil Shale	
	ADVANTAGES: 1) **Coal:** at present these are cheaper than nonconventional sources. 2) **Security:** As storage is easy and convenient. By storing certain quantity, the energy availability can be ensured for a certain period. 3) **Convenience:** These sources are very convenient to use.	

DISADVANTAGES:

1) Fossil fuels generate pollutants: CO, CO_2, NO_X, SO_X. Particulate matter & heat. The pollutants degrade the environment, pose health hazards & cause various other problems. CO_2 is mainly responsible for Global Warming.

2) Coal: It is also valuable petro-chemical and used as raw material for chemical, pharmaceuticals & paints, industries, etc. From long term point of view, it is desirable to conserve coal for future needs.

3) Safety of nuclear plants is difficult:

a) The waste material generated in nuclear plants has radioactivity of dangerous level.
b) Possibility of accidental Leakage of radioactive material from reactor.
c) Sophisticated Technology is required for using nuclear resources.

07 **Explain the Advantages &Limitations of use of Renewable (Non-conventional)Energy Sources** **10M**

ADVANTAGES:

1.Freely available in nature.(NCES are available in nature free of cost)
2. They produce no or very little pollution.
3. They are environmental friendly.
4. They are inexhaustible.
5. They have low gestation period.
6. They are Renewable source of energy.
7. They are available in abundance.
8. Renewable sources require less maintenance as compared to non-renewable energy sources.
9. Although their initial cost is high, once they are installed, you can benefit from them for a lifetime.
10. They will reduce the Power Bill.
11. They will reduce the Global Warming.
12. They will reduce Ozone layer Depletion.

DIS ADVANTAGES:

1) In general, the energy is available in dilute form from these sources.
2) The cost of harnessing energy from NCES is generally high
3) **Uncertainty of availability:** The energy flow depends on various natural phenomena beyond human control.
4) Difficulty in transporting this form of energy.
5) Difficulty in storage.
6) Low Efficiency Levels.
7) Inconsistent, unreliable supply (Depends upon weather, atmospheric conditions and the environment).
8) The storage cost of renewable energy is very high, and also it requires a lot of space for its installation.

08 **Write the Differences between Non-renewable Energy (Conventional) Sources of Energy and renewable Energy (Non-Conventional) Source of Energy.**

SNO	**Renewable(Non-Conventional) Energy resources**	**Non Renewable(Conventional Energy resources**
1	These are inexhaustible.	These are exhaustible.
2	Energy resources are continuously restored by nature after utilization.	Energy sources once used cannot be recovered any more.
3	Energy resources are present in unlimited quantities in nature.	Energy resources are present in limited quantities in nature.
4	These Sources are environment	Not Environment Friendly due to

			Friendly,(Except Biomass) When Suitably harnessed.	emission of Green house gasses and harmful pollutants.	
		5	Initial cost for utilizing energy sources is high, but operating and maintains costs are low.	Both initial and maintenance costs are comparatively high	
		6	The Total cost of these resources is low	The Total cost of these resources is Comparatively high.	
		7	Availability of energy is intermittent and hence continuous supply of energy and also in large quantities is not possible.	Large Quantities of energy With continuous Supply of energy is Possible.	
		8	The intermediate nature of available energy calls for storage devices, which is expensive, Especially for large-scale purpose.	No such Problems	
		9	Energy extraction depends on various natural phenomenons' that lie beyond human control.	Comparatively no complications.	
		10	Requires large land area for the installation of the power plants	Requires less land area for the installation of the power plants	
		11	Ex:Solar Energy, Wind energy,	Example:Coal,oil,Natural gas,etc.	
09	**Explain the Principles or Scientific principles of renewable energy.**				
	Scientific principles of renewable energy **1.Energy Currents (Availability)** **2. Dynamic characteristics** **3. Dispersed versus centralized energy** **4. Quality of supply** **5. Situation dependence** **6. Complex systems**				
	1.Energy Currents (Availability) • It is essential that a sufficient renewable current is already present in the local environment. • It is not good practice to try to create this energy current especially for a particular system. • The practical implication of this principle is that the local environment has to be monitored and analyzed over a long period to establish precisely what energy flows are present. • The energy current ABC must be assessed before the diverted flow through DEF is established.				

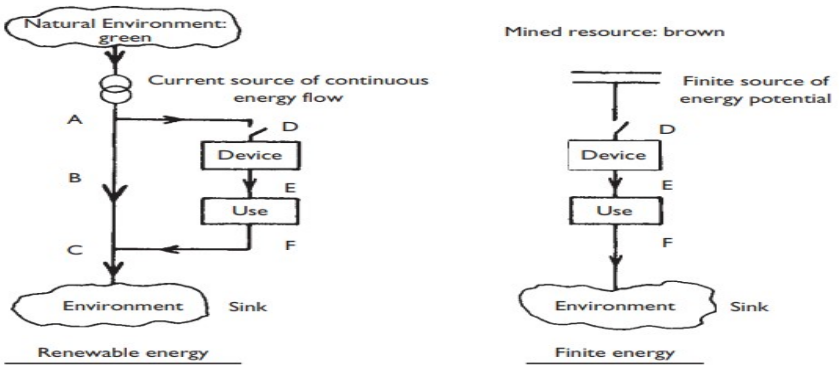


Figure 1.1 Contrast between renewable (green) and finite (brown) energy supplies. Environmental energy flow ABC, harnessed energy flow DEF.

2.Dynamic characteristics

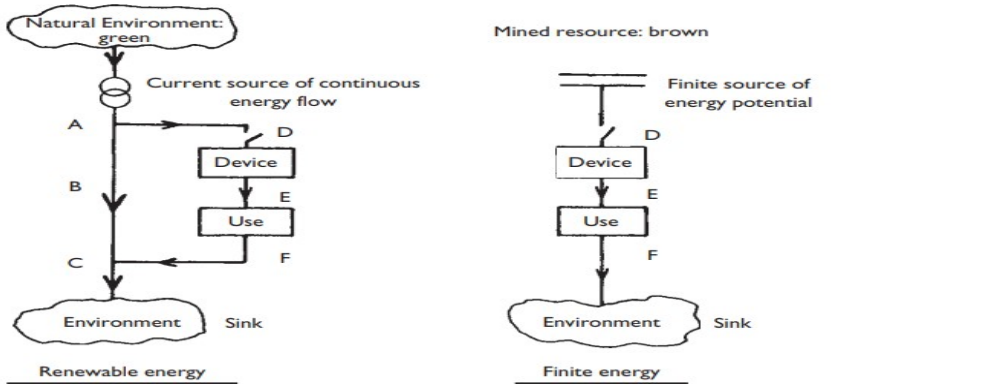
- End-use requirements for energy vary with time.
- For example, electricity demand on a power network often peaks in the morning and evening, and reaches a minimum through the night.
- If power is provided from a finite source, such as oil, the input can be adjusted in response to demand.
- Unused energy is not wasted, but remains with the source fuel.
- However, with renewable energy systems, not only does end-use vary uncontrollably with time but so too does the natural supply in the environment.
- Thus a renewable energy device must be matched dynamically at both D(Supply) and E(Demand) Figure 1.1; the characteristics will probably be quite different at both interfaces.
- The major periodic variations of renewable sources may well be greatly affected by irregularities.
- Systems range from the very variable (e.g. wind power) to the accurately predictable (e.g. tidal power).
- Solar energy may be very predictable in some regions but somewhat random in others.
- The requirements for energy usage (demand) vary dynamically must be match with dynamically available (Supply) renewable energy source in the local Environment.

3.Dispersed versus centralized energy

• Many non renewable energy is most easily produced centrally and is expensive to distribute.
• Renewable energy is most easily produced in dispersed locations and is expensive to concentrate.

4.Quality of supply

• Quality is defined as the proportion of an energy source that can be converted to mechanical work.

	• Renewable energy supply systems divide into three broad divisions: 1. Mechanical supplies, 2. Heat supplies, 3.Photon processes. 1. Mechanical supplies, such as hydro, wind, wave and tidal power. • The mechanical source of power is usually transformed into electricity at high efficiency. • The proportions are, commonly, wind 35%, hydro 70–90%, wave 50% and tidal 75%. 2. Heat supplies, such as biomass combustion and solar collectors. • These sources provide heat at high efficiency. 3. Photon processes, such as photosynthesis and photochemistry and photovoltaic conversion. • The broad band of frequencies in the solar spectrum makes matching difficult and photon conversion efficiencies of 20–30% are considered good.	
	5.Situation dependence • No single renewable energy system is universally applicable, since the ability of the local environment to supply the energy and the suitability of society to accept the energy vary greatly. • It is also necessary to conduct energy surveys of the domestic, agricultural and industrial needs of the local community. • Particular end-use needs and local renewable energy supplies can then be matched, subject to economic and environmental constraints.	
	6.Complex systems: • Renewable energy supplies are intimately linked to the natural environment, which is not the preserve of just one academic discipline such as physics or electrical engineering.	
10	**Write a Short notes on Energy and sustainable development.(or)**	
	 *Figure 1.1* Contrast between renewable (green) and finite (brown) energy supplies. Environmental energy flow ABC, harnessed energy flow DEF.	

- **This concept refers to generating energy with an awareness of the future** (ie. In a way that would enable future generations to meet their energy needs too).
- **Sustainable development can be broadly defined as living, producing and consuming in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs**.
- Energy for Sustainable development can be defined as the Development of obtaining, distributing, and exploiting the energy sector based on Sustainability principles.
- **Energy Strategies used for Sustainable Development.**

(1)Energy savings on the Demand side.
(2)Efficiency Improvements in the Energy Production.
(3)Replacement of Fossil fuels by various sources of renewable energy

- It has become a key guiding principle for policy in the 21st century.
- A sustainable global energy system should provide to optimize efficiency and limit emissions.
- The aim of sustainable development is for the improvement in quality of life & standard of living to be achieved at the same time as (whilst) maintaining the ecological processes on which life depends.
- Renewable energy supplies are much more compatible with sustainable development than are fossil and nuclear fuels, in regard to both resource limitations and environmental impacts.
- Renewable Energy plays a crucial role in achieving sustainability by addressing environmental concerns, enhancing energy security, fostering economic growth, and improving Social well-being.
- By reducing greenhouse gas emissions, mitigating air and water pollution, diversifying energy sources, creating jobs, and promoting public health, renewable energy contributes to a more sustainable and resilient future.
- Consequently almost all national energy plans include four vital factors for improving or maintaining social benefit from energy:

1. increased harnessing of renewable supplies
2. increased efficiency of supply and end-use
3. reduction in pollution
4. Consideration of lifestyle.

Importance of Sustainable Development

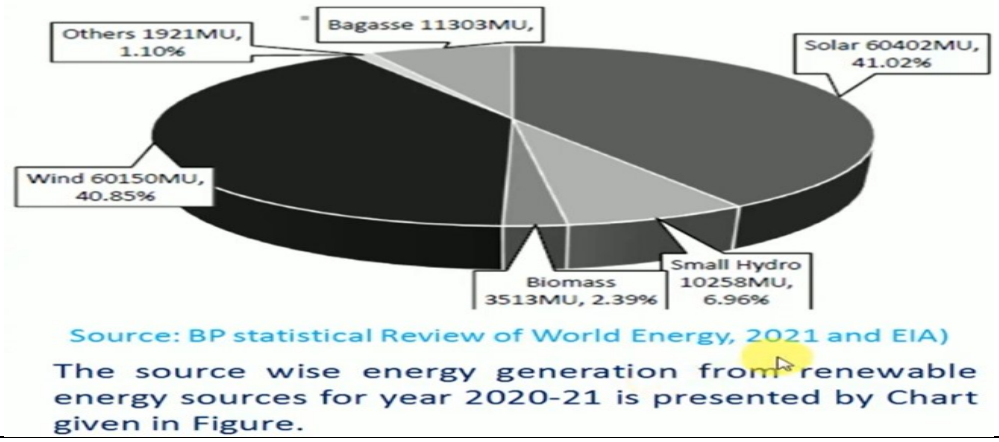
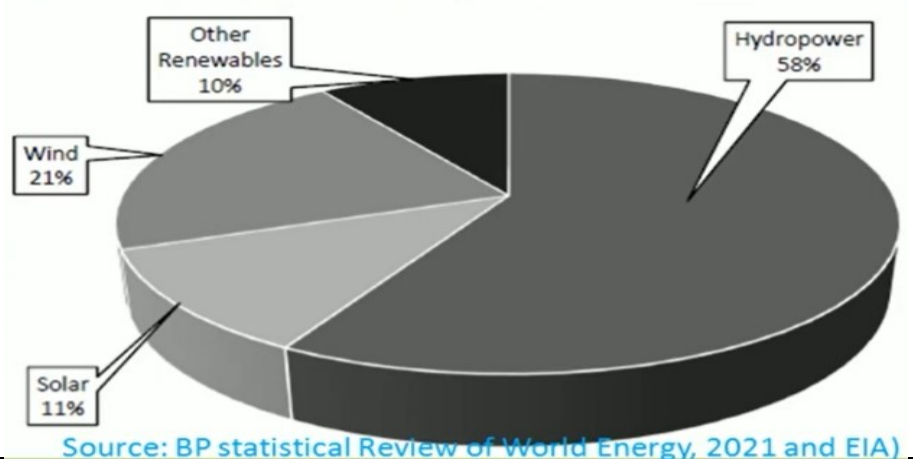
•Following are the importance of sustainable development:

1. Using the available resources judiciously and working towards

	maintaining the ecological balance. 2.To prevent degradation of the environment and laying emphasis on protecting the environment. 3. To prevent overexploitation of resources.	
11	**Explain the role of Renewable energy in Sustainable development.**	
	Sustainability is the concept of meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. It encompasses various aspects, including environmental, social, and economical considerations.	
	• The sources of Electricity production Such as Coal, oil, and Natural gas have contributed to one-third of global greenhouse gas emissions.	
	• One Crucial component of Sustainability is the transition to Renewable energy sources. • Renewable Energy plays a crucial role in achieving sustainability by addressing environmental challenges, Promoting energy security, fostering economic growth, and improving Social well-being.	
	1.Environmental Benefits:	
	Reduced Greenhouse gas Emissions: Renewable energy Sources such as solar, wind, hydro, and geothermal power produce little to no green house gas emissions during operation. By replacing fossil fuels, they mitigate climate change and contribute to a cleaner and healthier Environment.	
	Air and Water pollution Reduction:	
	• Unlike conventional energy sources, renewable energy does not release harmful pollutants such as Sulfur dioxide, Nitrogen oxide, and Particulate matter. • Consequently, it improves air Quality, reduce respiratory illnesses, and Protects ecosystems from acid rain. • Moreover, Renewable energy projects often have less water-intensive operations, Minizing stress on local water resources.	
	Conservation of natural Resources:- • Renewable energy sources harness the power of abundant, naturally replenished resources, such as sunlight, wind and water. • This reduces reliance on finite resources like fossil fuels, which are depleting and contribute to environmental degradation during extraction, transportation and Combustion.	
	2. Energy Security and Economic Benefits.	
	Diversification of Energy Sources:-	

	• Relying heavily on fossil fuels for energy leaves economies vulnerable to price fluctuations and Geopolitical Tensions. • Incorporating Renewable energy sources diversifies the energy mix, reducing dependence on imported fuels and increasing energy security.	
	Job creation and Economic Growth:- • The renewable energy sector has shown remarkable potential for job creation. • Investments in renewable energy infrastructure, manufacturing ,Installation, and maintenance provide employment opportunities, driving economic growth and contributing to local communities, • Studies have indicated that the renewable energy industries can create more jobs per unit of energy generated compared to fossil fuel-based energy..	
	Cost competitiveness and Price Stability: • Technological Advancements and Economies of scale have made renewable energy increasingly cost-competitive. • Solar and wind power, in particular, have experienced significant cost reductions in recent years. This price stability offers advantages over fossil fuels.	
	3.Social Benefits	
	Improved Public Health: • The transition to Renewable energy reduces the Emission of pollutants that are detrimental to human health. • Cleaner air and water contribute to a decrease in respiratory diseases, Cardiovascular issues, and other illnesses associated with pollution.	
	Access to Energy:- • Renewable energy offers the potential to provide electricity to remote and underserved areas. • Off-grid renewable solutions, such as Solar panels and Micro-hydro systems, can bring electricity to communities without access to traditional grid infrastructure, empowering them with opportunities for education, health care, and Economic development.	
	Resilience and Disaster Mitigation: • Renewable energy systems, particularly distributed generation from sources like solar panels, can enhance resilience of energy infrastructure. • In the face of natural disasters or grid failures, decentralized renewable energy systems can provide electricity, enabling critical services to function and improving disaster response and recovery.	

