ATME COLLEGE OF ENGINEERING

13th KM Stone, Bannur Road, Mysore - 560 028

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

(ACADEMIC YEAR 2023-24)

COURSE: RENEWABLE ENERGY SOURCES

SUB CODE: BETCK105E

SEMESTER: I

Vision & Mission of ATME College of Engineering

Vision

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

Mission

- To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
- To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torchbearers of tomorrow's society.
- To strive to attain ever-higher benchmarks of educational excellence.

Vision & Mission of Department of Electrical & Electronics Engineering

Vision of the department

To create Electrical and Electronics Engineers who excel to be technically competent and fulfill the cultural and social aspirations of the society.

Mission of the Department

- To provide knowledge to students that builds a strong foundation in the basic principles of electrical engineering, problem solving abilities, analytical skills, soft skills and communication skills for their overall development.
- To offer outcome based technical education.
- To encourage faculty in training & development and to offer consultancy through research & industry interaction.

PROGRAMME EDUCATIONAL OBJECTIVES AND PROGRAMME OUTCOMES

PROGRAMME OUTCOMES:

Engineering Graduates will be able to:

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of EXPERIMENTs, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Module-1:Introduction

Syllabus

1. Principles of Renewable Energy
2. Energy and Sustainable Development
3. Fundamentals and Social Implications.
4. Worldwide Renewable Energy Availability
5. Renewable Energy Availability In India
6. Brief Descriptions on Solar Energy
7. Wind Energy
8. Tidal Energy
9. Wave Energy
10. Ocean Thermal Energy
11. Biomass Energy
12. Geothermal Energy
13. Oil Shale
14. Introduction to Internet Of Energy (IOE).

Introduction:

Renewable energy sources are derived from natural resources that are continually replenished and can be used to generate power or provide heat without depleting their availability.

1. The principles of renewable energy can be summarized as follows:

Sustainability: Renewable energy sources are derived from naturally replenishing resources that are not depleted over time. They provide a sustainable and long-term solution to meet energy needs without harming the environment.

Environmental Friendliness: Renewable energy sources produce minimal to no greenhouse gas emissions or other harmful pollutants during operation. They help mitigate climate change, reduce air pollution, and minimize ecological damage.

Energy Independence: By diversifying energy sources and reducing reliance on imported fossil fuels, renewable energy promotes energy independence for countries. It enhances energy security and reduces vulnerability to price fluctuations and geopolitical tensions.

Resource Efficiency: Renewable energy technologies strive to maximize the efficient use of natural resources. They focus on harnessing energy from the sun, wind, water, and other sources in the most efficient and sustainable manner possible.

Technological Advancement: The development and adoption of renewable energy technologies drive innovation, research, and technological advancement. This leads to improvements in efficiency, cost-effectiveness, and the integration of renewables into existing energy systems.

Economic Benefits: Renewable energy investments create jobs, stimulate economic growth, and foster local and regional development. They provide opportunities for new industries and markets, particularly in rural and remote areas where renewable resources are abundant.

Community Engagement: Renewable energy projects often involve local communities, allowing them to actively participate in and benefit from the transition to clean energy. Community-owned renewable energy initiatives empower individuals and communities to take charge of their energy future.

Energy Access: Renewable energy plays a vital role in expanding access to electricity and clean cooking solutions in remote and underserved areas. Off-grid renewable systems can provide affordable and reliable energy to communities without access to centralized grids.

2. Energy and Sustainable Development

Energy and sustainable development are closely interconnected concepts that address the need for meeting present energy demands while ensuring the well-being and prosperity of future generations. Sustainable development aims to achieve economic growth, social progress, and environmental protection, all of which require a sustainable energy system. Here are some key points to consider:

Energy and Development:

- Energy is essential for economic development, providing power for industries, transportation, and infrastructure.

Environmental Challenges:

- Fossil fuel combustion contributes to air pollution, greenhouse gas emissions, and climate change.
- Dependence on non-renewable resources raises concerns about their depletion and geopolitical conflicts.

Renewable Energy Sources:

- Renewable energy, derived from sources such as solar, wind, hydro, and biomass, offers sustainable alternatives.

Energy Efficiency and Conservation:

- Improving energy efficiency in buildings, transportation, and industrial processes reduces energy consumption.

Policies and Strategies:

- Governments worldwide are implementing policies and strategies to promote renewable energy and sustainable practices.

Socio-economic Benefits:

- Transitioning to sustainable energy sources can create new job opportunities and stimulate economic growth.

Technological Innovations:

- Advancements in energy storage technologies, smart grids, and grid integration facilitate the integration of renewable energy.

3. Fundamentals and Social Implications

3.1 Fundamentals of Renewable Energy Sources:

i. **Availability and Renewability:** Renewable energy sources, such as solar, wind, hydro, geothermal, and biomass, are naturally replenished and available in abundance
ii. **Conversion and Utilization:** Renewable energy sources are converted into usable energy through various technologies.
iii. **Energy Storage and Grid Integration:** Renewable energy sources are intermittent in nature, dependent on factors like weather conditions. Energy storage technologies, such as batteries, allow excess energy to be stored for later use, ensuring a consistent and

