Module 1 Introduction

Energy

Energy, in physics, the capacity for doing work. It may exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other various forms. There are, moreover, heat and work. In this subject we are dealing with the electric energy and the sources of electric energy Sources of energy, Oil, Coal, Nuclear energy, Water, sun, tidal, Biomass.

Types of energy of Energy

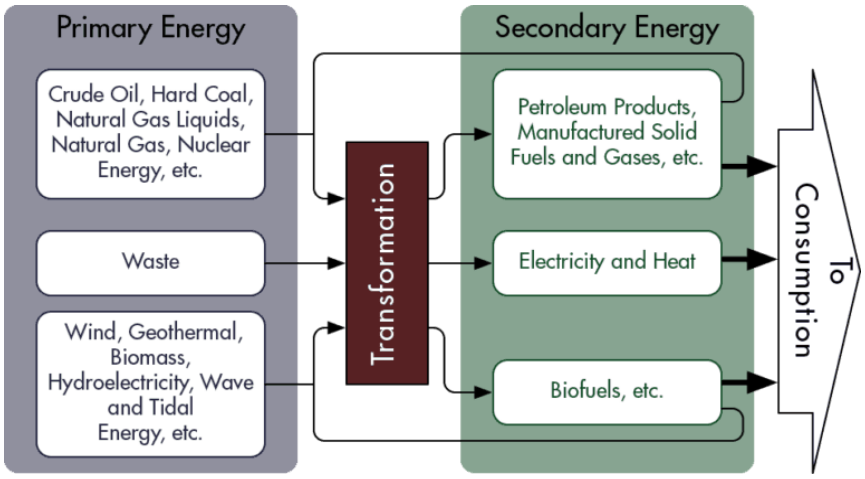
- **Primary and secondary energy**

1. Primary Energy

It is the source of the energy which is directly obtained from the nature.

2. Secondary energy

It is the converted from of primary energy, in the form of fuel or electricity to do useful work



- **Commercial and non commercial Energy sources:**

1. **Commercial Energy sources:**

The commercial energy is the lifeline for industrial, agricultural, Transport and commercial development in the modern world. In the industrially well-developed countries, the commercial energy is also largely used for many household tasks. By far the most important forms of commercial energy are electricity, coal, lignite, refined petroleum products and natural gas that are available in the market for a price.

2. **Non-Commercial Energy sources:**

The traditional fuels like firewood, cattle dung and agro wastes that are gathered for use inrural households, and not bought at a price, are classified as non-commercial energy sources are often ignored in energy accounting. The other form of non-commercial energy includes renewable sources of energy like solar and wind as well as animal power. The solar energy is used for electricity generation, water heating, drying grain, fish and fruits. The wind energy finds use for electricity generation and water lifting. The animal power is largely used in villages for lifting water for irrigation and crushing sugarcane, threshing and transportation.

- **Non Renewable energy or Conventional Energy and Renewable energy or Non-Conventional Energy**

1. Non-Renewable energy or Conventional Energy

Nonrenewable energy is the energy in which once the resources are used up, they cannot be replaced by nature or human Example, Coal, Petroleum products etc

2. Renewable energy or Non-Conventional Energy

Renewable energy is energy derived from natural sources that are replaced at a higher rate than they are consumed by nature Example, Solar, wind etc

Difference between Renewable energy and Non-Renewable energy

SL NO	**Renewable energy**	**Non Renewable energy**
1	Renewable energy is energy derived from natural sources that are replaced at a higher rate	Once these resources are used up, they cannot be replaced
2	It can be used continuously	It can not be used continuously, and it is can be exhausted
3	Low or No carbon emission, hence environmentally friendly	High carbon emission, hence not environmental friendly
4	High maintenance cost	Low maintenance cost
5	Large area is required	Less area is required
6	Continuous production of electricity is not possible, because it depends on seasons	Continuous production of electricity is possible
7	Basically they produce DC current, hence required batteries to store	Basically they produce AC current

- **Advantages of Renewable Energy Sources:**

1. Non-exhaustible.
2. Can be matched in scale to the need and can deliver quality energy.
3. Can be built near the load point.
4. Flexibility in the design of conversion systems.
5. Local self-sufficiency by harnessing locally available renewable energy.
6. Except biomass, all other sources are pollution free**.**

- **Disadvantages of Renewable Energy Sources:**

1. Intermittent nature of availability of energy such as solar, wind, tidal etc. is a major setback in the continuous supply of energy.
2. Solar energy received at the earth is dependent on local atmosphere conditions, time of the day, part of the year etc.
3. Sources such as wind, tidal etc. are concentrated only in certain regions.
4. Technology is not fully developed to meet the present energy requirements.
5. Systems such as solar cells require advanced technologies and hence costlier.
6. Application to transport sector has been found to be not viable as on today.

- **Advantages of Non-Renewable Energy Sources:**

1. Initial cost is lower. Hence widely used.

2. Unit power costs are much lower and so are economical
3. Sources are highly reliable.
4. Power generation technologies are well established.

- **Disadvantages of Non-Renewable Energy Sources:**

1. The sources are getting depleted and soon will be exhausted.
2. They pollute the atmosphere.
3. They are not freely available

Principles of renewable energy sources

Renewable energy sources are derived from natural processes that replenish themselves over time and have a minimal impact on the environment. The principles for the using renewable energy sources include:

1. Sustainability: Renewable energy sources are sustainable because they can be replenished naturally or through human intervention.

2. Clean and Environmentally Friendly: Renewable energy sources produce little to no greenhouse gas emissions or other pollutants during operation.

3. Diversification: Renewable energy sources provide a diverse range of options, including solar, wind, hydro, and biomass etc

4. Decentralization and Distributed Generation: Many renewable energy systems can be installed at various scales, from small-scale residential systems to large utility-scale installations. Long-Term Cost Effectiveness: Renewable energy technologies have witnessed significant cost reductions over the years.

5. Energy Independence: By harnessing renewable energy sources domestically, countries can reduce their reliance on imported fossil fuels. This enhances energy independence,

6. Innovation and Research: Continued research, development, and innovation in renewable energy technologies are essential. Advancements in areas such as energy storage, grid integration, etc to increase the efficiency

7. Public Awareness and Support: Public awareness and support are vital for the successful deployment of renewable energy sources.

Energy and Sustainable Development

What is sustainable energy?

Sustainable energy includes any energy source that cannot be exhausted and can remains forever. It does not need to be renewed or replenished; sustainable energy meets our demand for energy without any risk of going bad or running out.