12	**Write short notes on fundamental and social implication of Renewable energy.**	
	Fundamental Implication (Advantages & Disadvantages) **Advantages:-** 1. Less Global Warming. 2. Improved Public Health. 3. In exhaustible Energy. 4. Stable energy Prices. 5. Jobs and other Economic Benefits. 6. Reliability and Resilience.	
	Disadvantages:- **1. Renewable energy is not available round the clock.** **2. The Efficiency of renewable technologies is low.** **3. The initial cost of Renewable energy is high.** **4. Renewable energy sites require a lot of Space.** **5. Renewable energy devices require recycling.**	
	Social Implication(Advantages & Disadvantages) **Advantages:-** 1. Poverty Elimination. 2.Climite change mitigation(reduces the changes in climate/effective mitigation of climate change). 3. Improving the health by reducing pollution associated with gas emissions. 4. Socio economic stability in people will Improve. **5.** Reducing water Pollution and Air Pollution. 6. Improving the Standard of living of People.	
	Disadvantages:-	
	1. Dispersed living. • Renewable energy arrives dispersed in the environment and is difficult and expensive to concentrate. • Non renewable energy sources are energy stores that are easily concentrated at source and expensive to disperse. **2. Pollution and environmental impact.** • Renewable energy is always extracted from flows of energy already compatible with the environment. The energy is then returned to the environment, so no thermal pollution can occur on anything but a small scale. • Material and chemical pollution in air, water tend to be minimal. • An exception is air pollution from incomplete combustion of biomass.	
13	**What are Different names of Renewable Energy resources**	
	• Renewable energy resources **(OR)** **• Non-Conventional Energy resources** **(OR)** **• Green energy sources** **(OR)** **• Sustainable energy sources**	

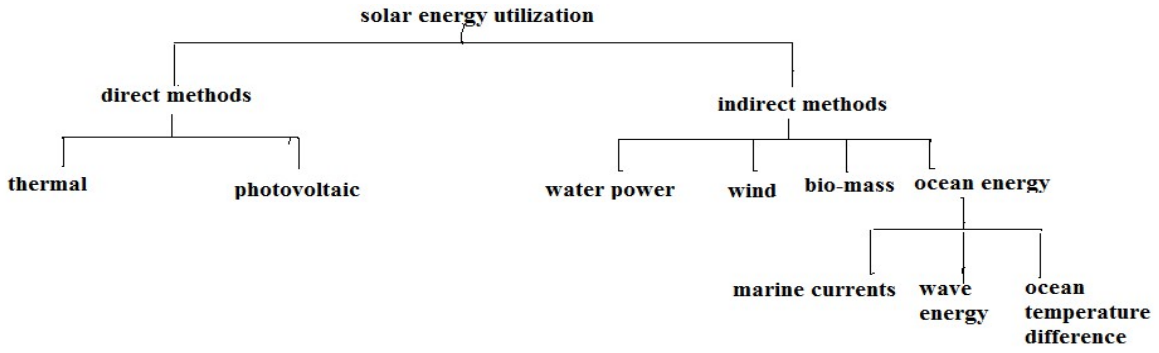
14	**Discuss India and worldwide renewable energy availability, (or) Discuss renewable energy availability in India.(or)Discuss renewable energy availability in worldwide.**	
	Renewable energy availability in India	
	 Source: BP statistical Review of World Energy, 2021 and EIA) The source wise energy generation from renewable energy sources for year 2020-21 is presented by Chart given in Figure.	
	• Renewable Energy has a Share of 26.53%in the total installed capacity in the Country. • India is on the third position in renewable energy country index 2021 and ranked 4th for the total installed renewable energy capacity with installed capacity of around 159.95GW as on 31st March 2022.	
	• India's installed renewable energy capacity has increased by 39.6% in the last 8.5years. • India has set a goal to achieve renewable energy installed capacity of 175GW with 100GW of solar, 65GW of wind, 10GW of Bio power by end of 2022. • As of March 2022, the total renewable energy installed capacity in India was 159.95GW.The shares of solar and other Renewable Energy resources are as follows. • Solar power—56.6GW. • Biopower---11.93GW. • Small Hydro power—4.83GW. • Large Hydro power---46.51GW. • Wind energy----40.08GW.	
	Renewable energy availability in World.	
	 Source: BP statistical Review of World Energy, 2021 and EIA)	

	• The use of energy based on the renewable energy Sources is greatly increasing around the world. • A transformation is observed from conventional energy use towards renewable energy. • In recent years the growth rate in the renewable energy market is higher as compared with the growth rate in the conventional fuel market. • The share of renewable energy to the total global energy was about 8.6%with 437GW installed capacity in the year 2010. • It was increased by more than 2.5 times in 2017and reached to 1236GW with share of 18.2% of total installed capacity. • It was further increased by 22.5%in the year 2020and reported as 2802GW. • It was increased to 3064GW in 2021. • The largest share in the total was of hydropower in 2021. • Hydropower generation capacity was 1230GW with percentage share of about 58%. • Wind and solar accounted for21% and 11% share, respectively. • The share of other renewable energy sources which includes geothermal, bioenergy,waste,tidal and wave energy was about 10% to the total renewable energy installed capacity. • The percentage share of different renewable energy sources is presented in figure for the year 2021.	
15	**Explain briefly about Solar Energy,advantages,disadvantages and applications.**	
	What Is Solar Energy? • Solar energy is defined as the transformation of energy(nuclear fusion) that is present in the sun. (Energy from the sun is called solar energy).Solar energy is a very large, inexhaustible source of energy.	
	• The Sun's energy comes from nuclear fusion reaction that takes place deep in the sun.	
	• Hydrogen nucleus fuses into helium nucleus. • The energy from these reactions flow out from the sun and escape into space. • Solar Energy is available in the form of Electromagnetic radiation. • These are different kinds of radiant energy emitted by sun. The most important are light infrared rays, Ultra violet rays, and X- Rays. • Solar energy reaching the top of the Earth's atmosphere consists about 8% U.V radiation, 46% of visible light, 46% Infrared radiation. • This energy is radiated by the Sun as electromagnetic waves of which 99% have wave lengths in the range of 0.2 to 4 micro meters. • Solar energy is sometimes called radiant energy.	
	• Solar power where sun hits atmosphere is 10^{17} watts, whereas the solar power on earth's surface is 10^{16} watts.	

• The total world wide power demand of all needs of civilization is 10^{13} watts.
• Ie. Sun gives us 1000 times more power than we need.
• solar energy could supply all the present & future energy needs of the world on a continuing basis. This makes it one of the most promising of the unconventional energy sources.

- All life on the earth depends on solar energy.
- Solar energy is received in the form of radiation, can be converted directly or indirectly into other forms of energy, such as heat & electricity.

Classification of methods for solar energy utilisation



Merits of solar energy /Advantages of solar energy

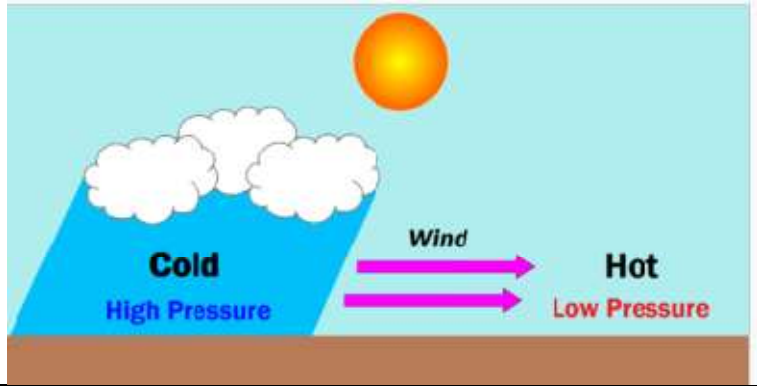
- Solar energy is a renewable source of energy, and it is available in large amounts.
- It is inexhaustible source of energy
- It is available free of cost in the environment.
- It is a pollution-free source of energy.
- It is available on almost every part of the Earth.
- It is a reliable source of energy.
- Low maintenance cost.
- Provide power in remote areas.
- Silent operation.
- No fuel costs, low operating & maintenance cost.
- Quick installation

Demerits of solar energy:/Dis advantages of solar energy.

1. **It is a dilute source of energy**

(Because even in hottest region the ra diation flux is available only 1 KW/m^2 & total radiation over a day is 7 KW/m^2. These are low values from the point of view of technological utilization.)

2. **Expensive-Installation and the initial cost of the materials are**

	expensive. 3. **It is required large collecting areas are required in many applications & these results increase of cost.** 4. **Solar energy storage is expensive.** 5. **Solar energy availability varies widely with time and local weather condition.(** It occurs because of the day-night cycle & also seasonally because of the Earth's orbit around the Sun [even local weather condition]. 6. **Needs more space.** 7. **Weather Dependent.** 8. **Solar energy is scattered, So it gets wasted.** 9. **Low energy density**	
	Uses of Solar Energy	
	1) Water heating (2) Heating, Cooling, ventilation of residential building (3) Heating of swimming pools (4) Solar drying of agricultural & animal products (5) Salt production by evaporation of sea water (6) Cooking purposes(7)Water Treatment-Desalination & disinfection of water(8)Solar engines for water pumping(9)Solar furnaces(10)Solar refrigeration.(11)Electricity generation -Solar PV cells & Concentrated solar power(12) Solar distillation (13)Solar production of hydrogen	
16	**Explain briefly about wind energy,advantages,disadvantages and applications.**	
	Wind Energy • Wind power is the process of harnessing energy from the movement of the wind and converting it to useful forms of mechanical power and electricity. • Wind is formed due to uneven heating of the Earth's surface. These surfaces absorb heat at different rates; for example sand on a beach can be too hot to walk on while nearby grass feels cool. As these surfaces absorb heat at different rates, the air just above the surface warms and begins to rise. The rising hot air creates a change in pressure in the area. Air naturally moves from the areas of high pressure to low pressure, which causes the horizontal movement of air.	**10**
		

Wind Farms

- As the name itself suggests, a wind farm is a collection of wind turbines which collectively power a given area.

Types of wind turbines

- Horizontal Axis Wind Turbine (HAWT)-Wind turbines that rotate around a horizontal (like a wind mill) axis.
- Vertical axis Wind Turbine (VAWT)-Wind turbines that rotate around vertical axis, are less frequently used (Savonius and Darrieus are the most common in the group).
- In India high speed winds are available in coastal areas of Saurashtra, Rajasthan and some parts of central India.

Wind Mill Types:

1. Multi-blade type Wind Mill
2. Sail type
3. Propeller type

Horizontal Axis

4. Savonius type
5. Darrieus type

Vertical Axis

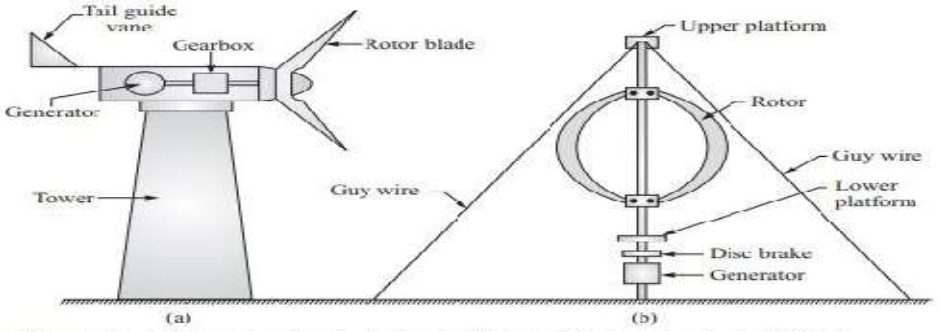


Figure 1.5 Horizontal and vertical axis windmills. (a) Horizontal axis windmill and (b) vertical axis windmill

Advantages

- Very clean form of energy
- Sustainable method of power generation
- No complex maintenance necessary
- Wind as a free resource
- Reduced energy costs for whole countries
- Power production in remote areas
- Creation of numerous jobs
- Needs lesser space for installation

Disadvantages

- Visual landscape impairment
- Negative impact on wildlife
- High noise level

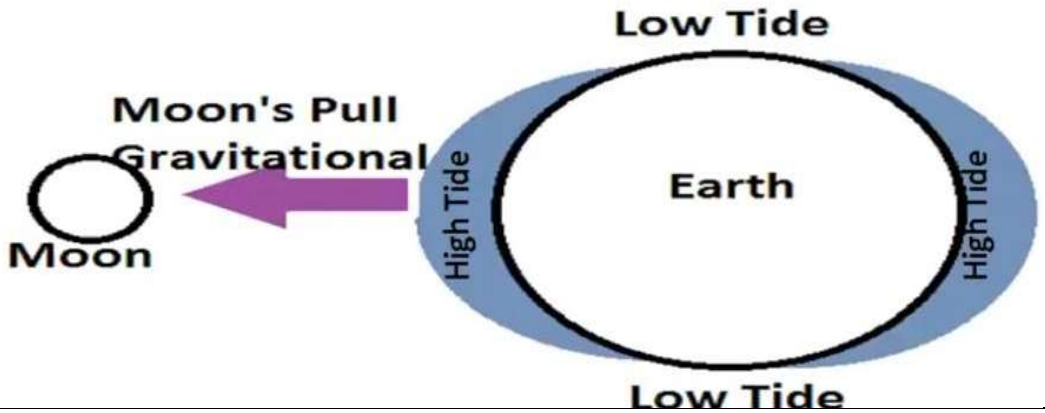
	• Hidden costs • Unsteady wind, unreliable source of energy • Difficulty in finding suitable areas	
	Uses of wind energy	
	• Generating electricity. • Milling grain. • Pumping water. • powering cargo ships • Reducing carbon footprint. • Sailing. • Windsurfing.	
17	**Briefly Describe energies from ocean.**	
	(1)Hydro power(2)Wave energy(3)Tidal Energy(4)Ocean thermal Energy conversion(OTEC)	
	(1)Hydro-power- • Solar heating evaporates water from the surface of the oceans, forms clouds, and condenses as rain falls over land, Causes Rivers to flow to dams that generate Electricity. • Potential energy of water (Stored water in Dam) is used for generating the Electricity/power.	
	(2)Wave energy: • Winds Generate large ocean waves that can be used to generate power from its potential energy and Kinetic energy. • Potential energy and Kinetic energy of ocean waves is used for generating the Electricity /Power. • wave power converts the periodic up-and-down movement of the oceans waves into electricity by placing the equipment on the surface of the oceans that capture the energy produced by the wave movement and converts this mechanical energy into electrical power	
	(3)**Tidal energy:-** • Tidal energy caused by the lunar and solar gravitational Forces. Acting together with that from the earth on the ocean waters to cteate tidal flows manifested by the rise and fall of waters that vary daily and seasonally from few centimeters up to 8-10meters in some parts of world. • The potential energy of the tides is tapped to generate power.	
	(4) Ocean thermal Energy conversion(OTEC)	

- Temperature gradient between the surface and bottom of ocean can be utilized in a heat engine to generate power.
- **Temperature of Surface water of sea is around 25^0C-35^0C**
- **Temperature of Deep water of sea is around 3^0C-7^0C(1000m depth)**
- This temperature difference between Surface water and Deep water of sea is used to produce Electricity.

