RAMAIAH
Institute of Technology

Department of Mechanical Engineering

Programme	B.E (UG)
Semester	I/II
Course Name	Renewable Energy Sources
Course Code	ETC144
Course Credits	3-0-0
Unit 1	**Introduction**: Principles of renewable energy; energy and sustainable development, fundamentals and social implications, renewable energy availability in India, applications of renewable energy, Introduction to Internet of energy (IOE).

UNIT 1
INTRODUCTION

1.1 FUNDAMENTALS

ENERGY RESOURCES

Energy is a fundamental concept in physics, with applications throughout the natural sciences. Can you imagine life without lights, fans, cars, computers and television or, of fetching water from the well and river? This is what life would have been like mad man, if it is not discovered the uses of energy – both renewable and non renewable sources. Energy is the driving force for humans and machines, without energy the whole world will comes to stand still (halt).

The total energy of a system can be subdivided and classified in various ways. For example, it is sometimes convenient to distinguish kinetic energy from potential energy. It may also be convenient to distinguish gravitational energy, electrical energy, thermal energy, and other forms. These classifications overlap; for instance thermal energy usually consists partly of kinetic and partly of potential energy. Energy is the primary and most universal measure of all kinds of work by human beings and nature. Most people use the word energy for input to their bodies or to the machines.

Energy: Energy is defined as the capacity for doing the work. The SI unit of energy is Joule (J).

Energy forms: Although every energy form is physically invisible, is presence is always felt. Energy can exist in various forms such as

1) Mechanical energy 2) Electrical energy
3) Chemical energy 4) Heat energy
5) Nuclear energy 6) Sound energy

Potential energy: The potential energy possessed by a body is due to its position or elevation relative to some datum plane.

Kinetic energy: The kinetic energy possessed by a body is due to the reason of its motion.

A body of mass m kg moving with a velocity V m/sec possesses an amount of kinetic energy = $mv^2/2g_c$ in Nm.

Energy sources: Energy either exists in earth or come from outer space.

Capital energy: The energy existing in the earth is known as capital energy.
Ex: fossil fuels (coal, Petroleum based fuel and natural gases), Nuclear fuels and heat traps.

Celestial energy or income energy: The energy comes from the outer space is called as celestial energy or income energy.
Ex: electromagnetic, gravitational and particle energy from stars.

- **NON RENEWABLE AND RENEWABLE ENERGY SOURCES**:

  - **Non -Renewable energy Sources (conventional sources):** The source which are formed in the earth crust over millions of year and which get depleted with their use are known as non-renewable or conventional energy sources.
    Ex: fossil fuels (coal, Petroleum based fuel and natural gases), Nuclear fuels.

  - **Renewable energy Sources (Non-Conventional):** The sources which will not deplete with their use are known as renewable or non-conventional energy sources.
    or
    The energy resources which are produced continuously in nature and are essentially inexhaustible at least in the time frame of human societies.
    Ex: solar energy, wind energy, tidal energy, hydal energy and ocean thermal energy

- **Difference between Renewable and Non-Renewable source of energy**

Renewable energy Sources	**Non -Renewable energy Sources**
1.The energy resources are non-exhaustible with their use.	The energy resources are exhaustible with their use
2. These are pollution free	Causes pollution
3. These are available at free of cost.	These are not directly available at free of cost
4. Initial cost to extract the energy source is more, but the maintenance cost is less	Initial cost is less but the maintenance cost is more.

5. The technology to extract the energy sources is not yet completely developed.	The technology to extract the energy sources is developed.
6. Ex: solar energy, wind energy, tidal energy, hydel energy etc.	Fossil fuels (coal, Petroleum based fuel and natural gases), Nuclear fuels.

1.2 ENERGY SOURCES

There are five ultimate primary sources of useful energy:

i. The Sun.
ii. The motion and gravitational potential of the Sun, Moon and Earth.
iii. Geothermal energy from cooling, chemical reactions and radioactive decay in the Earth.
iv. Human-induced nuclear reactions.
v. Chemical reactions from mineral sources.

Renewable energy derives continuously from sources i, ii and iii (aquifers).