Sustainable energy doesn't harm the environment (or at most, there is a minimal risk), increase climate change or cost a heavy price. Although there is a cost associated with creating and building ways to capture sustainable energy, the energy sources themselves are typically free.

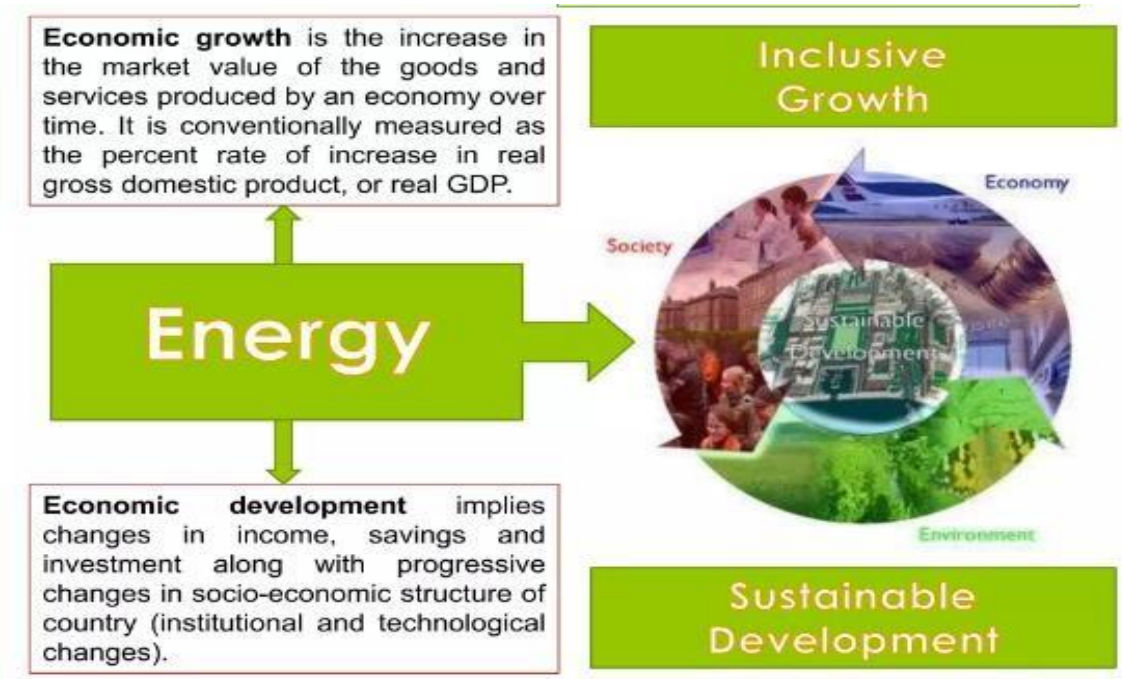
Sustainable development

Energy is a foundation stone of the modern industrial economy. Energy provides an essential ingredient for almost all human activities: it provides services for cooking and space/water

heating, lighting, health, food production and storage, education, mineral extraction, industrial production and transportation.

Energy powers computers, transportation, communications, cutting edge medical equipment and much more. For developing nations, the need for reliable and affordable energy is more fundamental. It can improve and even save lives

Role of Renewable Energy Technologies in Sustainable Development Renewable energy technologies play a crucial role in sustainable development by reducing greenhouse gas emissions, improving energy security and providing access to energy to communities that previously lacked it



Fundamentals and social implication

Fundamentals of Renewable energy

1. **Renewable energy.**

Energy obtained from natural and persistent flows of energy occurring in the immediate environment'. An obvious example is solar (sunshine) energy, where 'repetitive' refers to the 24-hour major period. Note that the energy is already passing through the environment as a current or flow, irrespective of there being a device to intercept and harness this power. Such energy may also be called Green Energy or Sustainable Energy.

2. **Non-renewable energy.** '

Energy obtained from static stores of energy that remain underground unless released by human interaction'. Examples are nuclear fuels and fossil fuels of coal, oil and natural gas. Note that the energy is initially an isolated energy potential, and external action is required to initiate the supply of energy for practical purposes. To avoid using the ungainly word 'non-renewable', such energy supplies are called finite supplies or Brown Energy.

- **Energy Sources**

There are five ultimate primary sources of useful energy:
1. The Sun.
2. The motion and gravitational potential of the Sun, Moon and Earth.
3. Geothermal energy from cooling, chemical reactions and radioactive decay in the Earth.
4. Human-induced nuclear reactions.
5. Chemical reactions from mineral sources.

- **Energy Planning**

Energy management is always important to improve overall efficiency and reduce economic losses. No energy supply is free, and renewable supplies are usually more expensive in practice than might be assumed. Thus, there is no excuse for wasting energy of any form unnecessarily. Efficiency with finite fuels reduces pollution; efficiency with renewables reduces capital costs.

- **Social Implications of energy**

1. Dispersed Living

Renewable energy arrives dispersed in the environment and is difficult and expensive to concentrate. By contrast finite energy sources are energy stores that are easily concentrated at source and expensive to disperse. Thus electrical distribution grids from fossil fuel and nuclear sources tended to radiate from central, intensive distribution points, typically with 1000MWe capacity.

2. Pollution and environmental impact

Harmful emissions can be classified as chemical (as from fossil fuel and nuclear power plant), physical (including acoustic noise and radioactivity) and biological (including pathogens); such pollution from energy generation is overwhelmingly a result of using ‘brown’ fuels, fossil and nuclear. In contrast, 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.

3. The Future

The influence of modern science and technology ensures that there are considerable improvements to older technologies, and subsequently standards of living can be expected to rise, especially in rural and previously less developed sectors. It is impossible to predict exactly the long-term effect of such changes in energy supply, but the sustainable nature of renewable energy should produce greater socio-economic stability than has been the case with fossil fuels and nuclear power.

RENEWABLE ENERGY – WORLDWIDE REVEWABLE ENERGY AVAILABILITY

- **Worldwide renewable energy availability**

Renewable energy is becoming increasingly available worldwide as countries recognize the importance of transitioning to clean and sustainable sources of power. The availability of renewable energy varies across regions and countries, depending on their geographical

location, natural resources, policy frameworks, and investments in renewable energy infrastructure. Here are some examples of renewable energy availability worldwide.