18 **Briefly Describe about Tidal Energy(or) Briefly Describe about Advantages, Disadvantages and Applications of Tidal Energy,**

Tidal Energy:-

- **Tidal Energy converts the energy of tides into the useful form of power,mainly in electricity.**
- **Tides are periodic rise and fall of water level of sea which are caused by the action of sun and moon on the water on the earth.**
- **They are mainly caused by the gravitational attraction of the moon&sun on the water of solid earth and Oceans.**



List out the advantages and disadvantages of Tidal plants.

Some advantages of tidal energy are:

- Environment-friendly
- A highly predictable energy source
- High energy density
- Operational and maintenance costs are low
- An inexhaustible source of energy.
- It's a Renewable Source of Energy.
- It Generates Energy at Low Speeds

Some of the disadvantages of tidal energy are:

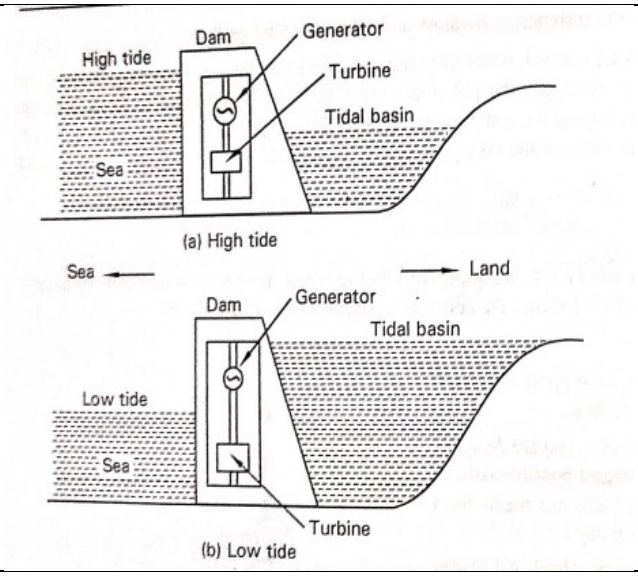
- High tidal power plant construction costs
- Negative influence on marine life forms
- Location limits
- The variable intensity of sea waves.
- Maintenance and Corrosion are an Issue

Uses of Tidal Energy/ Applications:-

- Tidal Electricity
- Grain Mills
- Energy Storage- Tidal Barrages and reservoirs can be modified to store energy.
- Provide Protection to Coast during High Storms-Tidal Barrages are capable to prevent damage to the coast during high storms.

19 **Explain about Working Principal of Tidal Energy.**

- ❖ Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the moon and the Sun, and the rotation of the earth.
- ❖ Tidal power plant is a power-generating station that harnesses the energy of ocean tides, which contains a large amount of Potential energy.
- ❖ Tides are of two types: High Tide and Low Tide.
- ❖ When the level of water is above the mean sea level, it is called high tide or flood tide, and when the level of water is below the mean sea level, it is called low tide or ebb tidew.



Construction & Working

- ❖ **A** tidal dam or barrage is built in such a way that the basin gets separated from the sea resulting in a pressure difference in the water level between the basin and the sea.
- ❖ Inside the dam, water turbine and flood gates (Sluice gate) are installed as shown in the figure (a).

Hide Tide

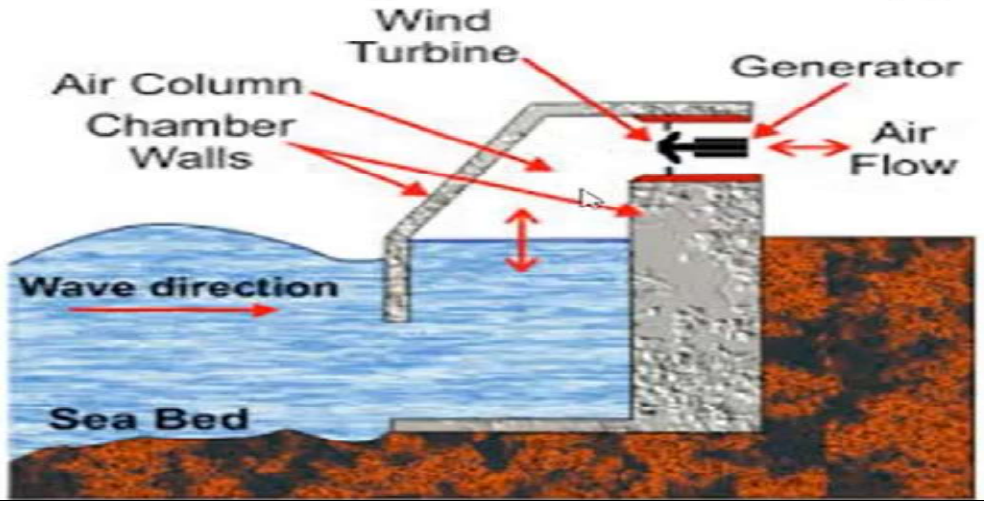
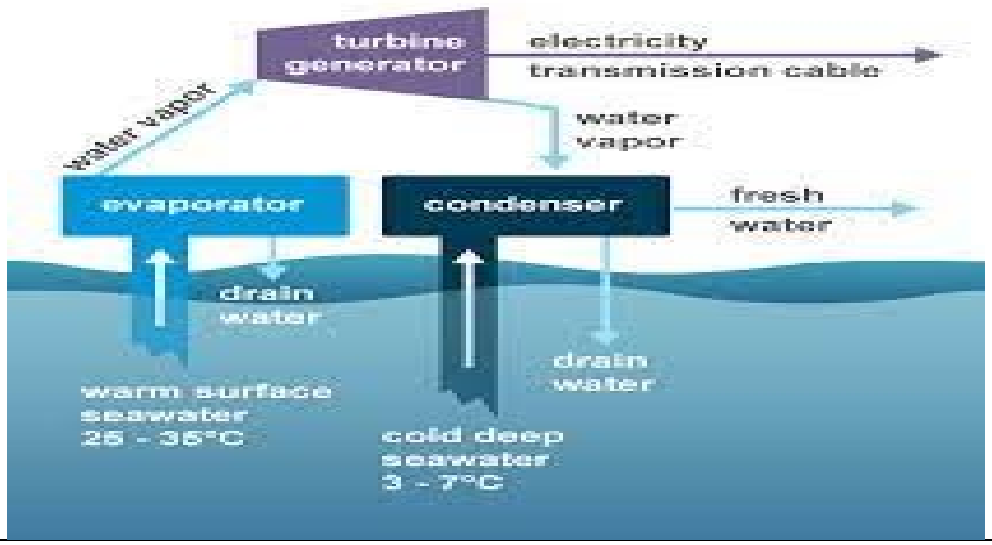
- ❖ During the high tide period, the level of tide in the sea is more than the level of water in the tidal basin. Refer figure.
- ❖ The opening of the flood gates (Sluice gate) thereby causes the tide to flow from the sea into the basin through the water turbine.
- ❖ The flowing water drives the turbine and in turn operates the generator to produce electricity.

Low Tide

- ❖ During the low tide period, the level of water in the tidal basin is more than that of the tide in the sea. Refer figure (b).

	❖ The opening of the flood gates causes the water to flow from the tidal basin to the sea through the water turbine. ❖ The flowing water drives the turbine and in turn operates the generator to produce electricity. ❖ The turbines are designed to be driven by the energy of the water in both the directions. ❖ The generation of electricity stops only when the level of water in the sea and the tidal basin are equal.	
	❖ Power generated during emptying and Filling the Basin. ❖ Reversible Turbine and Dual rotation generator are used in double cycle System.	
20	**Briefly Describe about wave energy (or) Briefly Describe about Advantages, Disadvantages and Applications of wave energy,**	
	❖ The unequal solar heating of the earth generates wind and wind ❖ Blowing over water generates waves. (or) ❖ Differential warming of the earth causes pressure differences in the ❖ atmosphere, which generate winds. ❖ As the wind move across the surface of open bodies of water, they transfer some of their energy to the water and Create waves. ❖ Wave energy is one from of the renewable energy source that uses the power of the waves to generate electricity ❖ wave energy uses the vertical movement of the surface water that produces tidal wave ❖ wave power converts the periodic up-and-down movement of the oceans waves into electricity by placing the equipment on the surface of the oceans that capture the energy produced by the wave movement and converts this mechanical energy into electrical power **Advantages** ❖ Available 24/7 on 365 days-therefore power produced from them is much steadier and more predictable. ❖ Waves can be accurately predicted 48 hours in advance and therefore forecast energy output (But irregularity in Wave amplitude, and direction). ❖ Good data on waves from wave monitoring buoys. ❖ Wave energy contains 1000 times Kinetic energy of Wind .(Can produce the same amount of power in Less space) ❖ Wave power is a renewable source of energy. ❖ A large amount of energy can be generated. ❖ It is a reliable source of energy. ❖ It is highly predictable. ❖ Wave Energy is a pollutant-free. ❖ Low operation cost. ❖ Sea waves have high energy densities and provide a consistent stream of Electricity generation capacity. ❖ It has no greenhouse gas emissions or water pollutants.	

	❖ Operating cost is low and operating efficiency is optimal. ❖ Damage to ocean shoreline is reduced. ❖ Wave energy is clean source of energy with limited negative environmental impacts. **Disadvantages:-** 1. High construction costs. 2. Marine life is disrupted and displaced. 3. Damage to the devices from strong storms and corrosion create problems. 4. Wave energy devices could have an effect on marine and recreation environment. 5. Marine life impact. 6. Difficult to transmit wave energy. 7. Variable output. 8. Suitable to Certain locations only. 9 Create hazards for some of the animals near to it. 10. Depends on the waves-Sometimes you will get loads of energy, sometimes almost nothing. 11Needs a Suitable site, where waves are consistently Strong. 12. Weak performance in rough weather. 13. Maintenance and Weather effects. 14. Few implemented 15 Visual impacts. **Applications of Wave Energy.** ❖ Electricity Generation. ❖ Water pumping. ❖ Employment and infrastructure opportunities. ❖ Desalination plants can also benefit from wave devices. ❖ Reduction of oil usage in island energy production.	
21	**Explain about Working Principal of wave energy.(or) What is Wave energy? Explain the working Principal of Wav energy or Wave energy converters**	
	❖ Wave energy is one from of the renewable energy source that uses the power of the waves to generate electricity. ❖ wave energy uses the vertical movement of the surface water that produces tidal wave. ❖ wave power converts the periodic up-and-down movement of the oceans waves into electricity by placing the equipment on the surface of the oceans that capture the energy produced by the wave movement and converts this mechanical energy into electrical power. ❖ Wave energy converters (WECs) are devices that convert the kinetic and potential energy associated with a moving ocean wave into useful mechanical or electrical energy. Working principle of WEC	

	❖ It's an enclosed chamber with an opening under the sea, which allows strong sea waves to flow into the chamber and back. ❖ The water level in the chamber rises and falls with the rhythm of the wave, and so air is forced forwards and backward via the turbines joined to an upper opening in the chamber. ❖ The compressed and decompressed air has enough power to propel the turbines. ❖ The turbine is propelled in the same direction by the back and forth airflow through the turbine. ❖ The propelling turbine turns a shaft connected to a generator.	
	➢ **Oscillating water column type**  	
22	**Briefly Describe about ocean thermal energy (or) Briefly Describe about Advantages, Disadvantages and Applications of ocean thermal energy,(or)**	
	 	

- Ocean Thermal energy Conversion(OTEC) is a form of Renewable energy technology that harnesses the solar energy absorbed by the oceans to generate electric power.
- Energy from the Sun heats the surface water of the ocean. Surface water can be much warmer than deep water. This temperature difference can be used to produce electricity.

❖ **Temperature of Surface water of sea is around 25^0C-35^0C**

❖ **Temperature of Deep water of sea is around 3^0C-7^0C(1000m depth)**

❖ **This temperature difference between Surface water and Deep water of sea is used to produce Electricity.**

ADVANTAGES of OTEC

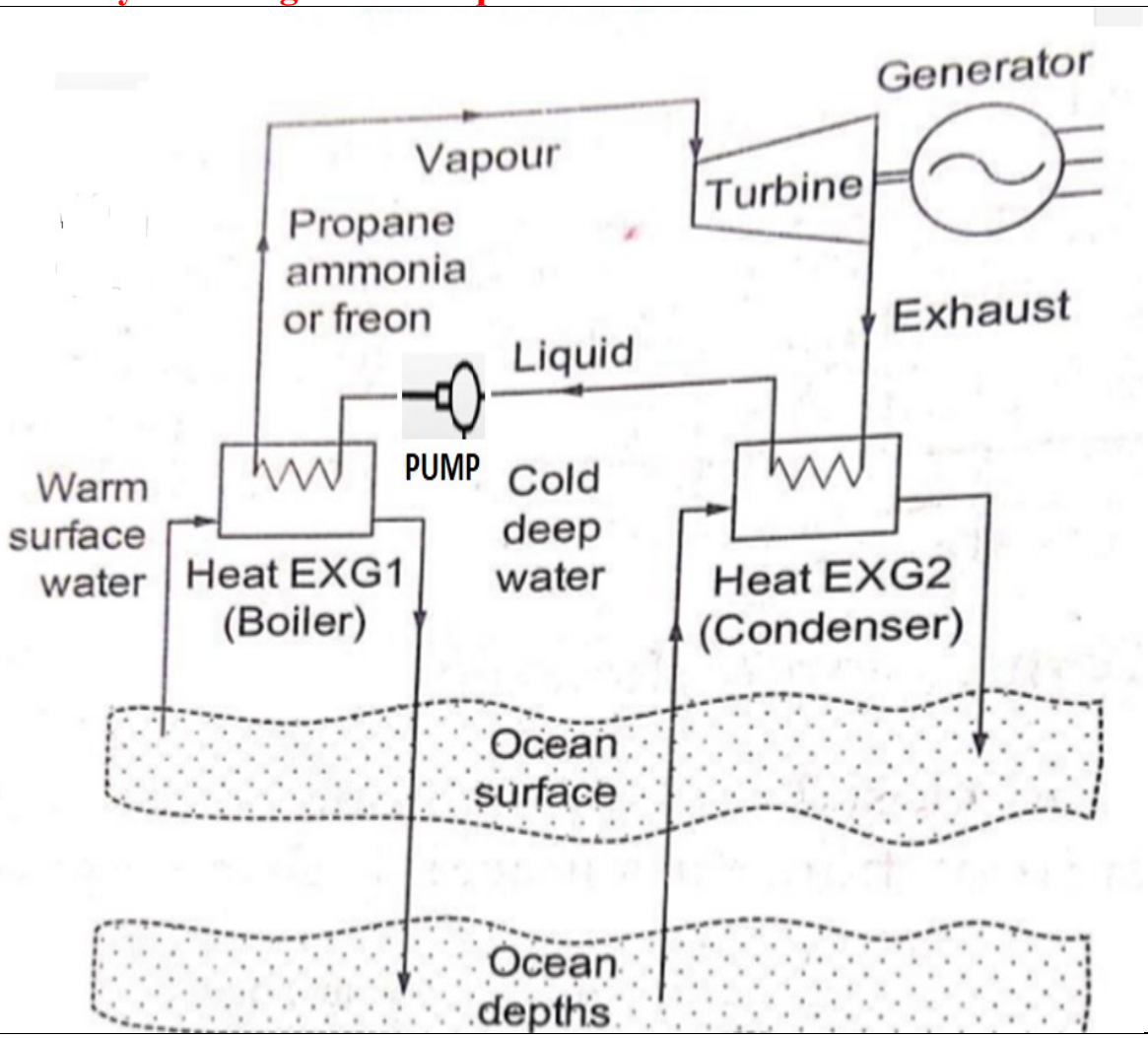
1)Renewable , clean natural resource.
2)Available in abundance.
3)Pollution free.
4)No green house effects.
5)Good source of fresh water
6)Used for marine culture plants
7)Power developed is continuous.
8)Very clean-no air pollution.