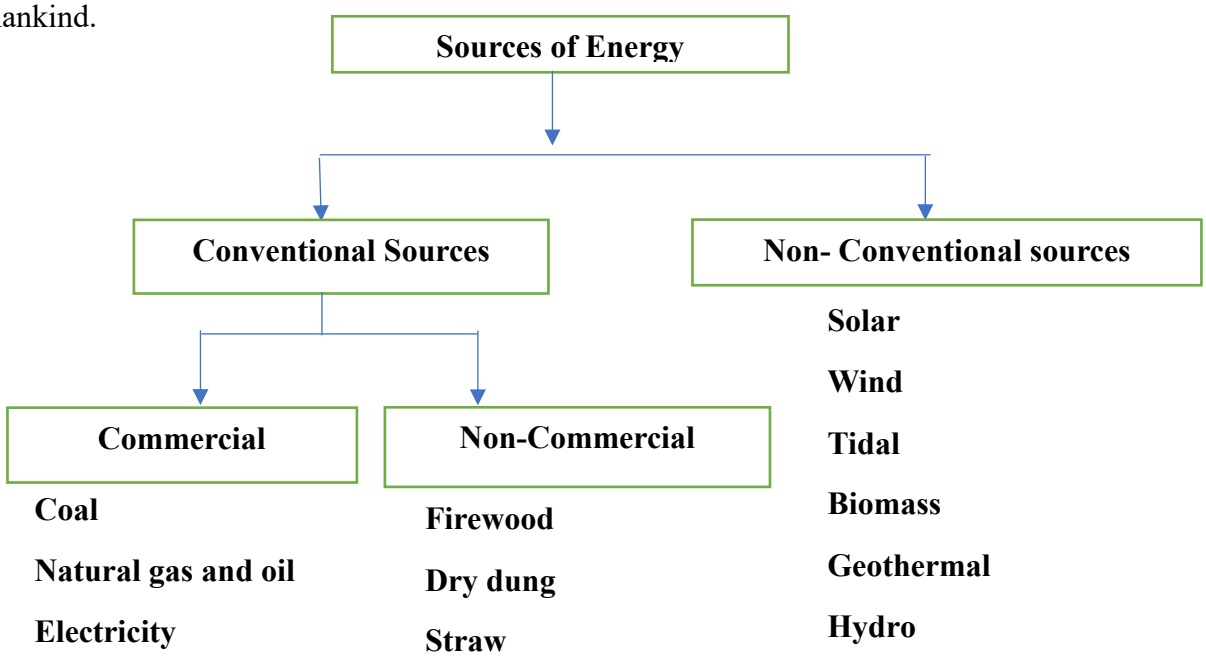
reliable power supply. Integration with the existing electrical grid is also crucial to effectively harness and distribute renewable energy.

3.2 Social Implications of Renewable Energy Sources:

1. **Climate Change Mitigation**: Renewable energy sources play a critical role in mitigating climate change by reducing greenhouse gas emissions. Renewable energy helps reduce carbon dioxide and other pollutants, leading to cleaner air and a healthier environment.
2. **Energy Access and Equity:** Renewable energy can improve access to electricity in underserved regions, particularly in developing countries.
3. **Job Creation and Economic Development:** The growth of renewable energy industries creates job opportunities across various sectors, including manufacturing, installation, operation, and maintenance.
4. **Health Benefits:** Transitioning to renewable energy sources can lead to significant health benefits. Compared to fossil fuel-based power generation, renewable energy produces fewer air pollutants, reducing respiratory diseases and improving overall public health.
5. **Community Engagement and Empowerment:** Renewable energy projects often involve local communities through consultation, participation, and even ownership. Community-led renewable energy initiatives empower individuals and communities to take part in the energy transition, fostering a sense of ownership, economic empowerment, and sustainable development at the local level.
6. **Energy Independence and Security:** Renewable energy sources reduce dependence on imported fossil fuels, enhancing energy independence and security. By diversifying energy sources and promoting domestic renewable energy production, countries can reduce vulnerability to price fluctuations, geopolitical tensions, and supply disruptions associated with fossil fuels.

4. Conventional and non-conventional energy resources:

Energy: Energy is one of the most important components of economic infrastructure. In a developing economy, the energy demand is high from sectors like agriculture, industry, residential and economic. Energy resources are very much necessary for the existence of mankind.



4.1 Conventional Sources of Energy: The energy sources that are present for a long time found naturally on or beneath the Earth and take a long time to produce or replenish are known as conventional sources of energy. Generally, these are also non-renewable energy sources. The conventional sources of energy are again divided into two categories, commercial and non-commercial energy sources.

i. **Commercial energy sources:** To get energy from these kinds of sources, we need to pay for it. The consumption price depends on various factors like demand and supply, availability, feasibility etc.
   a) **Coal:** It is a type of fossil fuel that is present beneath the surface of the Earth and was formed by decomposed organic materials due to the high compression and temperature due to Earth's layers. It takes millions of years to form coal which we use. Therefore it is a non-renewable energy resource.
   b) **Natural gas and oil:** These are also obtained from fossil fuels and are present beneath the surface of the Earth and formed from decomposed organic materials. They are in such form because of the high compression and temperature of the Earth's layers. Natural gas and oil also take a very long time to produce but can be used instantly therefore these are also known as non-renewable energy resources.

ii. **Non-commercial energy sources:** The energy resources which are generally available are free to use. Examples are firewood, cow dung, and straw. Firewood are obtained from trees and plants, dung is obtained from animal wastes and straw is obtained from the crop plants like wheat crops, rice crops, etc.

4.2 Non-Conventional Sources of Energy: The natural resources that can produce useful energy continuously for a long period of time and are available again and again for use even after it is exhausted are known as non-conventional sources of energy or renewable resources of energy. Some types of non-conventional sources of energy are; sunlight, wind, water flow, and ocean

i. **Solar energy:** The energy produced by the Sun is referred to as solar energy. It is formed due to nuclear fission and fusion inside the Sun. This energy travels in the form of radiation (electromagnetic waves). This energy is collected by some photovoltaic cell panels which absorb the solar energy and convert it into electricity that can be used for home appliances. Solar heating panels are used to heat the water in the solar heater.
ii. **Wind Energy:** When we talk about wind energy then it means that the wind speed should be high enough to produce a considerable amount of useful work. This kind of wind energy is usually available near coastal regions or near mountains where high wind flow is available at a constant rate. Big turbines, called **wind turbines** are installed at such sites to tap this wind energy which drives these turbines and as a result, electricity is generated.
iii. **Tidal energy:** We know the tides are created in the ocean due to the rotation of the Earth and the attraction between the Earth and the moon. Tides are nothing but the rise and fall of the water level in the ocean. We can observe it easily on the shores. The tidal energy is captured by forming narrow dams at the narrow entrances of rivers. During high tides and low tides, the motion of the water column is used to rotate the turbines that produce electricity.
iv. **Biomass energy:** Biomass energy is extracted from biological materials where biological materials are formed from living organisms and plants. In the biomass power plant, biomass is burnt into a combustor in order to produce heat which will be further converted into mechanical energy in order to generate electricity. Biomass can also be

converted into other forms of energy like fuels used in transportation, biodiesel or methane gas depending on the requirements.

v. **Hydro energy:** This energy is generally available in flowing rivers. A dam is formed to store the water of the river at some convenient location. This stored water contains the potential energy which can be converted into kinetic energy by giving a narrow passage to the flow. Thus we get a water stream with high speed that drives large turbines to produce electricity.