1.3 ENVIRONMENTAL ENERGY

The flows of energy passing continuously as renewable energy through the Earth are shown in Figure 1. For instance, total solar flux absorbed on earth is about 1.2×1017 W. Thus the solar flux reaching the Earth's surface is ∼20MW per person;

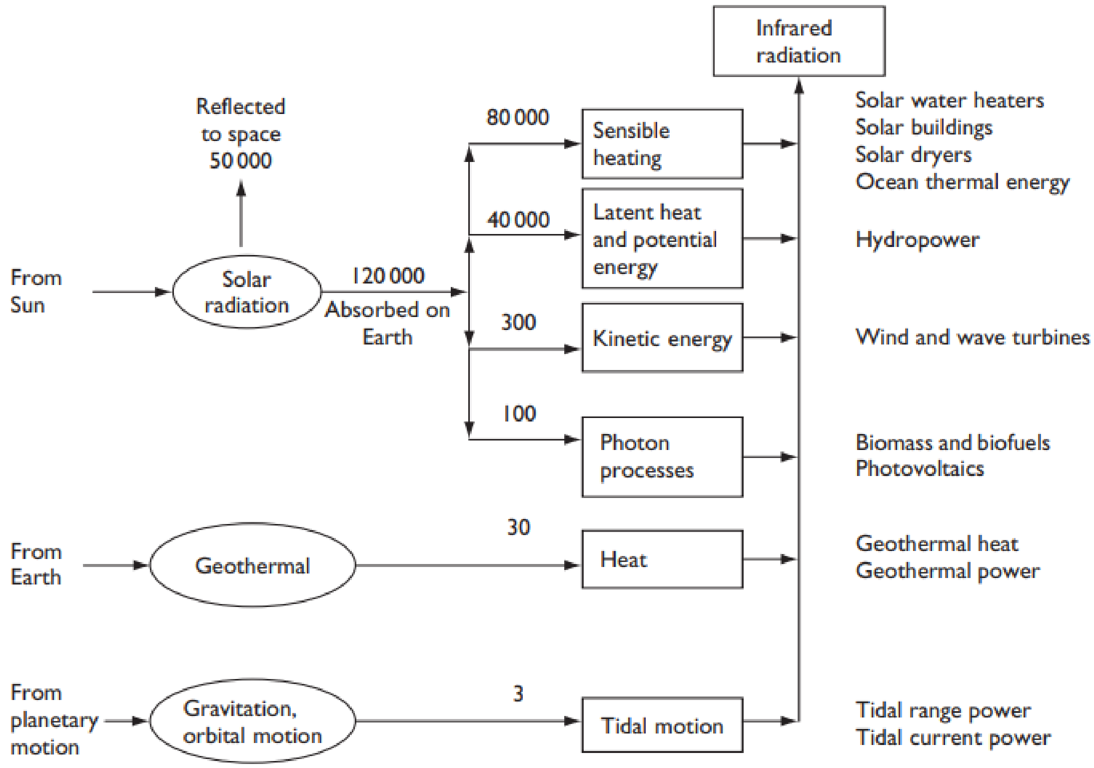


Figure 1. Flow of energy passing continuously as renewable energy through the Earth

Units in terawatts (10^{12} W)

1.4 PRINCIPLES OF RENEWABLE ENERGY

1.4.1 Energy currents:

It is essential that a sufficient renewable current is already present in the local environment. It is not good practice to try to create this energy current especially for a particular system. For a biomass energy station, the biomass resource must exist locally to avoid large inefficiencies in transportation. The practical implication of this principle is that the local environment has to be monitored and analysed over a long period to establish precisely what energy flows are present.

1.4.2 Dynamic characteristics:

End-use requirements for energy vary with time. For example, electricity demand on a power network often peaks in the morning and evening, and reaches a minimum through the night. If power is provided from a finite source, such as oil, the input can be adjusted in response to demand. Unused energy is not wasted, but remains with the source fuel. However, with renewable energy systems, not only does end-use vary uncontrollably with time but so too does the natural supply in the environment. Thus a renewable energy device must be matched dynamically.

1.4.3 Quality of supply:

Quality of supply is the theoretical maximum amount of work obtainable, at a particular environmental temperature, from an energy source. Thus electricity has high quality because when consumed in an electric motor >95% of the input energy may be converted to mechanical work, say to lift a weight; the heat losses are correspondingly small, <5%. The quality of nuclear, fossil or biomass fuel in a single stage thermal power station is moderately low, because only about 33% of the calorific value of the fuel can be made to appear as mechanical work and about 67% is lost as heat to the environment.