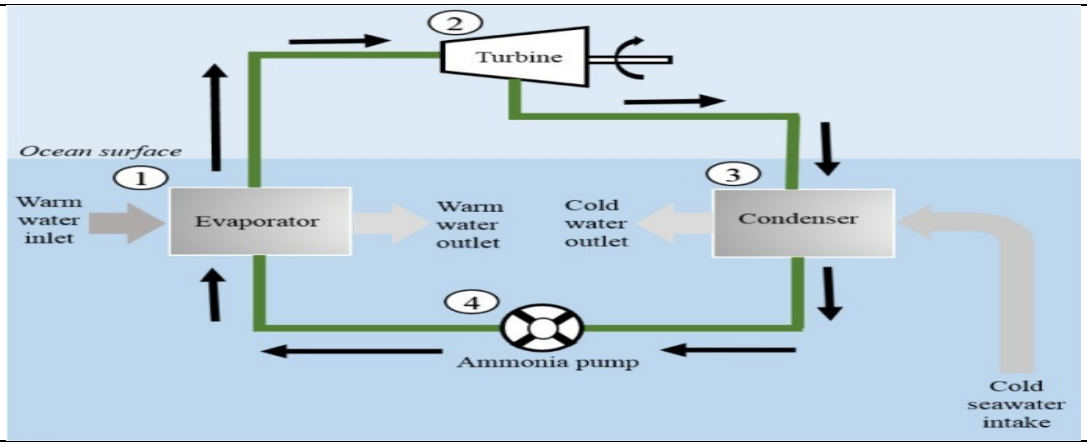
Disadvantages:-

1) Capital investment is very high.
2)Efficiency is very low,about 2.5%,as compared to 30-40% efficiency for conventional power plants.
3)Large setup size.
4) The low efficiency of these plants coupled with high capital cost and maintenance cost makes them uneconomical for small plants.
5)OTEC Plants will damage the Eco System.
6)Electricity generated by OTEC plants is more expensive than electricity generated by chemicls and nueclear fuels.
7)Harmful on Marine life.
8)Obstruct with navigation.
9) Location of OTEC plants is more Complex.
10)For the large scale production of electricity,OTEC Plants are poorly acceptable due to their high costs.

APPLICATIONS OF OTEC :-

- Electricity generation
- **Hydrogen Production**
- Ammonia and methanol production

	□ Desalinated water □ Aquaculture □ Chilled soil agriculture □ Air conditioning	
23	**Explain about Working Principal of ocean thermal energy.**	
	❖ **Temperature of Surface water of sea is around 25^0C-35^0C**	
	❖ **Temperature of Deep water of sea is around 3^0C-7^0C(1000m depth)**	
	❖ **This temperature difference between Surface water and Deep water of sea is used to produce Electricity.**	
	Major Components 1.Heat exchabger-1(Boiler) 2. Turbine coupled to a generator 3. Heat exchabger 2(Condenser) 4. Pumps	
	Primary Working Fluid:-Hot Sea Water	
	Secondary Working fluid:-Propane or Amonia or Freon	
		



Closed cycle system or Anderson Cycle

In closed cycle ,a separate working fluid such as ammonia or propane or freon is used in addition to water

The warm surface water is pumped to a boiler by a pump.

This warm surface water gives up its heat to the secondary working fluid(Ammonia or Freon) thereby losing its energy and is dischrged back to the surface of the ocean.

The vapours of the secondary working fluid generated in the boiler,drive a turbine for generating power.

The exhaust from the turbine is cooled in a surface condensor by using cold deep sea water,and is then circulated back to the boiler by a pump.

24 **Explain briefly about Biomass energy, advantages and disadvantages.**

Biomass Energy

- The energy that is generated from biomass is called biomass energy. These can be wood, leaves, pellets, fecal wastes, and other organic matters.
- The Bio-mass is produced in nature through Photosynthesis achieved by solar energy conversion.
- In simplest form the reactions in the Photosynthesis can be represented as:

$$CO_2 + H_2O + light + chlorophyllL \rightarrow (H_2CO)_6 + O_2 + chlorophyllL$$

(OR)

$$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$$

- At high temperature, it breaks and releases Heat of amount equal to 112 kcal/mole or 469 kJ/mole.

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + 112\ kcal/mole$$

- So the absorbed energy of photons is converted into carbohydrate which can then be used as source of energy.

- The energy derived from biomass can be processed directly by burning to produce heat, or converted directly into electricity.

Types of Biomass

- Agricultural residues.
- Animal waste.
- Forest residues.
- Industrial wastes.
- Solid waste and sewage.

1.Ways to produce Biomass energy- Thermal conversion

- The thermal conversion of biomass involves heating the feedstock so that thermal energy is released.
- The different processes of thermal conversion are direct firing, pyrolysis, co-firing, gasification, as well as anaerobic decomposition.

2.Ways to produce Biomass energy- Bio-fuel

- Biomass is considered a renewable source of bio-fuels like biodiesel and ethanol.
- Ethanol is produced by the fermentation process of biomasses that are rich in carbohydrates, and sugarcane. Ethanol can be mixed with gasoline, and this mixture can be used to power automobiles.
- Biodiesel can be made by combining Methanol/Ethanol with vegetable oil.

3.Ways to produce Biomass energy- Biochar

- Biochar is a byproduct of the pyrolysis process of biomasses. It is considered to be a valuable source of energy for agriculture and other environmental uses. When these biochars are added back to the soil, they can still absorb carbon from the surroundings.

4.Ways to produce Biomass energy- Black liquor

- Black liquor is a toxic byproduct in the production of paper from wood and it can retain almost 50% of the carbon content of the source material. Later it was used as a power source in several mills with the help of the recovery boiler. It was also tried to be gasified so that it can be used to generate electricity.

5.Ways to produce Biomass energy- Hydrogen fuel cells

- Hydrogen fuel cells are produced from biomass that is rich in hydrogen. These hydrogen atoms are chemically extracted from the biomasses and are used in batteries for generating powers and fuel machines and vehicles

Advantages

- Biomass is always and widely available as a renewable source of energy.
- It is carbon neutral-As a natural part of photosynthesis, biomass fuels only release the same amount of carbon into the atmosphere as was absorbed by plants in the course of their life cycle.
- It reduces the overreliance of fossil fuels.
- Is less expensive than fossil fuels.
- Biomass production adds a revenue source for manufacturers.
- Less garbage in landfills

Disadvantages

- **Biomass energy is not as efficient as fossil fuels**
- **It is not entirely clean**
- **Can lead to deforestation**
- **Biomass plants require a lot of space.**

25 **With neat sketch, explain the Production of oil from oil Shale and advantages and Disadvantages(Demerits) of oil Shale.**
(or)Write a Short note on oil Shale.

Fig. Oil shale

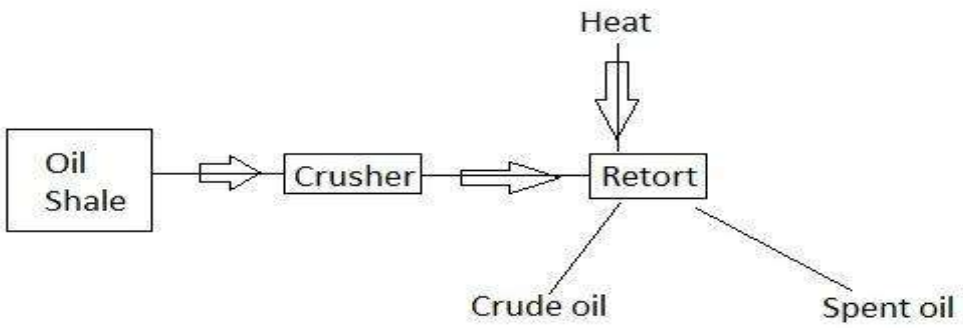


Fig. Production of crude oil from oil shale

- Oil shale [a sedimentary rock] refers to a finely textured rock mixed with a *solid organic material* called *kerogen*.
- In addition to kerogen, general composition of oil shales constitutes inorganic substance and bitumens.

- Oil shales vary considerably in their mineral content, chemical composition, age, type of kerogen, and depositional history.
- Just like petroleum, natural gas &coal, oil shale and kerogen are also fossil fuels.
- Oil shale contains a lower percentage of organic matter than coal.
- The organic components of oil shale derive from a variety of organisms, such as the remains of algae, spores, pollen, plant cuticles and cellular debris from other aquatic and land plants.
- Deposits of oil shale are found in US, Russia, Argentina,Estonia,brazil,Libya,Israel & China.

- When crushed, it can be burnt directly [like coal] & has a heating value ranging from 2000 to 17,000 KJ/Kg. It is used in this manner for generating electricity & supplying heat.
- Alternatively, the oil shale can be converted to oil. This is done by heating crushed oil shale to about 500 ˚C in the absence of air. Under the conditions, *pyrolysis* occurs & the kerogen is converted to oil.

Advantages:-

1)Moderate cost(sand)
2)Large Supply
3)Easily Transported.
4)Efficient Distribution.
5)Technology well-developed.

Dis-Advantages:-

1] Environmental concerns-

• The use of oil shale is the environmental degradation associated with surface mining& with the disposal of large amounts of sand & spent shale rock which remains after the crude oil is obtained.
• When shale oil heated, it releases CO_2, a green house gas
• Releases sulphides which cause suffocation
2] A large amount of energy is consumed in producing oil from these sources.
3] High processing costs
4] Low net energy yield.
5] Causes land & underground water degradation.
6] Land Disruption.
7]Water pollution.
8]Air pollution.

Applications

- Oil shale is utilized as a fuel for thermal powerplants,burning it (like coal) to drive steam turbines.
- Shale oil is burned to generate electricity.
- Shale oil was like petroleum and used to produce diesel, gasoline, LPG, paraffin

wax.

- Some oil shales yield sulfur, ammonia, alumina, soda ash, uranium as shale-oil extraction byproducts.
- In addition to its use as a fuel, oil shale may also serve in the production of specialty carbon fibers,adsorbent carbons, carbon black, phenols, resins,glues, tanning agents, mastic.etc.
  (However, oil shale use for production of these items remains small or only in experimental development).
- oil shale may also serve in the production of road bitumen, cement, bricks, construction and decorative blocks, soil-additives, fertilizers, rock-wool insulation, glass, and pharmaceutical products.
  (However, oil shale use for production of these items remains small or only in experimental development).

26 **Write the Classification of Oil shale.**

Classification of oil shales

1.Depositional history

a)In lakes(lacustrine)

- Formed from algae living in freshwater or brackish water. Eg. Lamosite, torbanite
- Lamosite deposits are some of the largest oil shale formations in the world.

b)In the ocean (marine)

- Formed from deposits of algae & plankton.
- Eg. Kukersite, tasmanite& marinite-most abundant oil shale.

c) On land (terrestrial)

- Formed in land from woody plants
- Eg:Cannel shale

2) By their mineral content

a)Carbonate rich shale

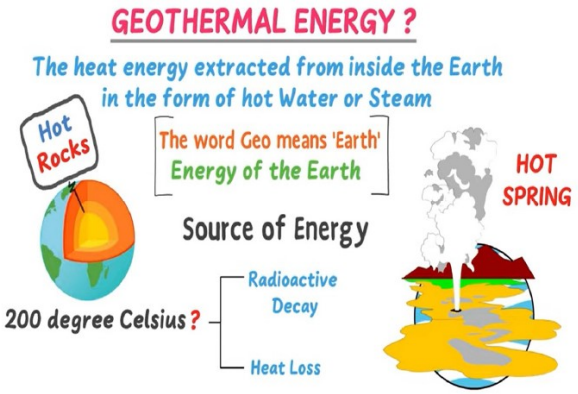
- Have high amounts of carbonate minerals.
- Eg.Calcite mineral is common in carbonate rich shales.
- Plankton, red algae and sponges are important source of calcite.

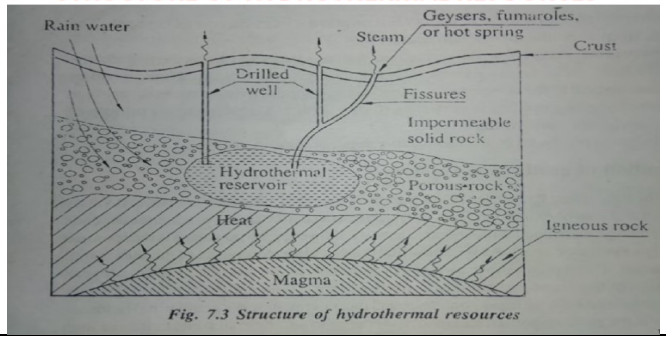
b)Siliceous shales

- Rich with the mineral silica or SiO2.
- Formed from algae(cell wall is made up of silica), sponges
- These oil shales are not as hard as carbonate rich shales.