1. **Solar Energy:** Solar power is available in abundance in many parts of the world, especially in regions with high solar irradiation. Countries like China, the United States, India, and Germany are among the largest producers of solar energy. Additionally, countries closer to the equator, such as those in the Middle East and North Africa, have significant solar energy potential.
2. **Wind Energy:** Wind power is widely available in various regions globally, particularly in coastal areas, plains, and mountain passes. Countries like China, the United States, Germany, India, and Spain have substantial wind energy resources. Offshore wind farms are also becoming increasingly common, especially in Europe.
3. **Hydropower:** Hydropower relies on water resources, such as rivers and dams, and is one of the most widely used renewable energy sources globally. Countries like China, Brazil, Canada, the United States, and Russia have significant hydropower capacity.
4. **Biomass Energy:** Biomass energy is derived from organic materials such as agricultural waste, wood, and dedicated energy crops. It is available in many countries with agricultural activities, forestry resources, or waste management systems. Brazil, the United States, China, India, and Germany are among the largest biomass energy producers.
5. **Geothermal Energy:** Geothermal power utilizes heat from within the Earth to generate electricity or provide heating and cooling. Geothermal resources are available in regions with active tectonic activity or areas with accessible geothermal reservoirs. Countries like the United States, Philippines, Indonesia, Turkey, and Mexico have significant geothermal energy potential.
6. Tidal and Wave Energy: Tidal and wave energy harness the power of ocean tides and waves to generate electricity. Coastal areas with strong tidal currents or reliable wave patterns have the highest potential for these energy sources. Countries like the United Kingdom, Canada, France, South Korea, and Australia have been exploring tidal and wave energy technologies.

- **World energy scenario:**

The international Energy outlook 2004 projects strong growth for worldwide energy demand over the 24 year projection period from 2001 to 2025. Total world consumption of marketed energy is expected to expand by 54%, from 404 quadrillion Btu in 2001 to 623 quadrillion Btu in 2025. The major growth in energy demand is developing countries as two billion people lack access to affordable and reliable energy supplies.

The world coal reserves are likely to last a little over 200 years but the oil and gas reserves are estimated at just 45 years and 65 years, respectively. Of the three major primary sources of energy- coal, oil and gas, the coal consumption is heavily concentrated in the electricity generation sector.

Almost 65% of the world's coal use for electricity generation. The power generation accounts for virtually all the projected growth in coal consumption worldwide. One exception is China, where coal continues to be the main fuel in rapidly growing industrial sector, electing the country's abundant coal reserves and limited access to other sources of energy.

Despite the rapid strides made in the development and adoption of new sources of energy, particularly renewable energy, petroleum remains the primary energy source all over the world. Since the first commercial exploitation of oil in Pennsylvania, USA, in 1859, the importance. In 1920, only 95 million tons of oil was produced annually around the world. This rose to 4 billion tonnes in 2003. The consumption of petroleum in the world, which started as

a few tonnes per year about 140 years ago, has now reached to over 3000 million metric Tonnes (MMT) per year.

- **Renewable energy availability in India**

India has been actively working towards increasing the availability of renewable energy sources in recent years. The country has set ambitious targets to expand its renewable energy capacity and reduce its dependence on fossil fuels. As of my knowledge cut-off in September 2021, here is an overview of renewable energy availability in India

1. Solar Energy: India has significant solar energy potential due to its geographical location. The government has implemented various initiatives and policies to promote solar energy. The country has a robust solar photovoltaic (PV) sector, with both largescale solar parks and rooftop solar installations. As of 2021, India has become one of the top solar energy producers globally.

2. Wind Energy: India has a vast onshore and offshore wind energy potential, particularly along its coastline and in states with favourable wind conditions. The country has been a leader in wind energy deployment, with large-scale wind farms and individual turbines installed across different regions.

3. Hydropower: Hydropower has been a traditional source of renewable energy in India. The country has a significant hydropower potential, with several major hydropower projects already operational. However, the development of new hydropower projects has faced challenges due to environmental concerns and social issues.

4. Biomass Energy: India has a substantial biomass potential, which includes agricultural waste, forest residues, and dedicated energy crops. Biomass energy is used for both heat and power generation in rural areas. The government has been promoting the use of biomass energy through various policies and incentives.

5. Geothermal and Ocean Energy: While India has some potential for geothermal and ocean energy, the development of these sources is still in the early stages. The government is exploring opportunities and conducting research to tap into these resources.

- **Renewable Energy in India**

With a population of 1.3 billion, India has a massive demand for energy to fuel its rapidly growing economy. From a power deficit nation at the time of Independence, the efforts to make India energy-independent have continued for over seven decades. Today, we are a power surplus nation with a total installed electricity capacity of over Four lakh MW

Keeping in mind the sustainable development goals, India's power generation mix is rapidly shifting towards a more significant share of renewable energy. Today, **India is the world's third largest producer of renewable energy**, with 40% of its installed electricity capacity coming from non-fossil fuel sources.

Solar	Wind	Small hydro	Large hydro	Bio power
48.55 GW	40.03 GW	4.83 GW	46.51 GW	10.62 GW

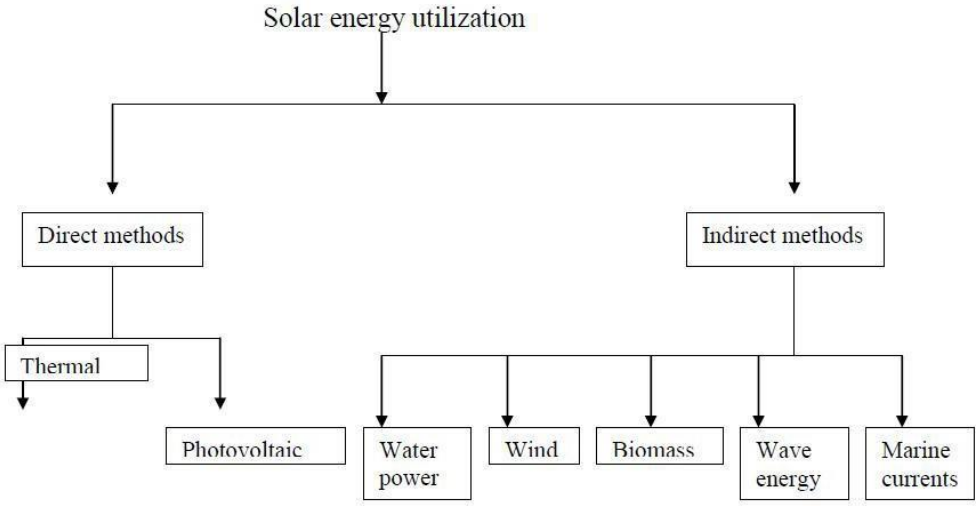
SOLAR ENERGY

Solar energy is energy derived from sun in the form of solar radiation. It is hardness by either direct sources (like solar cooker, solar steam systems, solar dryer, solar cells, etc.), or indirect sources (biomass production, wind, tidal, etc.).