4.3 Advantages and Disadvantages of Renewable Energy Sources:

Advantages:

i. Renewable energy sources can never run out because these sources are continuously filled by nature.
ii. As compared to non-renewable sources like fossil fuels, renewable energy sources are easily available to humans and are reliable because these energy sources are distributed equally on the planet.
iii. Renewable energy sources are environment-friendly because they are produced naturally, and they do not emit any harmful gases or pollutants that can cause damage to the ozone layer or to the environment.
iv. Renewable sources require less maintenance as compared to non-renewable energy sources.

Disadvantages:

i. Renewable energy sources are not available round the clock because these sources are natural forces that depend strongly on the weather condition.
ii. The efficiency of renewable energy is low because every type of energy requires a particular kind of technology to convert it into electricity.
iii. The storage cost of renewable energy is very high, and also it requires a lot of space for its installation.

4.4 Advantages and Disadvantages of Non-Renewable Energy Sources:

Advantages:

i. Resources such as oil and coal tend to provide us with more energy as compared to renewable energy like wind or solar energy, and the reason behind it is that non-renewable resources are high in energy.
ii. In the construction of natural gas pipelines, mining of coal, and selling of oil and petroleum, huge profits can be generated.
iii. Non-renewable resources are easy to use and quite easy to store. Also, non-renewable resources can be conveniently moved across the world.

Disadvantages:

i. One of the main drawbacks of non-renewable energy is that it consumes a lot of time and it takes a lot of effort.
ii. Non-renewable energy sources are slowly vanishing from the earth because they are formed over billions of years.
iii. Non-renewable energy causes pollution and also, they can cause respiratory problems in humans. Sources like coal, oil and natural gas are responsible for rapidly destroying the ozone layer because these sources release a large amount of carbon dioxide when burnt.

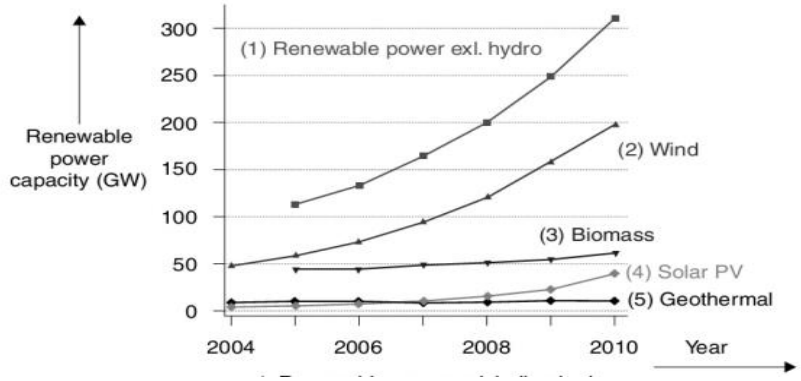
iv. Transportation of non-renewable sources is a very risky process because when huge oil tanks and cargo ships crash and spill the contents in the sea or somewhere else, then it can be deadly for human beings, sea animals and the vegetation in that area.

4.5 Difference between Renewable and Non-Renewable sources

Renewable Resources	Non-renewable Resources
It can be used again and again throughout its life.	It cannot be used again and again as it is limited which can be depleted one day.
They are the energy resources which cannot be exhausted.	They are the energy resources which can be exhausted one day.
It is environment-friendly as the amount of carbon emission is low.	It is not environment-friendly as the amount of carbon emission is high.
These resources are present in unlimited quantity.	These resources are present in a limited quantity only.
The total cost of these resources is low.	The total cost of these resources is comparatively high.
These resources are pollution free.	These resources are not pollution free.
The maintenance cost of the renewable resources is very high.	The maintenance cost of the renewable resources is low.
Requires large land area for the installation of the power plant.	Requires less land area for the installation of the power plant.
It is sustainable	It is exhaustible

5. Worldwide Renewable Energy Availability:

About 16% of global final energy consumption comes from renewable with 10% coming from traditional biomass, which is mainly used for heating, and 3.4% from hydroelectricity.



New renewable energy (small hydro, modern biomass, wind, solar, geothermal, and biofuel) accounted for another 3% and were growing very rapidly. The share of renewable energy in

electricity generation is around 19%, with 16% of global electricity coming from hydroelectricity, and 3% from new renewable energy.

Potential for Worldwide Renewable Energy

Energy Resource	Energy Amount
Solar energy	1,600 EJ (444,000 TWh),
Wind power	600 EJ (167,000 TWh)
Geothermal	500 EJ (139,000 TWh)
Biomass	250 EJ (70,000 TWh)
Mini hydropower	50 EJ (14,000 TWh)
Ocean energy	1 EJ (280 TWh)