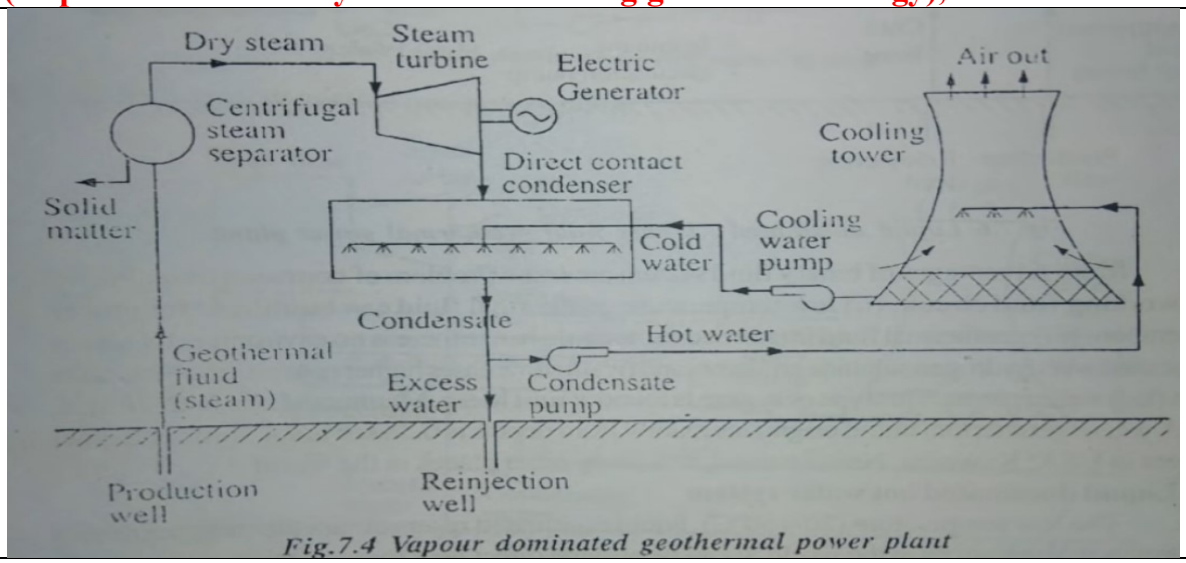
c)Cannel shale

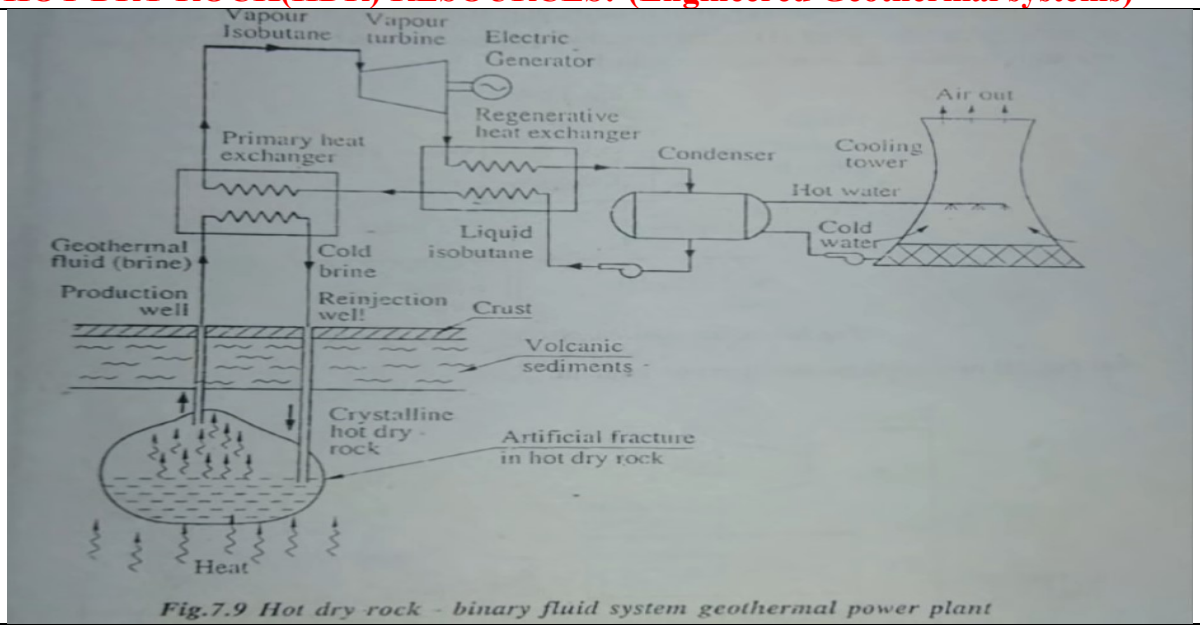
- Terrestrial origin
- Formed from remains of resin, spores and woody plants
- Rich in H_2 and burns easily.
- Contain minerals like inertinite & vitrinite.

27	**Explain the Different Methods of Producing Oil shale.**	
	1.Ex situ retorting • The oil shale mined and brought to ground surface. • The mined oil shale is heated at high temp (retorting) without oxygen (pyrolysis). At 60 ˚C - 160 ˚C , kerogen reaches its natural 'oil window' & at 120 ˚C -225 ˚C reaches its natural 'gas window'. • The resultant liquid is separated & collected. **2.In situ retorting (oil shale not mined or crushed)** • Heating oil shale while it is still underground. • Pumping the resulting liquid to the surface. **3.Hydraulic fracturing** • Injecting pressured water & chemicals into a well in order to break into underground reservoirs. • Steam can be injected underground in order to heat up the oil in the surrounding shale which then seep into the well. **4. Volumetric heating** • The rock is heated directly with an electric current. • The heating element is injected either directly in a horizontal well or into a fractured area of the rock until the oil shale begins producing shale oil. **5. Combined technologies-** Designed for both in situ & ex situ extraction	
28	**What is Geothermal Energy?**	
		
	Geothermal Energy originates from earth's interior in the form of heat. (or) Geothermal energy is the thermal energy in the Earth's crust. • which originates from the formation ofthe planet and from radioactive decay of materials. Geothermal reservoirs are naturally occurring areas of hydrothermal resources. • Volcanoes, geysers , hot springs and boiling mud pots are visible evidence of the great reservoirs of heat that lies within earth.	

	• The amount of Thermal energy within the earth is very large, useful geothermal energy is limited to certain sites only. • Sites are located near to Seismic zones and Volcanoes formation areas.	
29	**Classify and explain** about the **Geothermal sources**	
	1)Hydrothermal Resources 2)Geopressured Resources 3)Hot Dry Rock(Hdr) Resources 4)Magma. **1)Hydrothermal Resources** (A)Vapour Dominated(Dry Steam)System. (B)Liquid Dominated(Wet Steam) System (i)Liquid Dominated-High temperature system (ii) Liquid Dominated-low temperature system (C) Hot Water System.	
	STRUCTURE OF HYDROTHERMAL RESOURCES  *Fig. 7.3 Structure of hydrothermal resources*	
	• **Hydro thermal resources arise when under ground water has access to high temperature porous rocks, capped by a layer of solid impervious rock.** **• Water tapped in the underground reservoir(aquifers)and is heated by surrounding rocks.** **• Heat is supplied by magma by upward conduction through sold rocks below the reservoir. Thus it forms a giant underground boiler.** • Under high Pressure, the Temperature can reach as high as 350deg.C . • The hot water often escapes through cracks (fissures) in the rocks, thus forming hot springs or geysers. • Sometimes steam escapes through cracks in the surface. these are called fumaroles. • In order to utilize the hydrothermal energy ,wells are drilled either to intercept a fissure or more commonly into the hydrothermal reservoir. • The Hydrothermal resources are located at depth of 100m to 4,500m. • Temperatures for Hydrothermal reserves used for electricity generation range from 90 deg,C to 350 deg.C (Roughly 150deg.C to 250deg C).	
	GEOPRESSURED RESOURCES • While Drilling for oil and gas ,hot salt-water(Brine) reservoirs, at moderately high temperature(90deg-200deg.C),and under great pressure are found at a depth of 3to 6Km. • Because of the very high pressure of water ,up to 1350atm in the deepest layer, these reservoirs are referred as geopressured.	

	• A special feature of geopressured water is that it also contains a significant amount of dissolvedMethane gas usually 1.9-3.8 m3/m3 of water. • The solubility of methane in water at normal pressure is quite low, but increases with Pressure. • When the water is brought to the surface and its Pressure reduced ,the methane gas is released from the Solution. • Methane is Extracted from brine by Simple and Economical gravity Separation technique. • **These resource is economically promising because of three types of energy can be extracted from wells.** **(i)Thermal energy from the heated fluids.** **(ii)Mechanical (Hydraulic) Energy from the high pressure involved.** **(iii)Chemical energy from the Burning of Methane gas.**	
	3)HOT DRY ROCK(HDR) RESOURCES (Engineered Geothermal systems) • These are regions underground at temperatures exceeding 200deg.C,with little or No water. • The Rocks are impermeable and /or there is no surface water in the vicinity. • Resources up to a depth of 5Km are estimated to be Significant and worthy of Development as a Source of Energy. • Hot Dry Rocks are Much more common than Hydrothermal reservoirs and more Accessible. So their Potential	
	Magma Resources • At Some Places ,Molten or Partially Molten rock (Magma Chamber) at Temperature of 650deg.c to 1200deg.C occurs at depth of 5km to 10Km. • These resources are located especially in the vicinity of Resent volcanic activity(Hawaii). • Very high temperatures and large Volume make magma a huge Potential energy Source, the largest of all geothermal Resources. • However, Successful magma drilling technology has not been established yet. • Extracting magma energy is expected to be the most difficult of all Types of resource utilization.	
30	**What are the advantages, disadvantages and applications of Geothermal Energy?**	
	Advantages Geothermal Energy (1)It is a reliable and cheap source of energy (2)It is available 24 hours per day. (3)Its availability is independent of weather (4)No extra storage facility is required. (5)Geothermal plants require little land area. (6) Lot of opportunities for the development of relatively quick, cost-effective geothermal projects. (7)Multiple uses from single source. (8) Geothermal Energy is considered as Renewable source of energy.	
	Disadvantages of Geothermal Energy. 1) It is Site Specific. (There are not many places where you can build a geothermal	

	power station.) 2) Generally, energy is available as low-grade heat. 3) Continuous extraction of heated ground water may lead to subsidence (Setting or Slumping)of land. (it will cause the Slumping of Land) 4) Geothermal fluid also brings with it dissolved gases(H_2S,Co_2,NH_3 and Radon gas) and solute (as high as 25Kg/m3) Which leads to air and land pollution.(It will produce air and land pollution) 5) Drilling operation leads to noise pollution. 6) The available thermal energy cannot be distributed easily over long distances (longer than 30km). 7) Corrosive and abrasive geothermal fluid reduces the life of the plant. 8) Initial capital and installation costs are high.	
	Applications of Geothermal Energy. • It is used in generating electric power. • It is used in industrial process heat. • It is used in space heating for various kinds of buildings. • It is used in agricultural (crop drying) and related applications. • It is used in Melting of snow. • It is used in Aquaculture for warming of fish ponds, • It is used in Supplying hot water for cold climate conditions.	
31	**Explain with neat Sketch, the Working Principal of Geothermal Power plant (vapour Dominated System of Generating geothermal energy),**	
	 *Fig.7.4 Vapour dominated geothermal power plant*	
	Dry steam fields occur when the pressure is not much above the atmospheric pressure and the temperature is high.Water boils in underground and generates steam • Temperatures for Hydrothermal reserves used for electricity generation range from150^{0}C to 250 ^{0}C. **Working Principal:** Dry steam from wells is collected, filtered to remove abrasive particles, and passed through turbines that drive electric generators to generatre Electricity. **Working of Vapour Dominated geothermal Power Plant:**	

	➢ **The dry steam is extracted from the well is at** 200°C and Pressure of 35 bar.. ➢ Dry steam is nearly saturated at the bottom of the well. ➢ The extracted Steam is then cleaned in centrifugal seperator to remove Solid matter. ➢ While passing through the well,as well as centrifugal seperator the pressure of dry steam drops ,which causes dry steam is Slighty coverted to super heated steam. ➢ The steam is then supplied to turbine at temprature of 165^0C and pressure of about 7.8 Bar to (The temprature and Pressuure in the Reservoir are higher) expand(Striking the Turbine Blades). ➢ Turbine will drive the Generator to Produce electricity. ➢ The exhaust steam of Turbine is condensed in direct contact condensor,in which steam is condensed by direct contact with cooling water.(Stem is mixed with cooling water in condensor). ➢ The resulting warm(hot) Water is circulated (Pump) and cooled in cooling tower and returned to Condenser by Pump . ➢ The condensation of steam continiously increasing the volume of cooling water. ➢ Excess water is reinjected at some distantce deep into the ground for disposal. ➢ Non-Condesble gasses are removed from the Condenser by Steam jet Ejection.	
32	**With neat sketch, explain Generating geothermal energy system by Hot Dry Rock (HDR).**	
	HOT DRY ROCK(HDR) RESOURCES:-(Engineered Geothermal systems)	
	 *Fig.7.9 Hot dry rock - binary fluid system geothermal power plant*	
	• These are regions underground at temperatures exceeding 200deg.C, with little or No water. • The Rocks are impermeable and /or there is no surface water in the vicinity. • Resources up to a depth of 5Km are estimated to be Significant and worthy of Development as a Source of Energy. • Hot Dry Rocks are much more common than hydrothermal reservoirs and more Accessible. So their Potential is quite high. • The recovery of heat from HDR involves forming a man-made reservoir by	

	drilling deep into the hot rocks and then cracking it to form cavity or fractures. • Hydraulic Fracturing Method (Pumping of water at High Pressure into the rock formation) is used for fracturing of hot rocks. Working **Hot Dry Rock (HDR) geothermal energy system.**	
	• To recover heat, Water is pumped into the cracks from the surface, and withdrawn by another well at a distance. • Injection and production wells are joined to form a circulating loop through the man-made reservoir (fracturing of Hot Dry rock) to achieve a Steady flow of high temperature water. (or Water –Steam mixture). • When heat is extracted, the rocks cool down and new cracks are developed due to Temperature gradient. • Electricity can be generated by binary fluid System. • A binary fluid system is employed, where the heat of geothermal fluid is used to vapourize a volatile organic fluid, Such as isobutene (B.P=10^0C) and Freon(R-114), under pressure in a Primary Heat exchanger. • The geothermal Fluid is re-injected after extraction of heat. • This vapourized fluid (isobutene) serves as a working fluid in a Rankine Cycle. • Vapourized fluid (isobutene) strike (expansion in the Turbine) the turbine to generate the Electricity. • The exhaust vapour from turbine is cooled in the regenerative heat exchanger And then condensed in the condenser. • The condensed liquid isobutene is returned to Primary heat exchanger by way of the regenerative heat exchanger. • Binary Plants have no Emissions. • Thermal efficiency of such a plant is typically about 10-13 percent . • These plants do not produce any steam condensate and have to rely on external source of cooling water or Air- cooling.	
33	**List and explain the problems associated with geothermal system operation.**	
	1. Environmental issues • **There is an abundance of greenhouse gases below the surface of the earth. When geothermal energy is used, some of these gases escape towards the surface and into the atmosphere. These emissions tend to be higher near geothermal power plants.** • **Geothermal power plants generate small amounts of sulfur dioxide, carbon dioxide and silica emissions.** • **The reservoirs can also contain traces of toxic heavy metals including mercury, arsenic, and boron.** **2. Surface instability (earthquakes)** • **The construction of geothermal power plants can affect the stability of the land.** • **In fact, geothermal power plants have led to sinking of the Earth's surface.** • **Earthquakes can be triggered due to hydraulic fracturing, which is an intrinsic part of developing enhanced geothermal system (EGS) power plants.** • **The construction of a geothermal power plant can trigger earthquakes.**	

3. Expensive

- **Commercial geothermal power projects are expensive. Total installation costs usually end up some where between $2.5–$5 million for a geothermal power plant with a capacity of 1 megawatt (MW).**
- **The exploration and drilling of new reservoirs play a big role in driving up costs, typically accounting for half of the overall costs.**

4. Location-specific

- **Good geothermal reservoirs are hard to come by.**
- **Some countries have been blessed with great resources – Iceland and Philippines, for instance, meet nearly one-third of their electricity demand with geothermal energy.**
- **If geothermal energy is transported long distances by means of hot water (not electricity), significant energy losses have to be taken into account.**

5. Sustainability issues

- **Rainwater seeps through the earth's surface and into the geothermal reservoirs over thousands of years.**
- **Studies show that the reservoirs can be depleted if the fluid is removed faster than replaced.**
- **Efforts can be made to inject fluid back into the geothermal reservoir after the thermal energy has been utilized (the turbine has generated electricity).**
- **Geothermal power is sustainable if reservoirs are properly managed.**

34	**With neat Sketch, Explain the concept of Liquid dominated- Binary fluid system of Generating geothermal energy.**