The sun radiates more energy in one second than the world has used since time began. Only a small portion of this energy strikes the earth, one part in two billion. Yet this amount of energy is enough to meet the world's needs, if it could be harnessed.

The power from the sun intercepted by the earth is approximtely$A = 1.8\times10^{11}$ MW, which is roughly 10,000 times what is needed to power the world

Classification of methods for solar energy utilization



Applications of solar energy

- **Solar thermal applications**

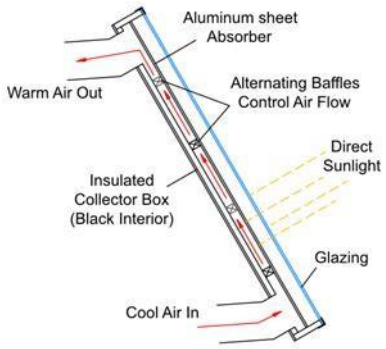
1. Solar drying of agricultural products
2. Solar cookers
3. Solar water and air heating
4. Salt production by evaporation of seawater
5. Solar distillation

- **Solar Photo voltaic application or solar electricity application**

1. Electricity generation through Photo voltaic cells
2. Solar Lantern
3. Solar streetlight
4. Solar pump

Solar air heaters

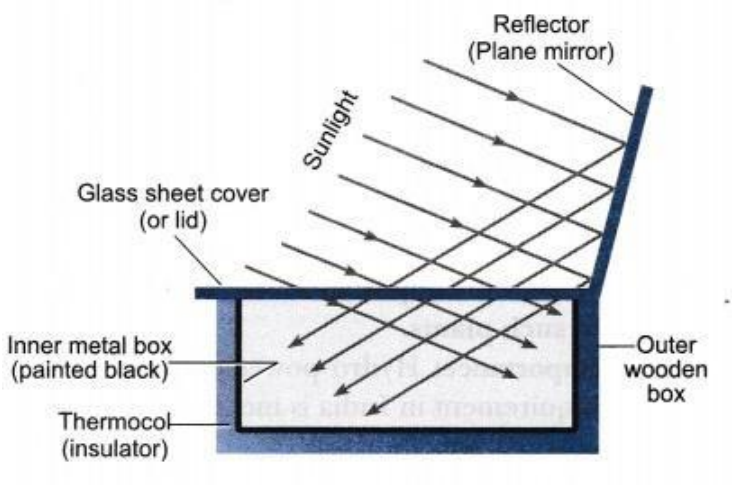
- Solar air heating is a solar thermal technology in which the energy from the sun, insolation, is captured by an absorbing medium and used to heat air. Solar air heating is a renewable energy heating technology used to heat or condition air for buildings or process heat applications.
- The heat absorbed by the absorber plate is transmitted to the air drawn into the collector. The hot air leaves the collector to a storage tank for further use



Back-pass Solar Air Collector

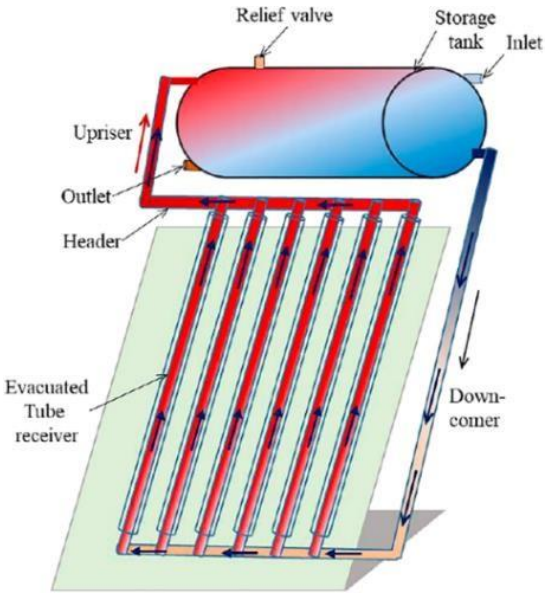
Solar cooker

- A 'solar cooker' is a device which uses the energy of direct sunlight to heat, cook or pasteurize food or drink. Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves
- The solar rays penetrate through the glass covers and absorbed by blackened metal trays (Boxes) kept inside the cooker
- Insulating material like glass wool saw dust or any other material is filled in the space which minimizes heat loss due to conduction.
- When this type of cooker is placed in the sun, the blackened surface starts absorbing sunrays and temperature rises. The food in the trays is cooked



Solar water heater

- A solar water heating unit comprises a blackened flat plate metal collector with an associated metal tubing facing the general direction of the sun. The plate collector has a transparent glass cover above and a layer of thermal insulation beneath it
- The collector absorbs solar radiations and transfers the heat to the water circulating through the tubing either by gravity or by a pump



Solar Photovoltaic systems

Solar photovoltaic system is used to produce electric current, applications are electricity for houses, pumps, solar lantern, solar street light etc

Solar photovoltaic systems generally consist of six individual components: the solar PV array, a charge controller, a battery bank, an inverter, a utility meter, and an electric grid.

- **Solar Photovoltaic Array**

A solar photovoltaic array consists of a number of solar PV panels that are electrically connected. The solar PV array generates DC electricity from sunlight.