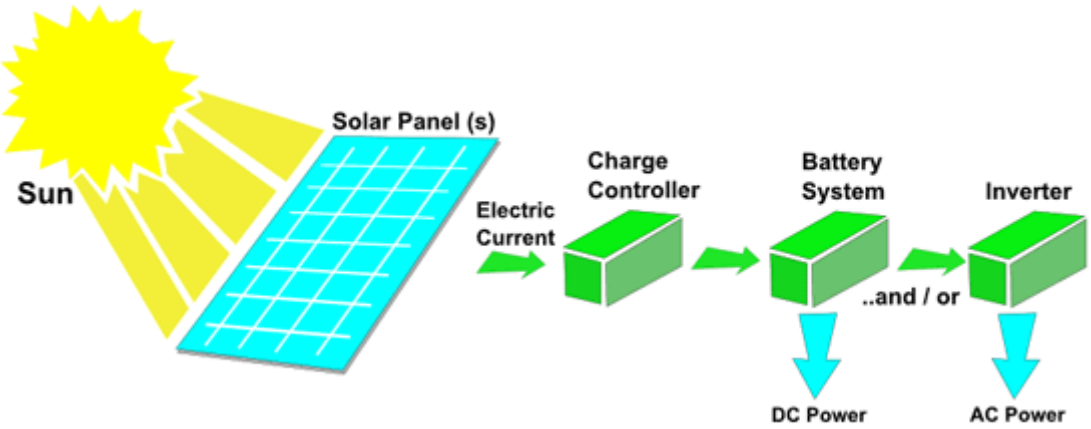
More than half of the energy has been consumed in the last two decades since the industrial revolution, despite advances in efficiency and sustainability. According to IEA world statistics in four years the world population increased 5%, annual C02 emissions increased 10%, and gross energy production increased 10%.

6. Renewable Energy in India:

It is a sector that is still in its infancy. As of December 2011, India had an installed capacity of about 22.4 GW of renewable technology-based electricity, about 12% of its total. For context, the total installed capacity for electricity in Switzerland was about 1 8 GW in 2009. Table 1.7 provides the capacity breakdown by various technologies. As of August 201 1, India had deployed renewable energy to provide electricity in 8,846 remote villages, installed 4.4 million family biogas plants, micro-hydel units, and 4.7 million square meters of solar water heating capacity. India anticipates adding another 3.6 GW of renewable energy installed capacity by December 2012. India plans to add about 30 GW of installed electricity generation capacity by 2017 based on renewable energy program conducted by the central government Ministry of New and Renewable Energy.

Type	Technology	Installed Capacity (MW)
Grid connected power system	Wind	14989
	Small Hydro	3154
	Biomass	1084
	Bagasse Cogeneration	1799
	Waste to energy	74
	Solar	46
Off-grid, Captive power	Biomass	141
	Biomass non-Bagasse cogeneration	328
	Waste to energy	76
	Solar	73
	Hybrid/Aerogen	01

7. Solar Energy:



Solar energy works by capturing the energy from the sun and converting it into usable electricity. This is done using solar panels, which are made up of photovoltaic cells that absorb sunlight and convert it into direct current (DC) electricity. This DC electricity is then converted into alternating current (AC) electricity using an inverter, which can be used to power homes and businesses.

Solar energy can also be stored in batteries for use when the sun is not shining. This allows people to use solar energy even when it is dark or cloudy outside. In addition, some homes and businesses can sell excess solar energy back to the grid, which can help offset the cost of their electricity bills.

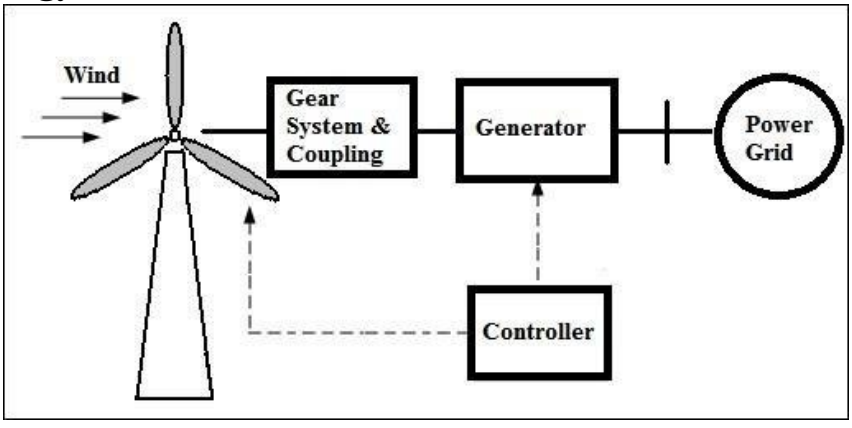
Advantages:

i. It is a clean and renewable source of energy.
ii. It does not produce greenhouse gases or other pollutants.
iii. It is a domestic source of energy, which means that it can help to reduce our reliance on imported energy.
iv. The cost of solar power generation has been declining in recent years.
v. Solar power generation is a growing industry.

Disadvantages:

i. The cost of solar panels and other equipment can be high.
ii. Solar panels can only generate electricity during the day.
iii. Solar panels can be damaged by snow or hail.

8. Wind Energy:



Harnessing the power of wind has become an increasingly popular way to generate electricity. Wind turbines work by capturing the kinetic energy of wind and converting it into electrical energy. The blades of a wind turbine are designed to rotate when wind blows past them, which turns a generator to produce electricity. This electricity can then be used to power homes and businesses.

Wind energy is a renewable source of energy, meaning that it will never run out. It is also a clean source of energy, as it does not produce any greenhouse gas emissions or other pollutants. However, like solar energy, wind energy generation is dependent on weather conditions, and may not be able to provide consistent energy output at all times.

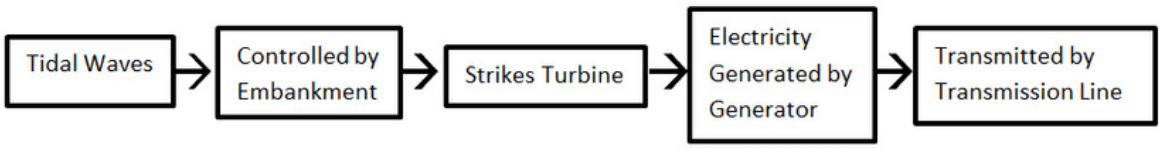
Advantages:

i. It is a clean fuel source.
ii. It contains zero carbon emission which is associated with the operation of wind turbines.
iii. The loss for farmers or any living beings doesn't occur that is why wind turbines use only a fraction of land.
iv. It depends on the combustion of fossil fuels.
v. Windmill doesn't pollute the air like a power plant.
vi. Wind energy is free.

Disadvantages:

i. It is not a continual energy source.
ii. It produces noise pollution.
iii. It also produces visual pollution.
iv. Birds have been killed by flying into rotational turbine blades.
v. The travel and maintenance cost of turbines increases.
vi. It is time-consuming.