Renewable energy supply systems divide into three broad divisions:

i. **Mechanical supplies**, such as hydro, wind, wave and tidal power. The mechanical source of power is usually transformed into electricity at high efficiency. The proportion of power in the environment extracted by the devices is determined by the mechanics of the process, linked to the variability of the source, as explained in later chapters. The proportions are, commonly, wind 35%, hydro 70–90%, and tidal 75%.

ii. **Heat supplies,** such as biomass combustion and solar collectors. These sources provide heat at high efficiency. However, the maximum proportion of heat energy extractable as mechanical work, and hence electricity, is given by the second law of thermodynamics and the Carnot Theorem, which assumes reversible, infinitely long transformations. In practice, maximum mechanical power produced in a dynamic process is about half that predicted by the Carnot criteria. For thermal boiler heat engines, maximum realisable quality is about 35%.

iii. **Photon processes**, such as photosynthesis and photochemistry and photovoltaic conversion. For example, solar photons of a single frequency may be transformed into mechanical work via electricity with high efficiency using a matched solar cell. In practice, the broad band of frequencies in the solar spectrum makes matching difficult and photon conversion efficiencies of 20–30% are considered good.

1.4.4 Dispersed versus centralized energy:

A pronounced difference between renewable and finite energy supplies is the energy flux density at the initial transformation. Renewable energy commonly arrives at about 1 kWm^{-2} (e.g. solar beam irradiance, energy in the wind at 10 ms^{-1}), whereas finite centralised sources have energy flux densities that are orders of magnitude greater. Finite energy is most easily produced centrally and is expensive to distribute. Renewable energy is most easily produced in dispersed locations and is expensive to concentrate. With an electrical grid, the renewable generators are said to be 'embedded' within the (dispersed) system.

A practical consequence of renewable energy application is development and increased cash flow in the rural economy. Thus the use of renewable energy favours rural development and not urbanization.

1.4.5 Complex systems:

Renewable energy supplies are intimately linked to the natural environment, which is not the preserve of just one academic discipline such as physics or electrical engineering. Frequently it is necessary to cross disciplinary boundaries from as far apart as, say, plant physiology to electronic control engineering. An example is the energy planning of integrated farming. Animal and plant wastes may be used to generate methane, liquid and solid fuels, and the whole system integrated with fertilizer production and nutrient cycling for optimum agricultural yields.

1.4.6 Situation dependence

No single renewable energy system is universally applicable, since the ability of the local environment to supply the energy and the suitability of society to accept the energy vary greatly. It is as necessary to 'prospect' the environment for renewable energy as it is to prospect geological formations for oil. It is also necessary to conduct energy surveys of the domestic, agricultural and industrial needs of the local community. Particular end-use needs and local renewable energy supplies can then be matched, subject to economic and environmental constraints. In this respect renewable energy is similar to agriculture. Particular environments and soils are suitable for some crops and not others, and the market pull for selling the produce will depend on particular needs. The main consequence of this 'situation dependence' of renewable energy is the impossibility of making simplistic international or national energy plans.

Unfortunately present-day large urban and industrialised societies are not well suited for such flexibility and variation.

1.5 SOCIAL IMPLICATIONS

Industrial development in all countries have profoundly affected social structures and patterns of living. The influence of changing and new energy sources has been the driving function for much of this change.

1.5.1 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. Industry has developed on these grids, with heavy industry closest to the points of intensive supply. Domestic populations have grown in response to the employment opportunities of industry and commerce.

This physical review of the effect of the primary flux density of energy sources suggests that widespread application of renewable energy will favor dispersed, rather than concentrated, communities. Electricity grids in such situations are powered by smaller-scale, embedded, generation, with power flows moving intermittently in both directions according to local generation and local demand. Thus the gradual acceptance of significant supplies of renewable energy could allow relief from the concentrated metropolises of excessive urbanisation, yet would not require unacceptably low population densities. A further advantage is the increased security for a nation having its energy supplies from such indigenous and dispersed sources.

1.5.2 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. Likewise material and chemical pollution in air, water and refuse tend to be minimal.