- **Charge Controller**

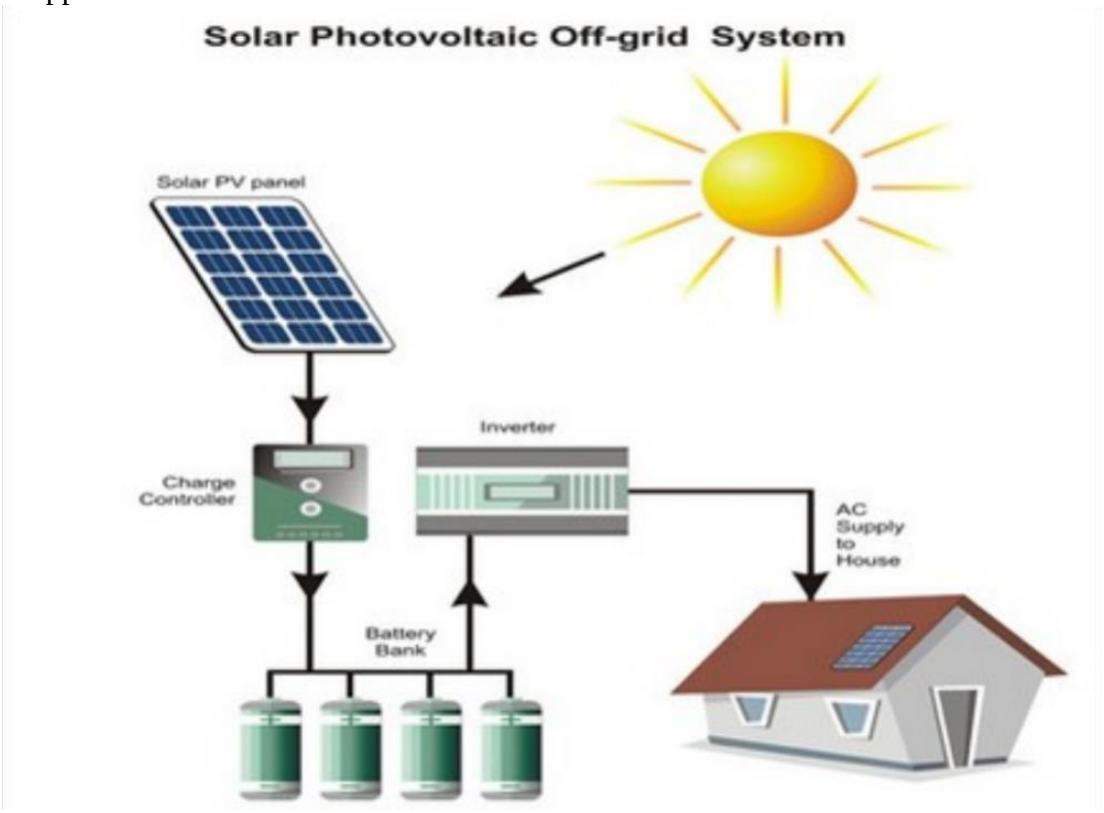
Charge controllers regulate the DC from the solar panels to make sure that the batteries don't overcharge. A charge controller can measure whether the batteries are fully charged and can stop the current from flowing in order to prevent the batteries from damage.

- **Battery Bank**

Stores the energy or current harnessed by PV cells

- **Inverter**

A solar power inverter is a key part of any solar photovoltaic system, as it converts electricity from DC to AC. This is necessary, since you need AC power for the energy supply of your home appliances

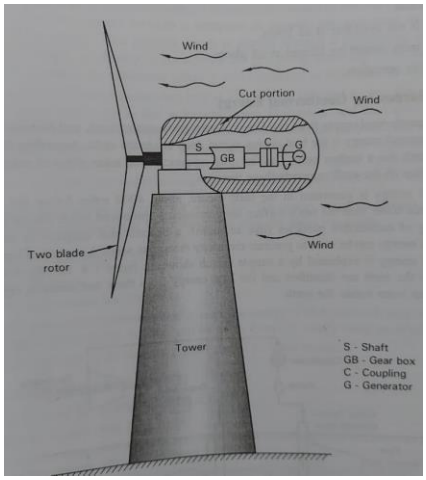


Advantages of Solar Energy	Disadvantages of Solar Energy
Reduces Electricity Bills	Weather Dependent
Diverse Applications	Solar Energy Storage is Expensive
Low Maintenance Costs	Uses a Lot of Space

Wind Energy

- Energy derived from wind velocity is wind energy.
- Wind is caused by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates
- The minimum speed of the wind required is 10km/hr.
- General applications of windmills are pumping water, fodder cutting, grain grinding, generation of power etc.

Windmill



When the air flows the blades of the windmill rotates, this makes the shaft to rotate. The shaft is coupled to the gear box which increases the speed hence the gears in the gear box rotate with high speed. The gear box is coupled to the generator with the help of shaft and couplings rotates the generator to produce the electricity. The power produced by the generator is transferred down the tower to the power grid system and then through transmission lines

Advantages

1) Free Fuel
2) One of the Cleanest Forms of Energy
3) Advances in Technology
4) Doesn't Disrupt Farmland Operations. ...
5) Reduces Our Dependence of Fossil Fuels

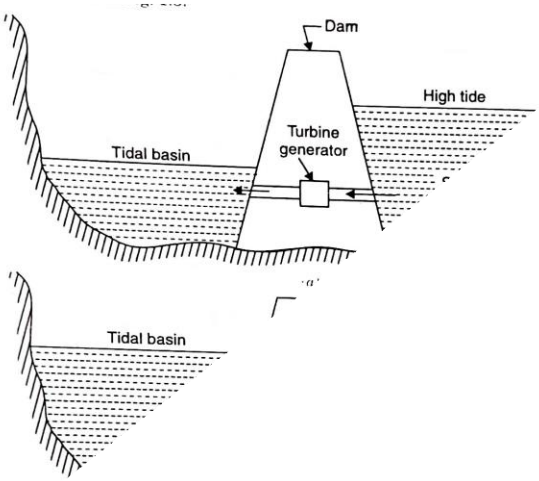
Dis advantages

1) Dangerous to Some Wildlife
2) Noisy
3) Expensive Upfront Cost

TIDAL ENERGY

- The main reason of tides are gravitational force, and this energy is harnessed from the oceans
- Tides occurs due to the gravitational pull of the moon and the sun
- The rise of seawater is called high tide and fall in seawater is called low tide
- Thus, enormous rising and falling movement of water is called tidal energy

- **Harnessing energy from tides**

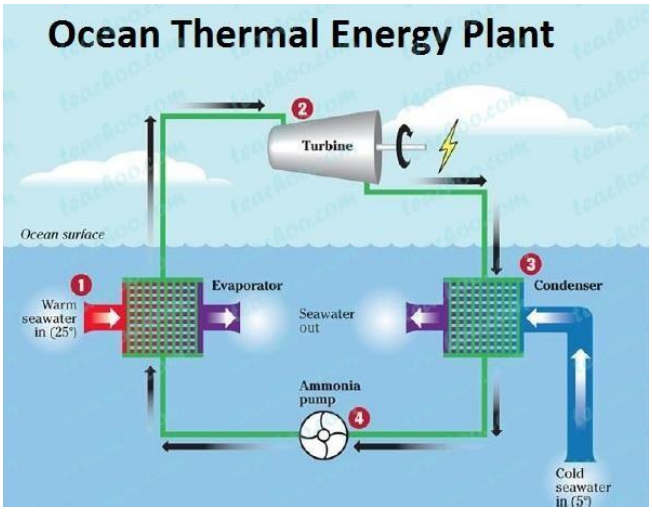


A dam (or barrage) is built in such a way that the basin gets separated from the sea resulting in a pressure difference in the water level between the basin and the sea. Inside the dam, water turbine and flood gates are installed as shown in the figure. During the high tide, the level of tide in the sea is more than the level of water in the tidal basin. The flood gates are opened thereby causes the tide to flow into the basin through the water turbine. The flowing water drives the turbine and ultimately the generator to generates electricity.