10. Tidal energy:



The ebb and flow of the tides can be harnessed to generate electricity through tidal energy generation. Tidal power plants work by using turbines that are turned by the movement of water as the tide flows in and out. This movement drives generators, which produce electricity. Tidal energy is a renewable source of energy that does not produce any greenhouse gas emissions or other pollutants.

Tidal energy is one of the oldest forms of energy generation. It is a renewable form of energy that converts the natural rise and fall of the tides into electricity. Tides are caused by the combined effects of gravitational forces exerted by the Moon, the Sun, and the rotation of the Earth. Tidal energy presents an evolving technology with tremendous potential.

However, it can only be installed along coastlines. Coastlines often experience two high tides and two low tides on a daily basis. The difference in water levels must be at least 5 meters high

to produce electricity. Tidal electricity can be created from several technologies, the main ones being tidal barrages, tidal fences and tidal turbines

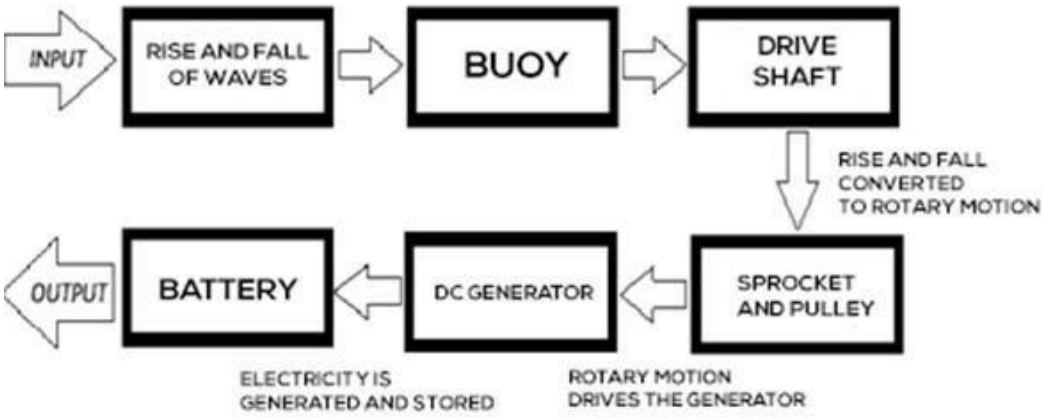
Advantages:

i. Tidal energy is an inexhaustible source of energy since water is available in most parts of the earth in large water bodies that can be utilized.
ii. Tidal energy is environment-friendly energy since it doesn't produce any harmful gases to cause pollution. The rise and fall of tides can be predictable and systems are built to use it effectively.
iii. Tidal energy is environment-friendly energy since it doesn't produce any harmful gases to cause pollution.
iv. Tidal Energy doesn't require any kind of fossil fuel to run thereby contributing to fuel conservation.

Diadvantgaes:

i. There is high-cost involvement in the construction of tidal power plants due to corrosion-free machinery.
ii. There are certain limitations for the construction of tidal energy power plants because they require setup in coastal regions only.
iii. The intensity of sea waves may vary so there can be an interruption in the power generation process.
iv. The process of tidal energy generation may Influences aquatic life to adversely die to control of water flow and large driving forces involved.
v. This technology used for utilization of tidal energy is still not very cost effective.

11. Wave Energy:



Wave energy is produced when the wind blows over open water and creates waves. The energy produced and caught up in that waterpower is enormous. Even though wave energy has proved challenging to harness effectively and economically, the world is suddenly looking at wave power as a viable option and source for our ever-increasing energy needs.
It is a renewable form of energy derived from the waves as they move across the water. Wave energy gets produced when electricity generators are placed on the surface of the ocean. The factors determining the energy output are wave height, wave speed, wave-length, and water density.

Wave energy can be harnessed in several different ways. Still, the approach generally de-pends on the condition and structure of the body of water where the wave energy is being sourced. Although many methods of harnessing wave power have been developed, there are three

primary forms used today — Oscillating Water Columns (OWCs), Surface-Following Attenuators (Line Absorbers), and Buoyancy Unit/Point Absorbers. All three methods involve equipment that floats at the surface (or just below the surface) of the water, with additional equipment below the water that converts the force and power of the waves into electricity.

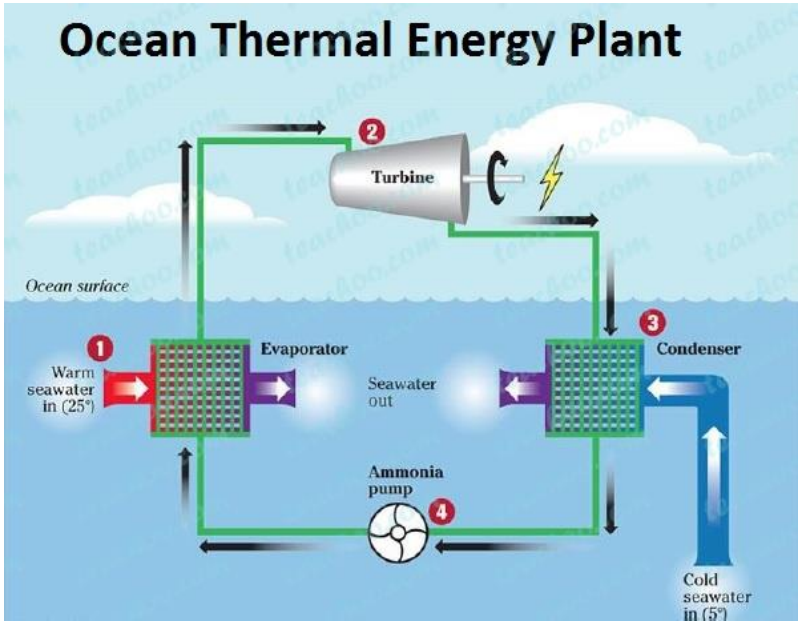
Advantages:

i. Zero emissions during generation
ii. Renewable form of energy
iii. High energy potential
iv. Reliable source of energy
v. Less dependency on fossil fuels
vi. It causes no damage to the land.