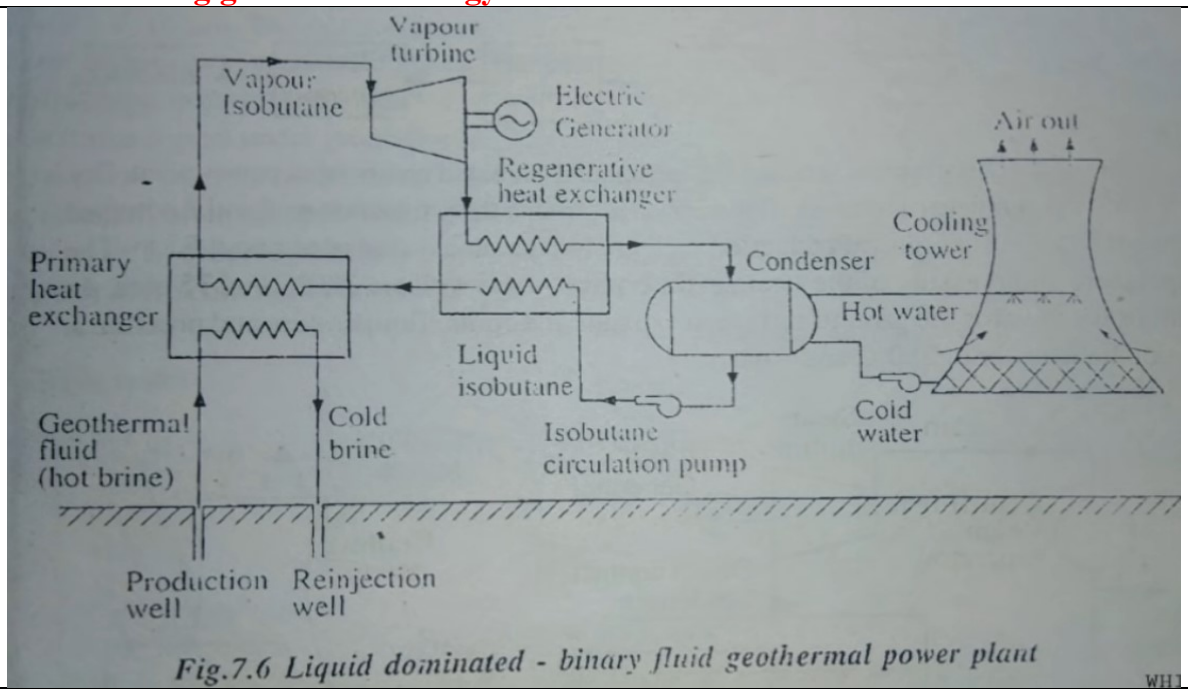
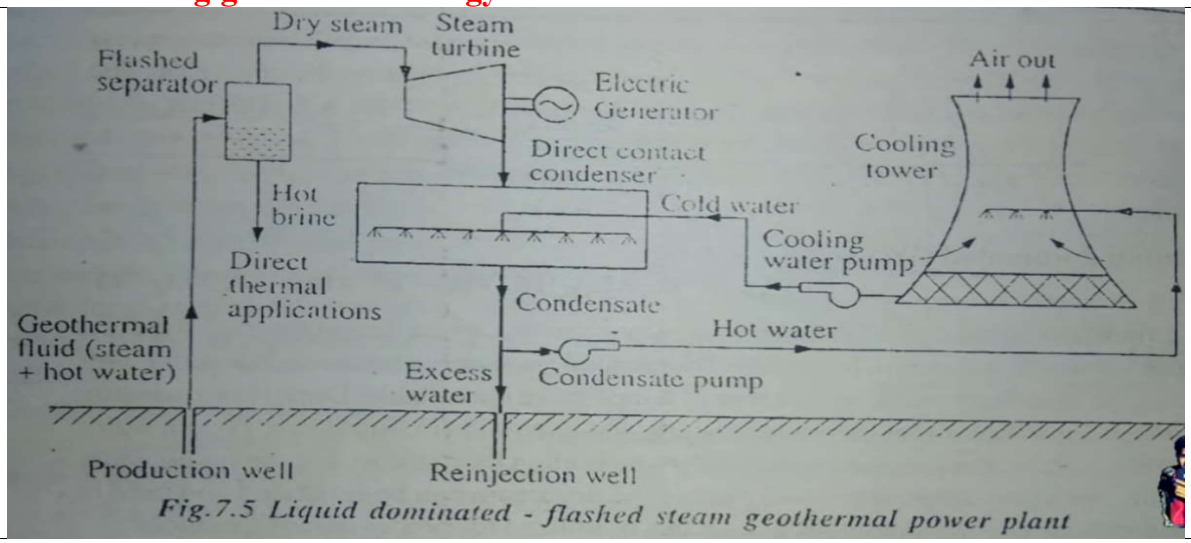
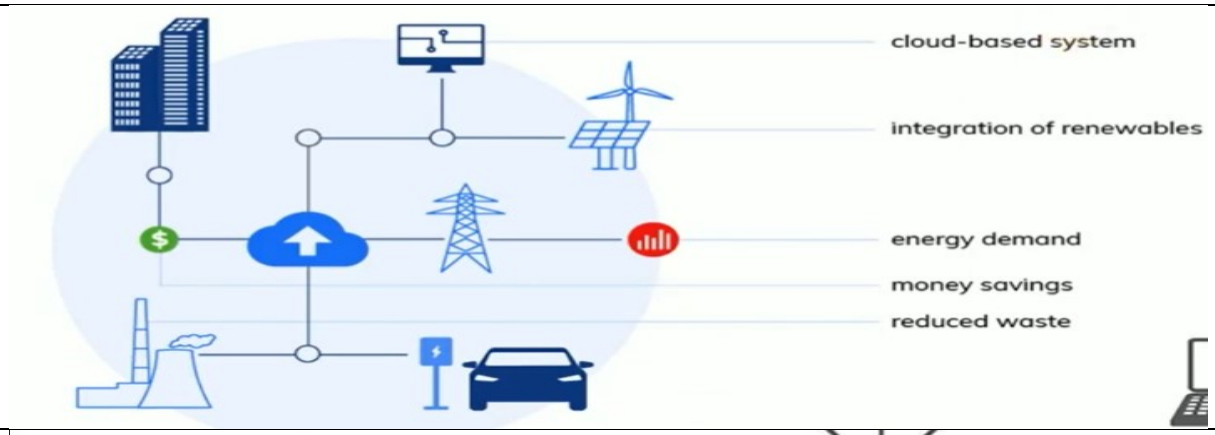


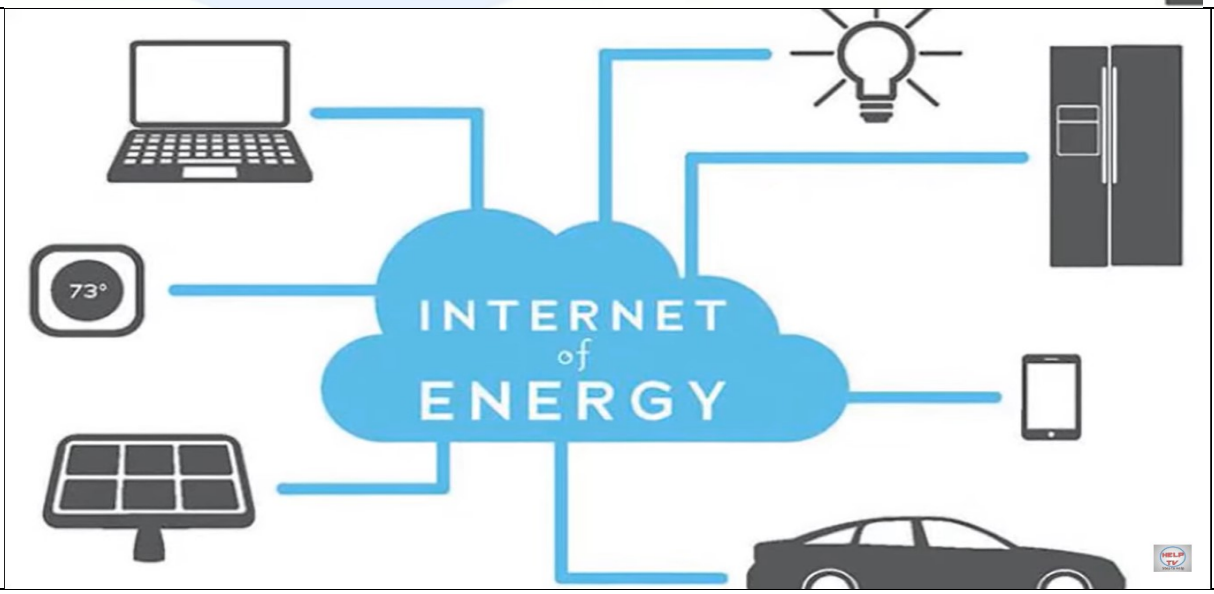
Fig.7.6 Liquid dominated - binary fluid geothermal power plant

- **These resources are available at moderate Temperature ranges of 90deg.C to 175deg.C.**
- **This temperature is not enough for efficient flash Steam production.**
- A binary fluid system is employed for this type of Plants.
- Geothermal fluid (Hot water or Hot brine) is used as a Primary Fluid.

	• **Isobutene (BP=10deg.C) is used as Secondary fluid.**	
	• The heat extracted from the geothermal fluid (Hot water or Hot brine) is used to vapourize a volatile organic fluid, Such as isobutene (B.P=10^0C) and Freon(R-114), under pressure in a Primary Heat exchanger. • The geothermal Fluid is re-injected after extraction of heat. • This vapourized fluid (isobutene) serves as a working fluid in a Rankine Cycle. • Vapourized fluid (isobutene) strike (expansion in the Turbine) the turbine to generate the Electricity. • The exhaust vapour from turbine is cooled in the regenerative heat exchanger And then condensed in the condenser. • The condensed liquid isobutene is returned to Primary heat exchanger by way of the regenerative heat exchanger. • Binary Plants have no Emissions. • Thermal efficiency of such a plant is typically about 10-13 percent. • These plants do not produce any steam condensate and have to rely on external source of cooling water or Air- cooling.	
35	**With neat Sketch, Explain the concept of Liquid dominated (WET Steam) system of Generating geothermal energy.**	
	 *Fig.7.5 Liquid dominated - flashed steam geothermal power plant*	
	.In liquid dominated plants, geothermal plants are built upon liquid reservoirs within the earth's surface. This liquid is sent through one or more separators in order to lower the pressure of the water, creating steam. This steam then propels a turbine generator causing it to produce electricity.	
	In the liquid dominated reservoir, the water temperature is above the normal boiling point 100 degrees C. However, it does not boil but it remains in a liquid state because the water in the reservoir is under pressure. When the water comes to the surface, the pressure is reduced, then rapid boiling occurs and the liquid water “flashes” into a mixture of hot water and steam. The steam can be separated and used to generate electric power or to provide space and process heat or it may be distilled to yield the purified water.	
	In liquid dominated plants, geothermal plants are built upon liquid reservoirs within the earth’s surface. This liquid is sent through one or more separators in order to lower	

	the pressure of the water, creating steam. This steam then propels a turbine generator causing it to produce electricity. This steam is then condensed back into a liquid and placed back into the liquid reservoir it originated from. This type of geothermal plant is very common and provides a sustainable, reusable form of energy. Liquid dominated power plants are also referred to as flash steam power plants; as they conduct flash steam by pressurizing hot water from the surface of the earth. Such power plants operate using water reservoirs with temperatures greater than 360 degrees Fahrenheit. Liquid dominated reservoirs are more common than others, causing them to produce more electricity and power more stations. These reservoirs are found in specific locations including rift zones, mantle hot spots, and near new volcanoes in the Pacific Ocean. The largest liquid-dominated system in the world is found at Cerro Prieto.	
28	**Write a Short note on Internet of Energy (IOE).**	
	Internet of Energy • Internet of Energy is a technological term that refers to the upgrading and automating of electricity infrastructures for energy producers and manufacturers. • IoE allows energy production to move forward more efficiently and cleanly with the least amount of waste. • The main objective of Internet of Energy (IOE) increase efficiency of Systems during Energy generation, energy transmission, Energy Distribution, Energy Storage and Energy Consumption by Reducing the wastage of Energy. • Benefits of using IoE include increased efficiencies, significant cost savings, and a reduction in the wastage of energy. • IoE is the use of Internet of Things (IoT) technology with a variety of different energy systems. The Internet of Things refers to the idea of connecting devices to the internet. This includes anything from smart phones, tablets, and television sets to major appliances, headphones, and automobiles. • By using IoE technology, manufacturers and producers can reduce inefficiencies in existing energy infrastructure by increasing generation, transmission, and use of electricity. Making updates to electric infrastructures allows an ease in flow of energy which can maximize its potential, therefore cutting down on any wastage of energy. • Adding IoE technology to the process can also lead to the installation of smart grid technology. Smart grid technology allows users to integrate communication systems, control power and electrical flow, measure usage, monitor the health of their systems, and automate their power systems among other things.	
	Examples of Internet of Energy (IoE) • Uses of IoE can be found in a variety of different applications. An example of IoE technology includes utilizing smart sensors which are common among other IoT technology applications. This allows IoE-facilitated mechanics such as power monitoring, distributed storage, and renewable energy integration.	





- General Electric-Multinational General Electric (GE) as a real world example using IoE technology. The company launched its own startup, pairing LEDs and solar panels with software. This allows the system to gather data to apply insights to corporate operations that aim to increase savings related to lighting and productivity.

- **Benefits of Internet of Energy (IoE)**
  There are many benefits that result from the implementation of IoE for both manufacturers and energy producers including solar and utility companies.
- As noted above, it reduces inefficiencies, making the transmission of energy much more productive.
- There are also significant savings in money as well as a great reduction in the wastage of energy. This, in turn, can be passed down to consumers or end users, who will may also see a cost saving.
- Monitoring and Control of Energy generation, energy transmission, Energy Distribution, Energy Storage and Energy Consumption.
- Optimization of Power system operations.
- Reduce the Power wastage during Energy generation, energy transmission, Energy Distribution, Energy Storage and Energy Consumption.
- Automation of Energy generation, energy transmission, Energy Distribution,

Energy Storage and Energy Consumption.

- Reduction in operational cost of Energy Sector.
- Increase the Safety and Security of Energy Systems.
- Entire Information Available for Customer or Consumer in internet related to Energy generation, energy transmission, Energy Distribution, Energy Storage and Energy Consumption,

Different Monitoring and Controlling Functions performed by IOE Technologies in Different stages Energy generation to Energy Consumption.