During low tide period, the level of water in the tidal basin is more than that of the tide in the sea. 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 ultimately the generator to generate electricity. Thus, electricity can be generated during both the tides. The turbines are designed to be driven by the energy of the water in the directions.

Ocean thermal Energy

Ocean thermal energy conversion (OTEC) is a method to produce electricity by using the temperature difference of ocean water at different depths between warm ocean surface and cool deep ocean water to run a heat engine.



The warm water from the ocean surface is collected and pumped through the heat exchanger to heat and vaporize a working fluid which is flowing in the tubes through turbine heat exchanger, turbine, condenser, and pump. Then, the vaporized working fluid is sent to turbine, and strikes

the turbine blades and turbine starts rotate. The turbine is coupled to an electric generator that generates electrical power

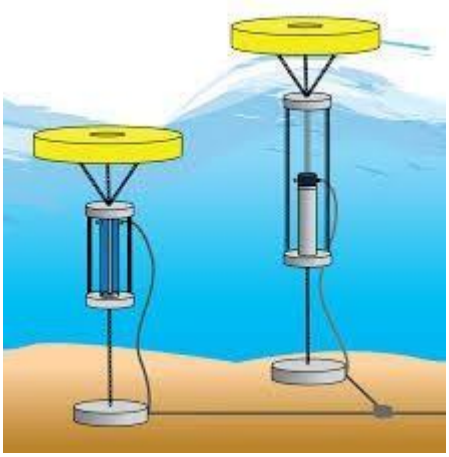
The working fluid vapor coming out of the turbine is condensed back into liquid by a condenser with the help of cold deep ocean water which is pumped through condenser where the vapour is cooled and returns to liquid state. The liquid (working fluid) is pumped again through heat exchanger and cycle repeats.

Wave energy

Wave energy is a form of renewable energy that can be harnessed from the motion of the waves. There are several methods of harnessing wave energy that involve placing electricity generators on the surface of the ocean. Waves get their energy from solar energy through the wind. Solar energy causes winds to blow over vast ocean areas, which in turn cause waves to form

Similar to solar, wind, and geothermal energy, wave energy is a renewable source. As long as the Earth continues to track around the sun, and the moon around the Earth, waves will continue to be a viable source of kinetic energy. Wave energy also produces fewer carbon emissions than energy from traditional fossil fuels, such as coal or oil, making it an eco-friendlier option

- **Harnessing electricity from wave**



The most common and simplest type of WEC is called a point absorber, made up of a buoy (float) placed on the surface of water, a generator (like a cylinder contains generator coils and column of magnets), and a mooring(a foundation which is anchored tightly to the sea bed).

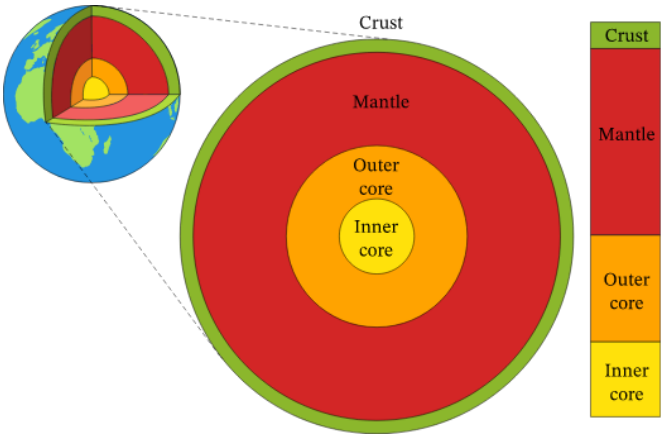
As the surface of the water moves up and down the float is also stats to move up and down by pulling and pushing the cable below which is connected to the float and magnet. When the float moves the magnet also moves in the direction od float in between the coils, hence the current is induced in the coils and the current is stored in the batteries for further usage.

Geothermal Energy

It is the heat from high pressure stream coming from within the earth

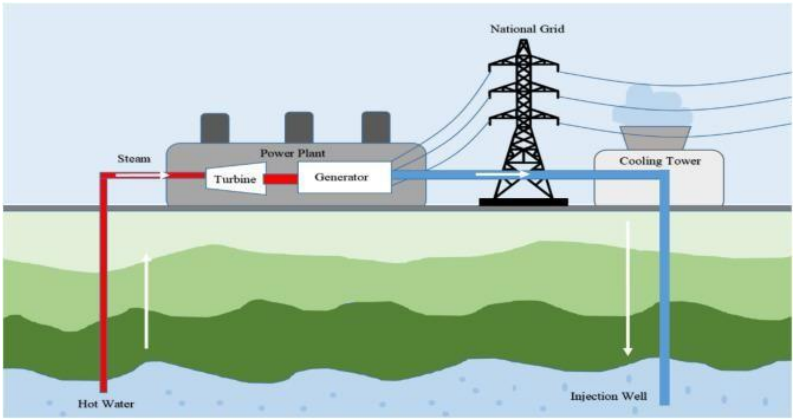
- Geothermal energy is the thermal energy produced and stored inside the Earth’s crust. (Geo means “earth,” and thermal means “heat” in Greek.)

- It comes from heat generated during the original formation of the planet and the radioactive decay of materials. This thermal energy is stored in rocks and fluids in the center of the earth
- The difference between the temperature in the earth's core and the surface drives a continuous conduction of thermal energy from the center to the exterior of the planet.
- High temperatures of over 4000°C cause some of the rock in the center of the Earth to melt and form hot molten rocks called magma.
- The rock and water in the Earth's crust can reach heats of around 370°C.
- Thermal energy contained in the rocks and fluids can be found from shallow depths right down to several miles below the Earth's surface.
- Hot rocks in the earth's core emit heat which generates steam and pressure and thus comes out of the earth's surface. This steam is used to run turbines and produce electricity.