Disadvantages:

i. Effects on the environment
ii. Highly expensive at the moment
iii. Scalability issues
iv. High maintenance costs
v. Low performance in unfavorable weather
vi. Noise and visual pollution

12. Ocean Thermal Energy:



Ocean thermal energy conversion is an electricity generation system. Ocean Thermal Energy, also called Ocean Thermal Energy Conversion (OTEC), refers to using the temperature difference between the deep parts of the sea, which are cold and the shallow parts of the sea, which are cold, to run a heat engine and produce useful work. The deeper parts of the ocean are cooler because the heat of sunlight cannot penetrate very deep into the water. Here the efficiency of the system depends on the temperature difference. Greater the temperature difference, the greater the efficiency. The temperature difference in the oceans between the deep and shallow parts is maximum in the tropics, 20o C to 25o C.Tropics receive a lot of sunlight which warms the surface of the oceans, increasing the temperature gradient.

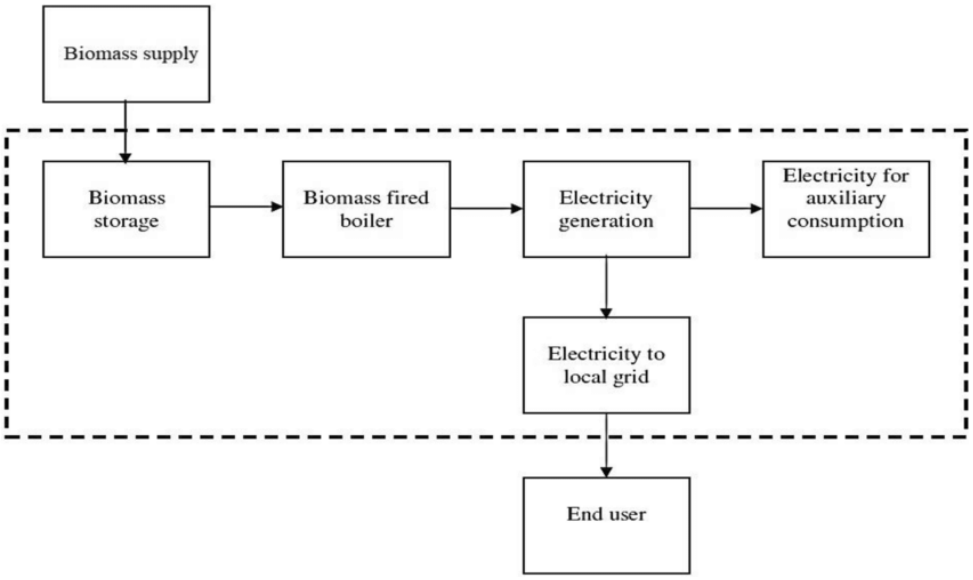
Advantages:

i. Ocean Thermal Energy is an instance of renewable energy.
ii. It can be utilised continuously for 24 hours a day throughout the year with a bit of ongoing cost.
iii. It creates electricity without the discharge of greenhouse gases.
iv. Different from other kinds of energy, the output of OTEC shows little daily or seasonal variation.

Diadvantages:

i. The expense of fitting the device and continuance of the power plant is high.
ii. It causes disruptions in aquatic and marine life.
iii. A constant supply of cold and warm water is needed. So the plant can be built in only appropriate for tropical areas.
iv. Conversion efficiency is very low about 3-4% because of small temperatures in between the deep water and surface water.

13. Biomass Energy:



Biomass energy generation is the process of generating electricity by burning organic matter such as wood, crops, and agricultural waste. This technology involves converting biomass into heat, which is then used to generate steam that drives a turbine to produce electricity. Biomass energy generation is a renewable source of energy that can help reduce our reliance on fossil fuels. It is also considered carbon neutral because the carbon dioxide released during combustion is offset by the carbon dioxide absorbed by the plants during their growth.

One of the benefits of biomass energy generation is that it can be produced locally, reducing our dependence on foreign oil. Additionally, biomass energy generation can help reduce waste by using agricultural and forestry residues that would otherwise be discarded. However, there are also concerns about the sustainability of biomass energy generation, as it can lead to deforestation and other environmental issues if not managed properly.

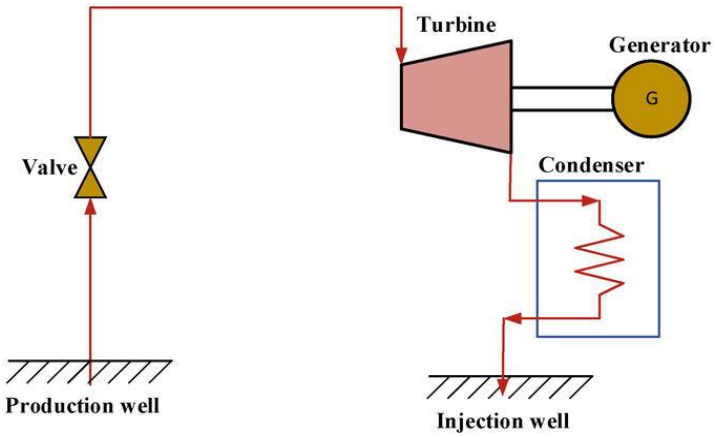
Advantages:

i. Renewable energy source.
ii. Reduces waste disposal costs
iii. Provides a reliable source of energy
iv. Can be used to supplement traditional fuels
v. Helps to reduce greenhouse gas emissions
vi. Can be produced locally, reducing dependence on foreign oil
vii. Provides economic benefits to rural communities
viii. Offers a potential solution to waste management problems
ix. Can be used to generate electricity, heat, and fuel
x. Has a lower environmental impact compared to traditional energy sources

Disadvantages:

i. Not a completely carbon-neutral energy source
ii. Requires large amounts of land
iii. Can compete with food production for resources
iv. Harvesting and processing can be labor- intensive
v. Can emit harmful pollutants during combustion
vi. Requires specialized equipment for harvesting and processing
vii. Biomass energy production can lead to Deforestation
viii. Availability of biomass can be limited
ix. Transportation costs can be high
x. Production can be affected by weather conditions

14. Geothermal Energy:



Geothermal energy is the heat that is released from the Earth's sub-surface. It is stored within the rocks and the fluids beneath the crust of the Earth and can also be excavated as far down as the hot molten rock, magma of the Earth.