1.5.3 The Future

In short, we see that many changes in social patterns are related to energy supplies. We can expect further changes to occur as renewable energysystems become widespread. 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. In particular we expect the great diversity of renewable energy supplies to be associated with a similar diversity in local economic and social characteristics.

1.6 ENERGY SUSTAINABILITY:

Sustainable development is "**development that meets the needs of the present without compromising the ability of future generations to meet their own needs"**

Ex: 1.Solar energy: Harnessing the solar energy to reduce pollution in the environment.

2.Crop Rotation: Planting different types of crops on the same land on a rotational basis for improving soil fertility.

Sustainable Development Goals

- To promote the kind of development that minimizes environmental problems.
- To meet the needs of the existing generation without compromising with the quality of the environment for future generations.
- Emissions and on energy security.
- The environmental dimension of sustainability includes greenhouse gas emissions,
- Impacts on biodiversity and ecosystems,
- Hazardous waste and toxic emissions,
- Water consumption,
- Depletion of non-renewable resources

Achieving Sustainable Development

- Sustainable development can be achieved if we follow the following points:
- It can be achieved by restricting human activities.
- Technological development should be input effective and not input utilising.
- The rate of consumption should not surpass the rate of salvation.
- For renewable resources, the rate of consumption should not surpass the rate of production of renewable substitutes.
- All types of pollution should be minimised.
- It can be achieved by sensible use of natural resources.

Examples of Sustainable Development

- Wind energy
- Solar energy
- Crop rotation
- Sustainable construction
- Efficient water fixtures
- Green space
- Sustainable forestry

1.7 RENEWABLE ENERGY AVAILABILITY IN INDIA

As of 31st August 2022, Renewable energy sources, including large hydropower, have a combined installed capacity of 163 GW.

The following is the installed capacity for Renewable:

- Wind power: 41.2 GW
- Solar Power: 59.34 GW
- Biomass/Co-generation: 10.2 GW
- Small Hydro Power: 4.88 GW
- Large Hydro: 46.85 GW