(Energy generation, energy transmission, Energy Distribution, Energy Storage and Energy Consumption)

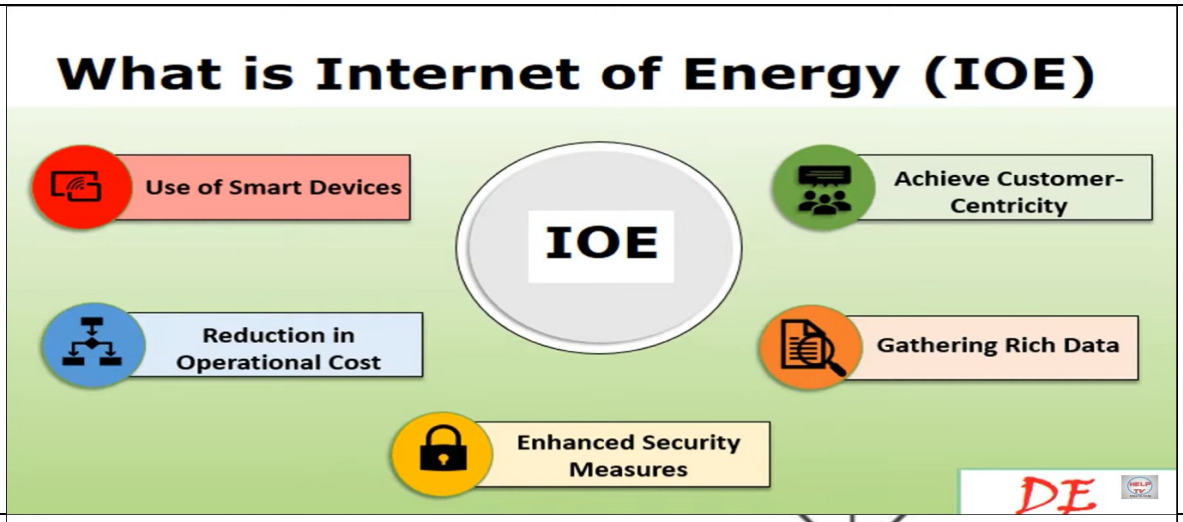
SG Stage	Application Type	Communication	Security
Generation	Real Time Monitoring	✓	✓
	Power Plant Control	✓	✓
	Distributed Generation	✓	✓
	Renewable Sources	✓	✓
Transmission	Substation Monitoring	✓	✓
	Line Fault Monitoring	✓	✓
	Line Measurements	✓	✓
	Power Quality Analysis	✓	✓
Distribution	Direct Load Control	✓	✓
	Smart Transformer Control	✓	✓
	AMI and DSM	✓	✓
	Substation Automation	✓	✓
Consumption	Home Energy Management System	✓	✓
	Microgrid Management	✓	✓
	Electric Vehicle Control	✓	✓
	Appliance Control	✓	✓

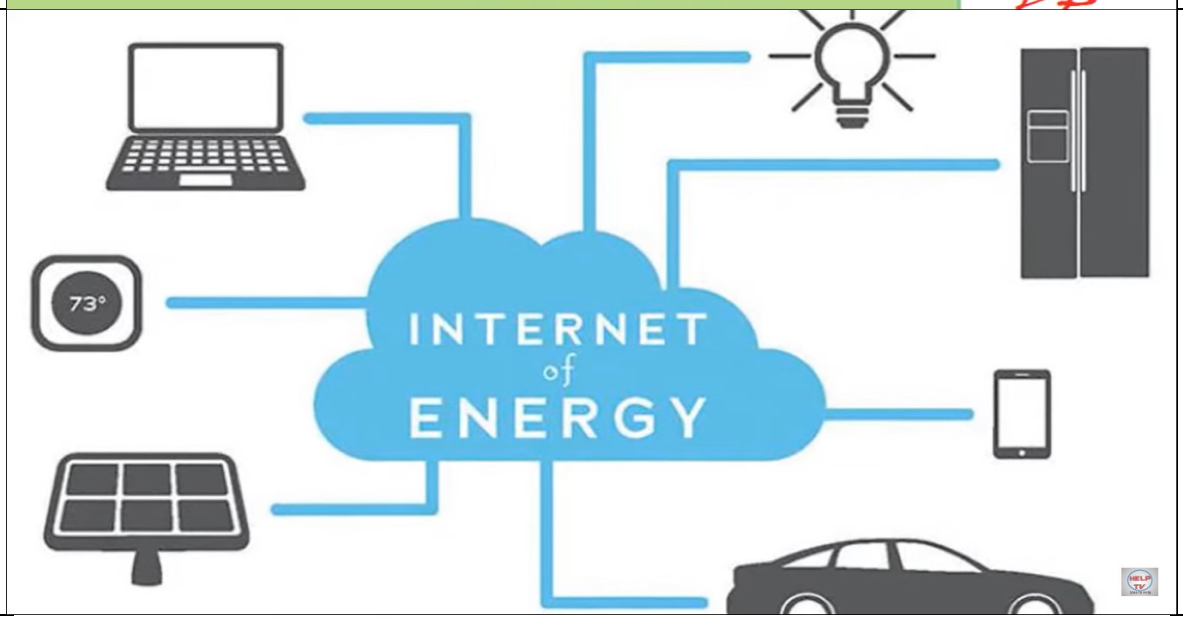
Some of Technologies used in IOE

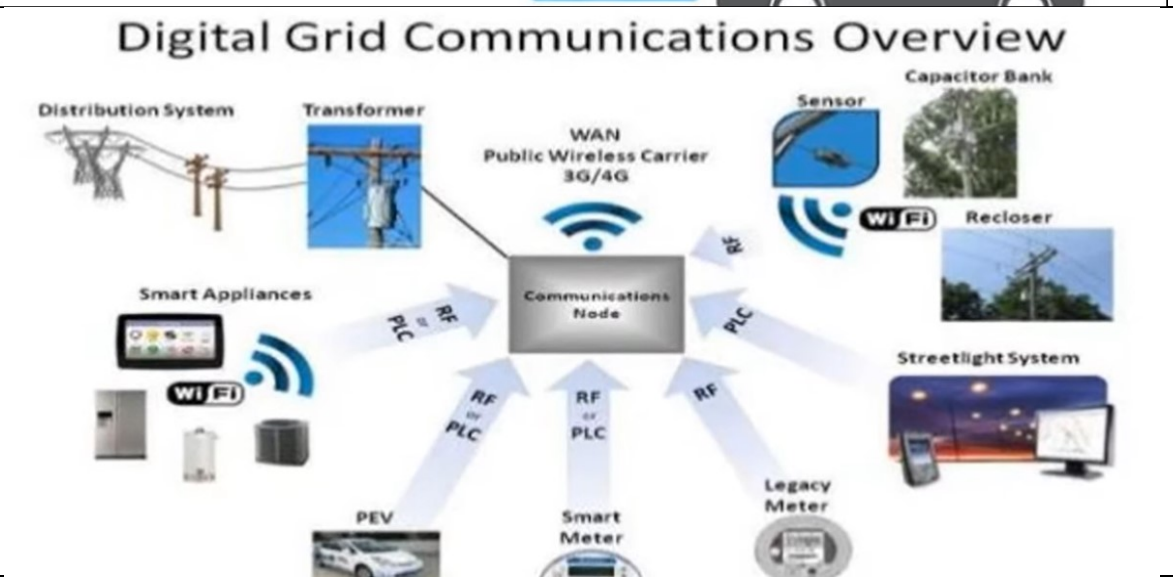
(1)Smart Sensors.
(2)Smart grids.
(2)Smart meters.
(3)Micro grids.
(4)Smart Buildings
(5)Digital Grid Communication Systems.
(6)Smart Manufacturing.
(7)Networking of Worldwide Energy Sources.

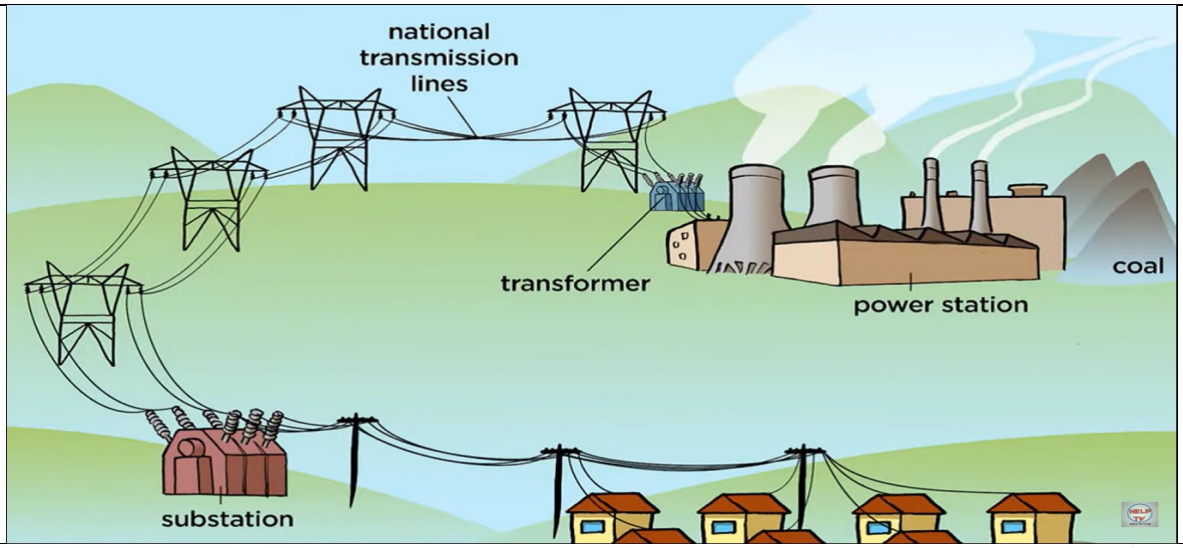
**********END**********

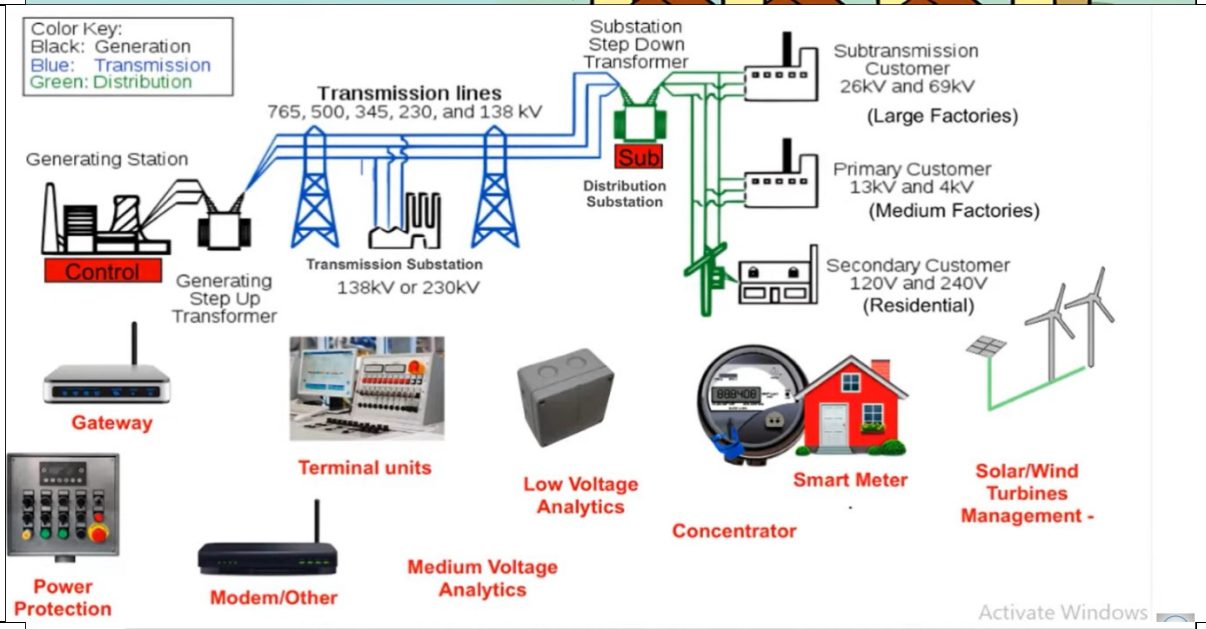
Extra Pictures related to IOE


What is Internet of Energy (IOE)
Use of Smart Devices
IOE
Achieve Customer-Centricity
Reduction in Operational Cost
Gathering Rich Data
Enhanced Security Measures
DE

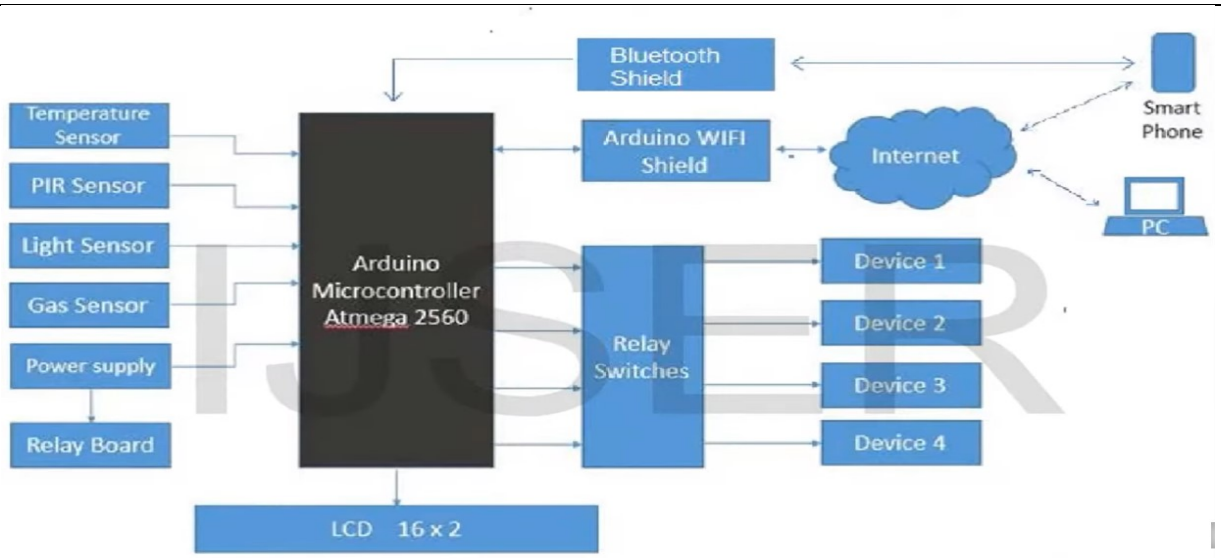

73°
INTERNET
of
ENERGY

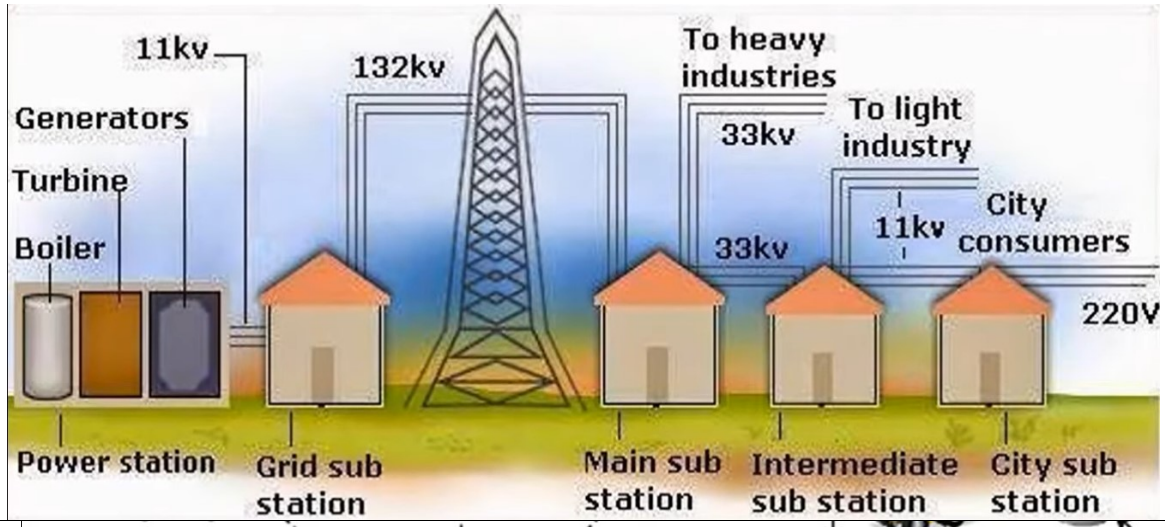

Digital Grid Communications Overview
Distribution System
Transformer
WAN
Public Wireless Carrier
3G/4G
Sensor
Capacitor Bank
Recloser
Smart Appliances
Communications Node
Streetlight System
PEV
Smart Meter
Legacy Meter
RF
PLC