For generating power from the geothermal energy, wells have to be dug for about a mile deep into the underground reservoirs for accessing the steams and hot water present there, which is going to be used for operating turbines connected to the electricity generators. There are three variations of geothermal energy plants – flash, dry steam, and binary.

Geothermal energy is believed to be currently one of the most advantageous energy sources. Apart from being a renewable source of energy, is also available in most areas, outshining even some conventional energy sources in many aspects.

Advantages:

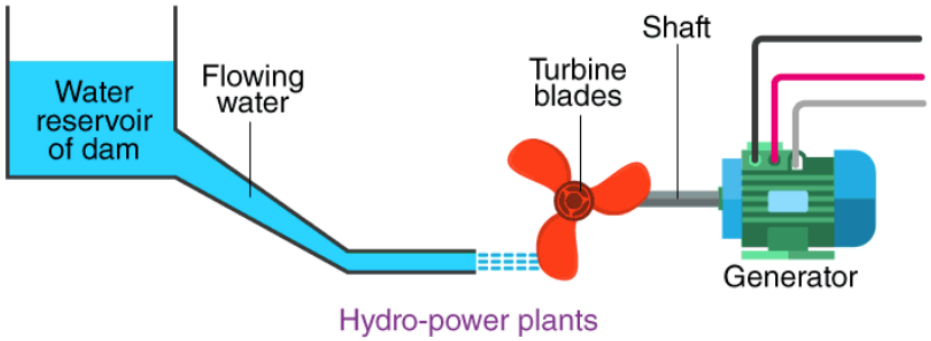
i. Geothermal energy sourcing is good for the environment.
ii. Geothermal energy isa reliable source of renewable energy.
iii. Geothermal systems have high efficiency.
iv. There is no too little geothermal system maintenance needed.
v. There is an unlimited supply of geothermal energy.

Disadvantages:

i. The extraction of geothermal energy causes greenhouse emissions.
ii. There is a possibility of depletion in geothermal sources.
iii. There is a high-cost investment needed for geothermal systems.
iv. It is hard to implement geothermal systems in big cities.
v. Geothermal reservoirs cannot easily be found.

15. Hydro energy

- It is derived from the movement of water, such as rivers, streams, and ocean tides. Hydroelectric power plants are used to capture the energy of moving water and convert it into electricity.
- The availability of hydro energy depends on the availability and flow of water in a particular region.
- A conventional dam holds water in a man-made lake, or reservoir, behind it. When water is released through the dam, it spins a turbine connected to a generator that produces electricity. The water returns to the river on the downstream side of the dam.



Advantages of Hydroelectric Energy

1. Electricity can be produced at a constant rate once the dam is constructed

2. The gates of the dam can be shut down if electricity is not needed, which stops electricity generation. Hence by doing this, we can save water for further use in future when the demand for electricity is high.

3. One of the biggest advantages of hydroelectric power plants is that they are designed to last many decades, and so they can contribute to the generation of electricity for years.

4. Large dams often become tourist attractions because the lake that forms in the reservoir area behind the dam can be used for leisure or water sports.

5. The water from the lake of the dam can be used for irrigation purposes in farming.

6. Since the water is released to produce electricity, the build-up of water in the dam is stored to produce extra energy until needed.

7. Hydroelectric energy generation does not pollute the atmosphere because the hydroelectric power plant does not produce greenhouse gases.

8. Hydropower plants can be considered a reliable energy generation source. Since hydropower totally depends on water present on this planet, this energy source will remain inexhaustible because of the water cycle as it continuously keeps on maintaining balance on the Earth.

Disadvantages of Hydroelectric Energy

1. It is not an easy task to assemble a hydropower plant because the dams are extremely expensive to build, and they require extremely high standards and calculations for their construction.

2. It becomes important that the hydropower plant must serve for many decades because of its high cost of construction, and this totally depends on the availability of water resources.

3. If flooding happens due to natural calamities or the failure of dams, it would impact a large area of land, which means that the natural environment can be destroyed.

4. People are forcibly removed from the particular area where a hydropower plant is going to be assembled. This affects the day-to-day life of people living in that area.

5. A serious geological damage can be caused due to the construction of large dams.

6. To construct a hydro plant, it is important to block the running water source due to which the fishes can't arrive at their favourable place, and as the water stops streaming, the areas along the riverside start to vanish out which eventually influences the life of creatures that depend on fish for food.

16. Oil Shale:

The rapid depletion rates of global reserves of conventional fossil fuel (oil) have led to an increased focus on unconventional oil sources, many of which are associated with 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. All of the kerogen consist mainly of hydrocarbons, smaller amounts of Sulphur, oxygen, and nitrogen, and a variety of minerals.

They were formed millions of years ago by the 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. Similar to traditional petroleum, natural gas, and coal, oil shale, and kerogen are also fossil fuels. Fossil fuels are developed from the remains of algae, spores, plants, pollen, and a variety of other organisms that lived millions of years ago in ancient lakes, seas, and wetlands.

Oil shale generally contains enough oil that it will burn without any additional processing, and it is known as the rock that burns.

There are several different types of shale found throughout the world including oil shale and bituminous shale. These two types are important sources of various grades of unconventional oil. The difficulty of extracting and producing oil from shale and environmental damage made

it a less attractive resource compared to oil from conventional wells. Most processes of shale oil production use significant amounts of water and the chemicals used may harm humans and animals. The process is energy intensive and can require the burning of more fossil fuels in order to provide the necessary power supply.

16.1 Extraction of Shale Oil:

Oil shale is underground rock formations that contain trapped petroleum. The petroleum trapped within the rocks is known as tight oil and is difficult to extract. Oil shale can be mined and processed to generate oil similar to oil pumped from conventional oil wells. However, extracting oil from oil shale is more complex than conventional oil recovery and currently it is more expensive.