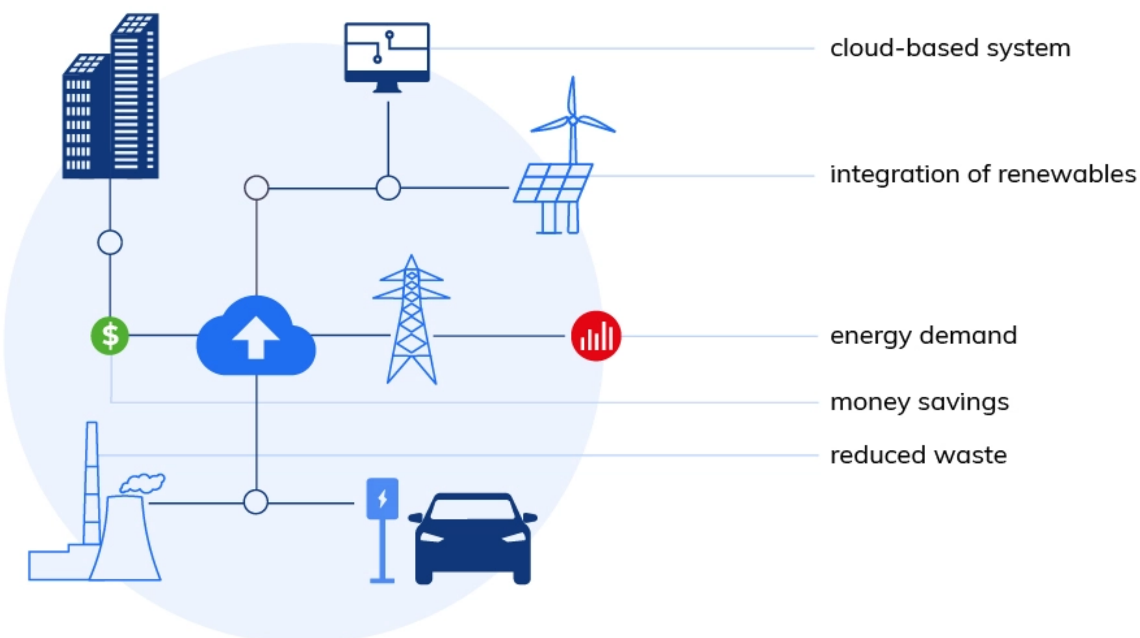
1.8 APPLICATIONS OF RENEWABLE ENERGY

Type of Renewable energy	Applications
Solar energy	1. Solar water heaters ➢ Hotels: Bathing, kitchen, washing, laundry applications ➢ Dairies: Ghee (clarified butter) production, cleaning and sterilizing, pasteurization ➢ Textiles: Bleaching, boiling, printing, dyeing, curing, ageing and finishing. ➢ Breweries & Distilleries: Bottle washing, wort preparation, boiler feed heating. ➢ Chemical /Bulk drugs units: Fermentation of mixes, boiler feed applications ➢ Electroplating/galvanizing units: Heating of plating baths, cleaning, degreasing applications ➢ Pulp and paper industries: Boiler feed applications, soaking of pulp. 2. Solar Electricity Generation 3. Solar Water Pumps
Wind energy	1. Utility interconnected wind turbines generate power which is synchronous with the grid and are used to reduce utility bills by displacing the utility power used in the household and by selling the excess power back to the electric company. 2. Wind turbines for remote homes (off the grid) generate DC current for battery charging. 3. Wind turbines for remote water pumping generate 3 phase AC current suitable for driving an electrical submersible pump directly.

Type of Renewable energy	Applications
Bio Energy	1. Water pumping and Electricity generation 2. Heat generation by Gasifier for cooking
Hydro Energy, Tidal Energy Ocean Thermal Energy Conversation	Electricity generation

1.9 INTRODUCTION TO INTERNET OF ENERGY (IOE):

Internet of Energy (IoE) is a technological term that refers to the upgrading and automating of electricity infrastructures for energy producers and manufacturers. This allows energy production to move forward more efficiently and cleanly with the least amount of waste. The term is derived from the increasingly prominent market for Internet of Things (IoT) technology, which has helped develop the distributed energy systems that make up the IoE. 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.



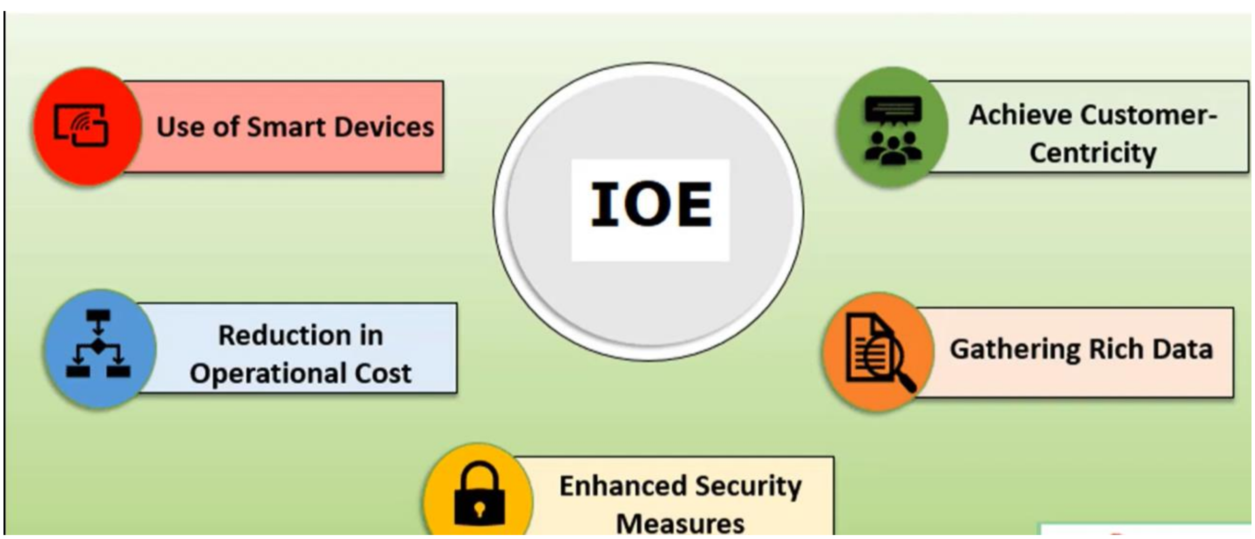
Benefits of IoE

1. Monitoring and Control
2. Optimization of power system operation

3. Reduce the power wastage
4. Automation

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

ADVANTAGES OF IOE



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