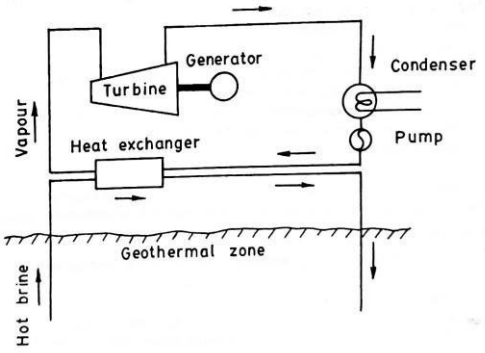


Harnessing electricity from geothermal energy

Dry steam plants: These plants run on the natural steam that comes from the underground reservoirs to generate electricity, sometime from the underground directly the stem is obtained so this steam is sent to the turbine to run the turbine intern the turbine operates the generator and electricity is generated. The steam which run the turbine is then cooled in the cooling tower and then it is sent back to the underground



Binary power plants: These plants use hot water or brine from the underground to heat a 'secondary liquid' in the heat exchanger and converts it to vapor then that vapor turns the turbines to generator the electricity with the help of generator. The vaporized liquid is then condensed and reused.

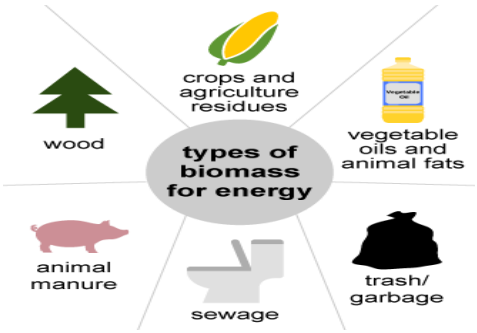


Biomass Energy

Biomass is renewable organic material that comes from plants and animals. Biomass contains stored chemical energy from the sun. Plants produce biomass through photosynthesis. Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes.

Biomass sources for energy

- **Wood and wood processing waste—**Firewood, wood pellets, and wood chips, lumber and furniture mill sawdust and waste, and black liquor from pulp and paper mills
- **Agricultural crops and waste materials:** Corn, soybeans, sugar cane, switch grass, woody plants, and algae, and crop and food processing residues, mostly to produce biofuels
- **Biogenic materials in solid waste:** Paper, cotton, and wool products, and food, yard, and wood wastes
- Animal manure and human sewage for producing biogas/renewable natural gas.



Methods of converting biomass into energy

1. **Direct combustion:** It is the most common method for converting biomass to useful energy. All biomass can be burned directly for heating buildings and water, for industrial process heat, and for generating electricity in steam turbines. Example: Wood burning

2. **Thermochemical conversion of biomass:** This is the thermal decomposition processes in which biomass feedstock materials are heated in closed, pressurized vessels called *gassifiers* at high temperatures. They mainly differ in the process temperatures and amount of oxygen present during the conversion process.

Types of thermos chemical conversion of biomass

a. Pyrolysis - heating organic materials to 400–500 in the near complete absence of free oxygen. Biomass pyrolysis produces fuels such as charcoal, bio-oil, renewable diesel, methane, and hydrogen.

b. Hydro treating is used to process bio-oil (produced by *fast pyrolysis*) with hydrogen under elevated temperatures and pressures in the presence of a catalyst to produce renewable diesel, renewable gasoline, and renewable jet fuel.

c. Gasification - heating organic materials to 800–900ºC with addition of controlled amounts of free oxygen and/or steam into the vessel to produce a carbon monoxide and hydrogen rich gas called synthesis gas or *syngas*. Syngas can be used as a fuel for diesel engines, for heating, and for generating electricity in gas turbines. It can also be treated to separate the hydrogen from the gas, and the hydrogen can be burned or used in fuel cells.

3. Biological conversion: It includes fermentation of biomass to convert the biomass into ethanol and anaerobic digestion of the bio mass to produce renewable natural gas.

Advantages of Biomass energy

- A renewable source
- Carbon Neutral
- Improves water quality
- A great alternative to fossil fuels
- It reduces waste in landfills.
- Versatile

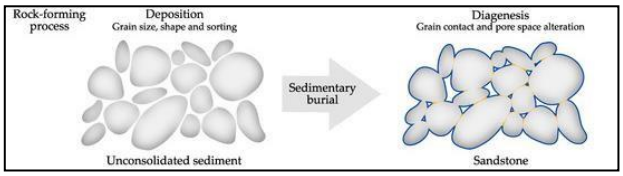
Disadvantages of Biomass energy

- Usage of domestic sewage and manures can also harm environment by producing methane gas.
- Application of biomass for energy generation is usually costly than that of fossil fuels.
- Deforestation may occur
- Requires a significant amount of water
- Not fully commercial
- Increased greenhouse gases like methane produced from organic biomass can cause global warming and climate change

Oil Shale

Oil shale is a fine-grained sedimentary rock that contains solid bituminous materials (called kerogen, which is an organic matter) that release petroleum-like liquids (shale oil or gas) when the rock is heated from which oil or gas can be extracted. Similar to traditional petroleum, natural gas, and coal, oil shale and kerogen are also fossil fuels

They were formed millions of years ago by deposition of silt and organic debris on lake beds and sea bottoms. Heat and pressure then transformed the materials into oil shale in a process similar to that forms oil over long periods of time. Deposits of oil shale are found in many areas around the world and large areas of the United States, Russia, Argentina, Libya, Israel, and China are known to have shale oil and gas reserves



- **Extraction of Shale Oil**

The important extraction processes of shale oil are as follows:

1. **Ex situ retorting:**

- Since the oil substances in oil shale are solid and cannot be pumped directly out of the ground, the following steps must be involved:
- The oil shale must be mined and brought to ground surface.
- The mined oil shale is then heated at a high temperature (a process called retorting). It involves heating kerogen in a process called pyrolysis. Pyrolysis is a form of heating without oxygen. At about 60°C–160°C, kerogen reaches its natural 'oil window', and at 120°C–225°C, kerogen reaches its natural 'gas window'.
- The resultant liquid must then be separated and collected.