The important extraction processes of shale oil are as follows:

1. Ex situ retorting: The oil substances in oil shale are solid and cannot be pumped directly out of the ground.

i. The oil shale must be mined and brought to ground surface.
ii. The mined oil shale is then heated at a high temperature (a process called retorting). It involves heating kerogen in a process called pyrolysis.
iii. The resultant liquid must then be separated and collected.

2. In situ retorting: In 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.

i. Heating the oil shale while it is still underground
ii. Pumping the resulting liquid to the surface

However, improvements in drilling technology, such as the emergence of directional drilling, has made the 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 in order 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 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 until the oil shale begins producing shale oil. The oil could then be pumped directly from underground.

5. Combined technologies: Some methods are designed for both in situ and ex situ extraction. The internal combustion process uses a combination of gas, steam, and spent shale produced by ex situ processing. These compounds are burned for pyrolysis. The hot gas is continually cycled through die oil shale, pyrolyzing the rock and releasing Oil.

16.2 Classification of Oil Shales:

1. Depositional history: A sedimentary rock depositional history is the history of the type of environment in which the rock developed. The depositional history of an oil shale includes the organisms and sediments that were deposited, as well as how those deposits interacted with pressure and heat.

i. **In lakes (lacustrine):** Oil shales from lacustrine environments are formed mostly from algae living in freshwater, saltwater, or brackish water. Lamosite and torbanite are the types of oil shales associated with lacustrine environments. Lamosite deposits make up some of the largest oil shale formations in the world.
ii. **In the ocean (marine):** Oil shales from marine environments are formed mostly from deposits of algae and plankton. Kukersite, tasmanite, and marinite are the types of marine shales. Marinite, the most abundant of all oil shales, is found in environments that once held wide, shallow seas. Although marinite is abundant, it is often a thin layer and not economically practical to extract.
iii. **On land (terrestrial):** Oil shales from terrestrial environments are formed in shallow bogs and swamps with low amounts of oxygen. The deposits were mostly the waxy or corky sterns of hardy plants. Cannel shale, also called cannel coal or 'candle coal', is probably the most familiar type of terrestrial oil shale.

2. By their mineral content: Oil shales are classified into three main types based on their mineral content:

i. **Carbonate-rich shale:** The deposits have high amounts of carbonate minerals. Carbonate minerals are made of various forms of the carbonate ion (a unique compound of carbon and oxygen). Calcite, for instance, is a carbonate mineral common in carbonate-rich shales. Calcite is a primary component of many marine organisms. Calcite helps form the shells and hard exteriors of oysters, sea stars, and sand dollars. Plankton, red algae, and sponges are also important sources of calcite.
ii. **Siliceous shale:** It is rich in the mineral silica or silicon dioxide. Siliceous shales are formed from organisms such as algae, sponges, and microorganisms called radiolarians. Siliceous oil shale is sometimes not as hard as carbonate-rich shale and can more easily be mined.
iii. **Cannel shale:** It has terrestrial origins and is often classified as coal. It is formed from the remains of resin, spores, and corky materials from woody plants. It can contain the minerals inertinite and vitrinite. Cannel shale is rich in hydrogen and burns easily.

16. 3 Use of Shale Oil (Tight Oil): Shale oil has been used for more than thousands of years by mankind for meeting their energy requirements for road construction, caulking ship, and pipes leakage, and developing burning arrows (Agni band) for use during battle and decorative mosaic.

i. Shale oil was used for a variety of products including paraffin wax.
ii. R&D efforts proved that it can be used immediately as a fuel or upgraded as a refinery. feedstock specification by adding hydrogen and removing Sulphur and nitrogen impurities similar to crude oil.
iii. It is burned to generate electricity.
iv. Shale oil is similar to petroleum and can be refined into many different substances including diesel fuel, gasoline, and liquid petroleum gas (LPG).
v. Companies can also refine shale oil to produce other commercial products such as ammonia and Sulphur. The spent rock can be used in cement production.

16.4 Problems Associated with Shale Oil Production:

1. High processing costs: The high costs of heating and drilling wells made commercial oil shale production unprofitable, especially when cheaper crude oil is available.

2. Environmental concerns: Mining for oil shale can have damaging effects on the environment, such as the following:

i. When shale oil is combusted (heated), it releases carbon dioxide into the atmosphere. Carbon dioxide is a greenhouse gas.
ii. Substances in the oil shale, such as sulfides, react with water to form toxic compounds that are harmful to the environment and to human beings. Sulphides can cause effects from eye irritation to suffocation.
iii. Water containing toxic substances is unusable and expensive to decontaminate. The ash by-product can pollute ground, air, and water sources.
iv. Another environmental disadvantage is that extraction of shale oil requires enormous amounts of freshwater. Water is necessary for drilling, mining, refining, and generating power.
v. It causes land and underground water degradation.

17. Introduction to Internet of energy (IOE):

- 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.
- Benefits of using IoE include increased efficiencies, significant cost savings, and a reduction in the wastage of energy.

17.1 Understanding Internet of Energy (IoE): 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 smartphones, 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. Without any critical updates, a lot of that energy is lost along the line because they can't transmit it efficiently. Put simply, the lines simply don't have the capacity to carry all the energy being sent.

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. Smart grids allow users to make better business decisions and to make forecasts for the future.

17.2 Special Considerations: As countries around the world invest more in green energy and renewable resources, the inefficiencies of existing power infrastructures around the world are often overlooked. This means renewable energy cannot be provided at its optimum level of efficiency because the grid cannot fully support it.

One potential solution to the problem of energy inefficiency is ultra-high voltage (UHV) transmission. This is a system that allows energy to be transmitted rapidly over long distances.

UHV solves the problem of energy production being located too far from load centers. China first implemented UHV in 2009, but its development is constantly expanding to meet demand.

In coming years, as the world works toward harvesting renewable energy sources, the use of nonrenewable resources is expected to fall, which will reduce the need for outdated infrastructures that handle resources such as coal and oil.

17.3 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.

17.4 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.