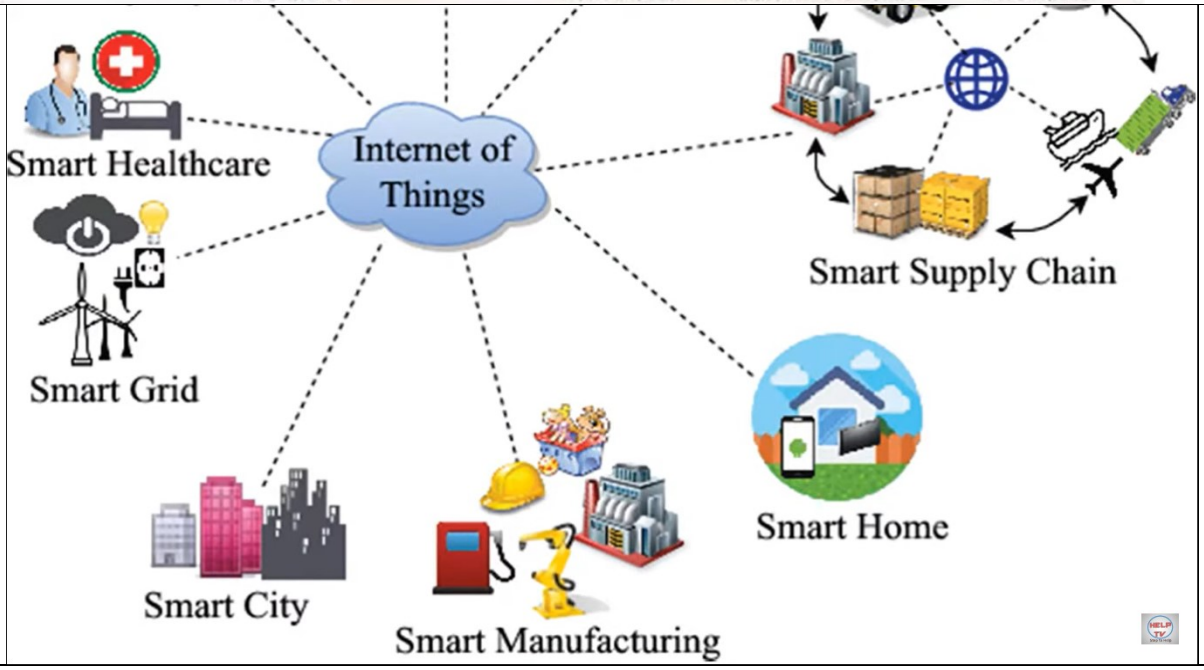




SG Stage	Application Type	Communication	Security
Generation	Real Time Monitoring	✓	✓
	Power Plant Control	✓	✓
	Distributed Generation	✓	✓
	Renewable Sources	✓	✓
Transmission	Substation Monitoring	✓	✓
	Line Fault Monitoring	✓	✓
	Line Measurements	✓	✓
	Power Quality Analysis	✓	✓
Distribution	Direct Load Control	✓	✓
	Smart Transformer Control	✓	✓
	AMI and DSM	✓	✓
	Substation Automation	✓	✓
Consumption	Home Energy Management System	✓	✓
	Microgrid Management	✓	✓
	Electric Vehicle Control	✓	✓
	Appliance Control	✓	✓


Bluetooth Shield
Temperature Sensor
PIR Sensor
Light Sensor
Gas Sensor
Power supply
Relay Board
Arduino Microcontroller Atmega 2560
Arduino WIFI Shield
Internet
Smart Phone
PC
Relay Switches
Device 1
Device 2
Device 3
Device 4
LCD 16 x 2


11kv
132kv
To heavy industries
33kv
To light industry
Generators
Turbine
Boiler
11kv
City consumers
33kv
220V
Power station
Grid sub station
Main sub station
Intermediate sub station
City sub station


Smart Healthcare
Internet of Things
Smart Supply Chain
Smart Grid
Smart Home
Smart City
Smart Manufacturing

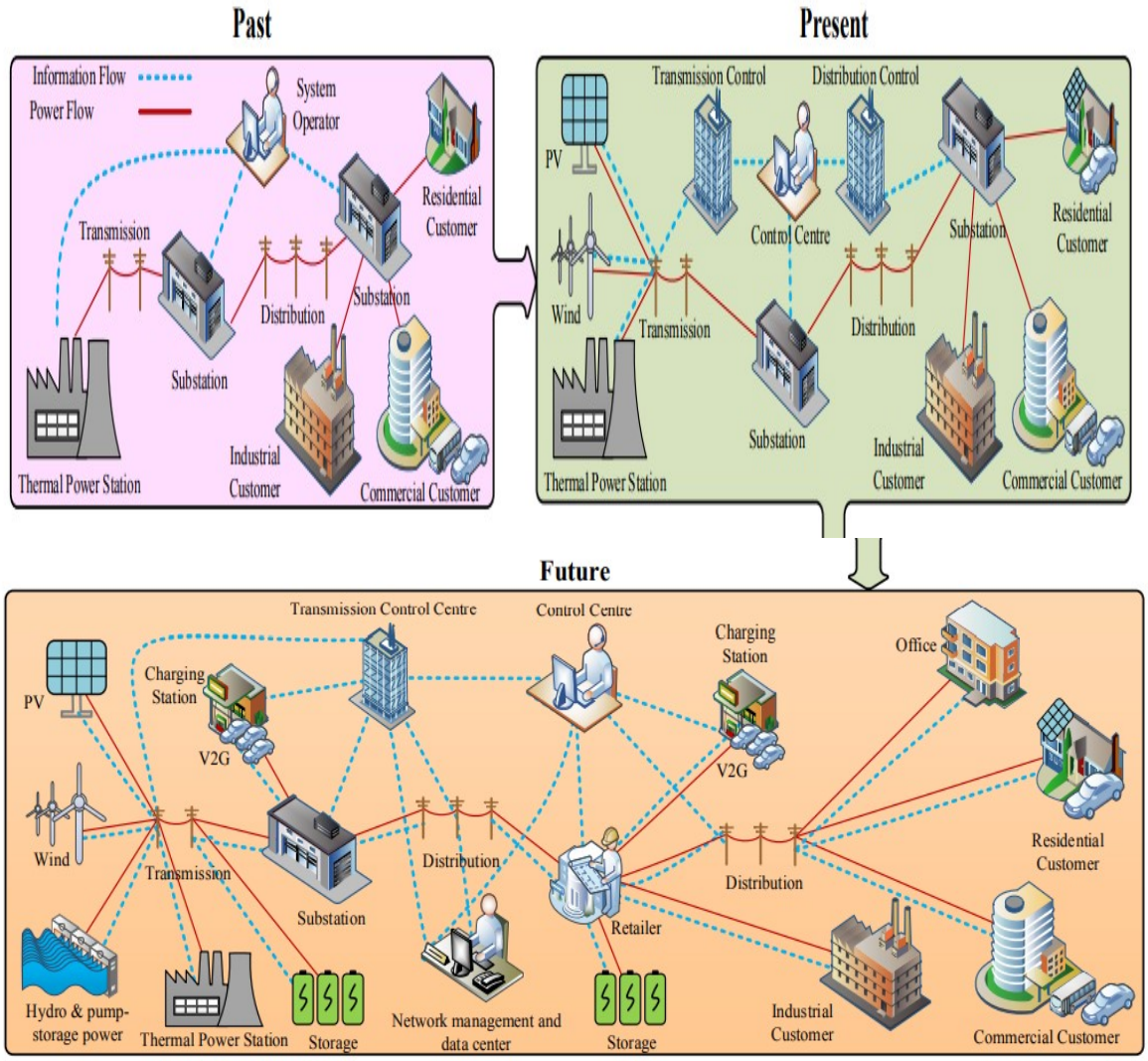


Fig. 1. IoE and future networks

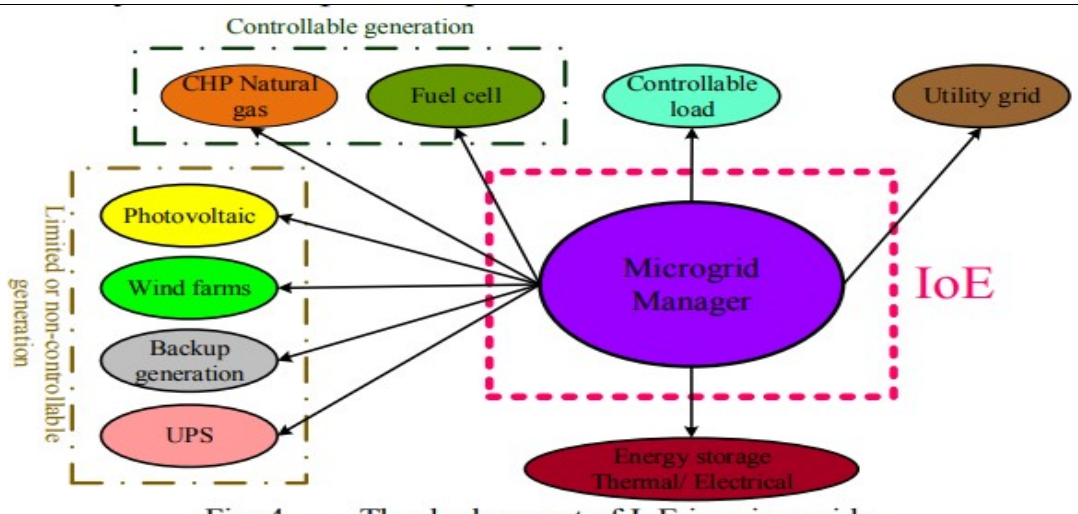


Fig. 4. The deployment of IoE in microgrids

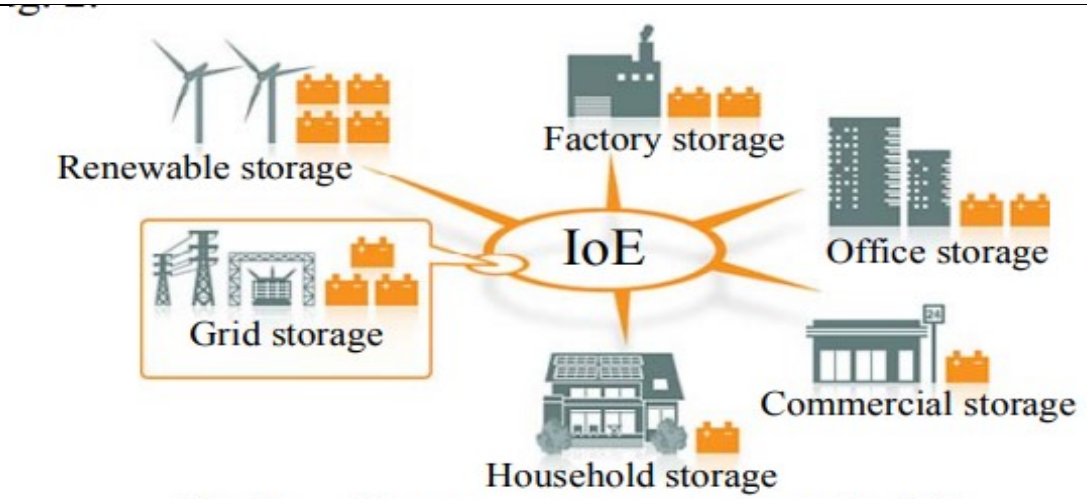


Fig. 2. The energy storage management by IoE

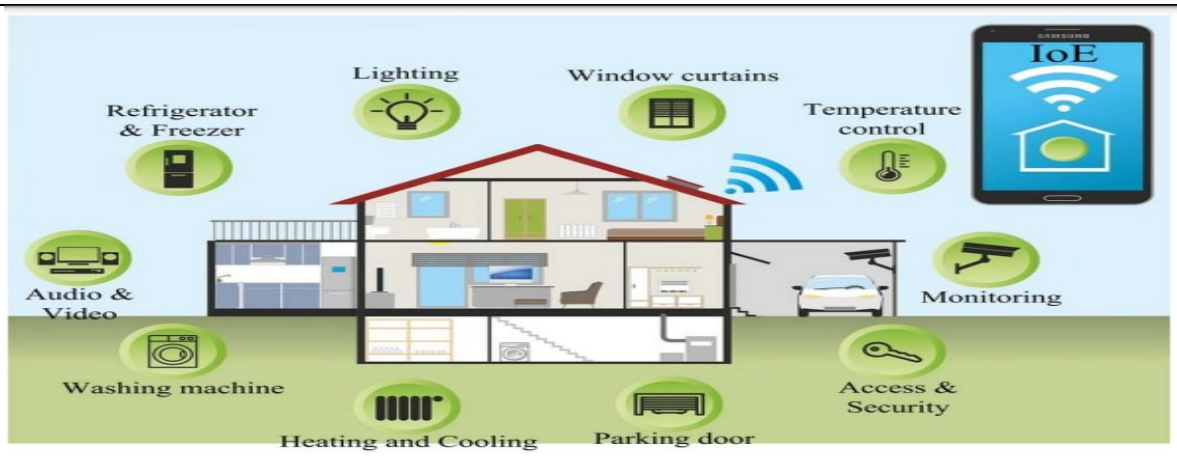
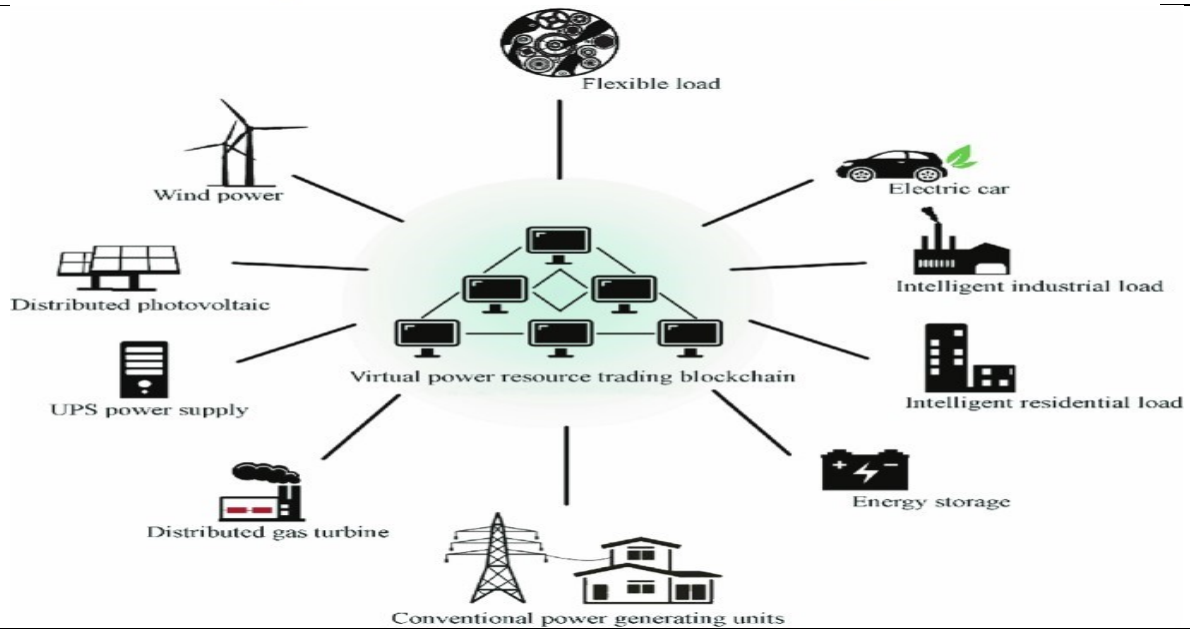


Fig. 5. The schematic of a smart building



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