2. **In situ retorting:**

An alternative method of extracting shale oil under experimental investigation is referred to as *in situ* retorting. During the *in situ* process, oil shale is not mined or crushed. Instead, the rock is heated to its oil window while it is still underground.
It involves the following steps:

- Heating the oil shale while it is still underground
- Pumping the resulting liquid to the surface
- However, improvements in drilling technology, such as the emergence of directional drilling, has made extraction of oil from shale less cost prohibitive. Production companies use a variety of methods to extract oil from shale

3. **Hydraulic fracturing (fracking):**

It involves injecting pressured water and chemicals into a well in order to break into underground reservoirs. Steam can be injected underground to heat up oils in the surrounding shale formation, which then seep into the well. Acids can also be injected in order to increase the permeability(porosity) of rock surrounding the well.

4. **Volumetric heating:**

In this process, 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. The oil could then be pumped directly from underground.

Advantages and Disadvantages of Oil shale

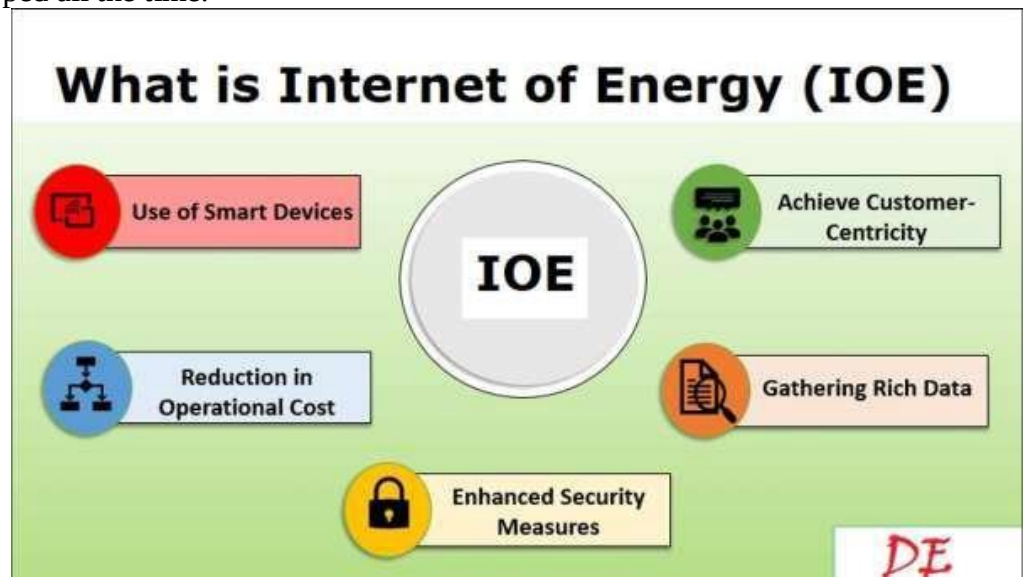
Advantages	Disadvantages
• Moderate cost (oil sand) • Large potential supply esp. oil sands in Canada • Easily transported • Efficient distribution system • Technology is well developed	• High cost (oil shale) • Low net energy yield- takes large amounts of energy to make it. • Large amounts of water needed for processing • Severe water pollution and air pollution • Severed land disruption • CO_2 emissions when burned

Applications of oil shale

- Shale oil, similar to crude oil, can be refined into many different substances, including *diesel fuel*, *gasoline*, and *liquid petroleum gas* (LPG) - (domestic and automobile fuels).
- Refined shale oil is used to produce other commercial products, such as ammonia and sulfur.
- Spent rock (solid residue) is used in cement processing.
- Oil shale is utilized as a fuel for thermal power-plants, burning it (like coal) to drive steam turbines

Introduction to Internet of energy (IOE)

The Internet of Energy (IoE) is a system of interconnected devices that collect and share data about energy production, consumption, and distribution. IoE uses sensors, actuators, and communication technologies to monitor and control energy flows in real time. This information can be used to improve the efficiency of energy systems, reduce waste, and make energy more reliable and sustainable. The IoE is a rapidly growing field, with new applications being developed all the time.



Some of the most common IoE applications include

Benefits of IoE:

1. Increased efficiency: IoE can help to improve the efficiency of energy systems by monitoring and controlling energy flows in real time. This can lead to reduced energy consumption and lower costs.
2. Reduced waste: IoE can help to reduce energy waste by identifying and eliminating inefficiencies in energy production and distribution. This can help to protect the environment and conserve resources.
3. Improved reliability: IoE can help to improve the reliability of energy systems by making them more resilient to disruptions. This can help to prevent blackouts and keep businesses and homes running smoothly.
4. Increased sustainability: IoE can help to make energy systems more sustainable by integrating renewable energy sources and energy storage systems. This can help us to reduce our reliance on fossil fuels and protect the environment.

The IoE is still in its early stages of development, but it has the potential to revolutionize the way we produce, consume, and distribute energy. By making energy systems more efficient, reliable, and sustainable the IoE can help us to create a cleaner, healthier, and more prosperous future.

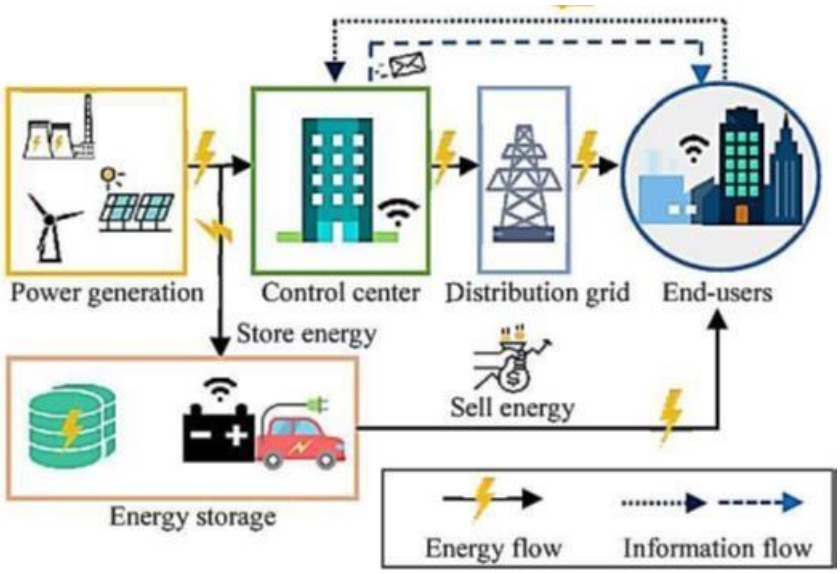


Figure: IOE framework