MODULE: 9
RENEWABLE ENERGY TECHNOLOGIES AND APPLICATIONS

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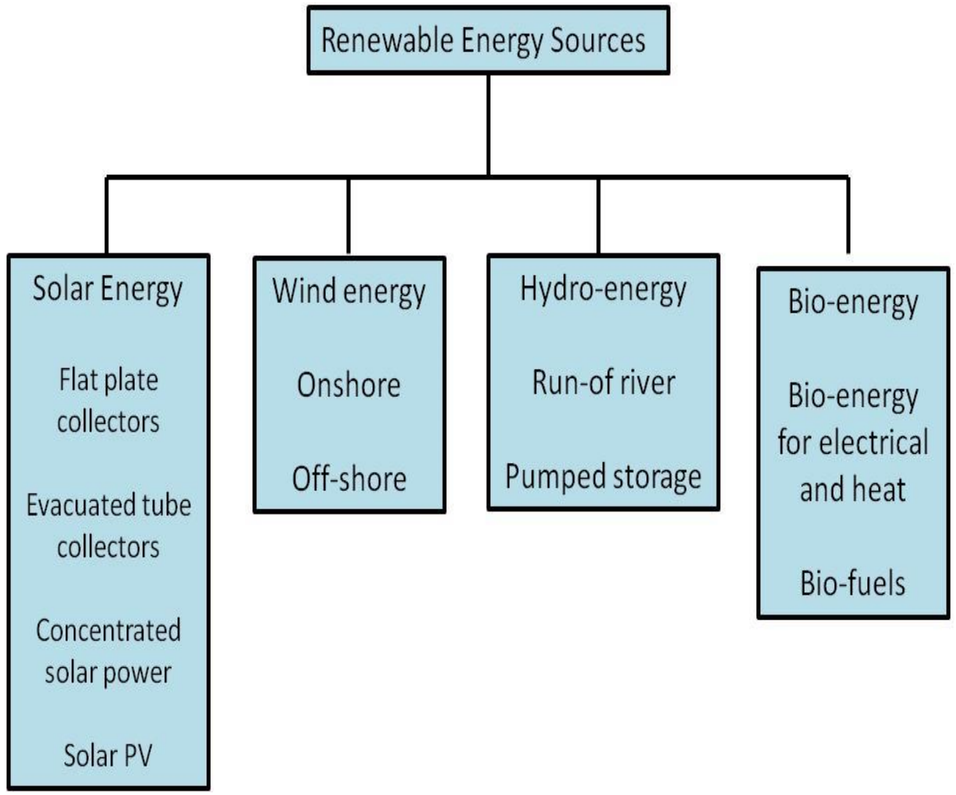
INTRODUCTION

1 Introduction

- The world is currently undergoing irreversible climatic change due to the effects of global warming arising from the massive production and consumption of fossil fuels.
- Reduce the usage of fossil fuels and find alternate energy sources.
- Among the alternate energy sources, renewable energy sources have huge potential to meet the energy requirements and mitigate the climate change impacts.
- The global renewable energy installed capacity was 921 GW (2017), and India’s share was around 70 GW.
- The Government of India has set an ambitious target of achieving 175 GW of renewable energy by 2022
- This target comprises 100 GW solar power, 60 GW wind power, 10 GW bio-energy, and 5 GW small hydro power.
- The target is to achieve 21% share of renewable energy in its total electricity consumption by 2022.

TYPES OF RENEWABLE ENERGY SYSTEM

TYPES OF RENEWABLE ENERGY SYSTEM



Various Forms of Renewable Energy Resources

2 Types

- Renewable energy system is based on converting the energy found in sunlight, wind, falling-water, sea-waves, geothermal heat, or biomass into a form that can be used such as heat or electricity. The various forms of renewable energy resources are shown in Figure

INSTALLABLE POTENTIAL AND CAPACITIES

INSTALLABLE POTENTIAL AND INSTALLED CAPACITIES

3 Installable Potential Capacities

- The status of renewable energy in India potential versus installed capacity— is shown in the Table:

S. No.	Source	Potential	Installed
1	Wind Power	302251 MW @100m,102788 MW @80 m, 49130 MW@ 50 m	34193.20 MW
2	Solar Power - Ground Mounted	50 MW/sq.km	21118.64 MW
3	Solar Power - Roof Top	-	1210.75 MW
4	Biomass Power	23700 MW	9375.61 MW
5	Bagasse Cogen		4493.20 MW
6	Small Hydro (up to 25 MW	15000 MW	-
7	Tidal / Wave	Tidal:8000–9000 MW, Wave:40000	-
8	Ocean Thermal Energy Conversion (OTEC)	180000 MW	-
9	Geothermal	10000 MW	-

SOLAR ENERGY

4 Solar Energy

- Solar Energy can be used in two ways—thermal and electricity.
- **Solar Thermal Technology** uses the solar heat energy to heat water or air or power production. Solar photovoltaic technology on the other hand converts solar energy directly into electricity using photovoltaic (PV) solar cell.
- Solar Thermal Applications: the sun's heat can be collected and transferred in a medium, and the stored energy can be used for heating and cooling a home, heating water, cooking food, or producing electricity.
- Concentrated Solar Power (CSP): This solar thermal generation technology creates the effect of multiplying effects of the sun to produce electricity or direct heating. Solar concentrators include parabolic dish collectors, linear parabolic trough collectors and linear Fresnel collectors. Parabolic dish collector—which is the predominant technology in India—can generate temperatures of up to 400°C.

4 Solar Energy

- **Solar Electric Technology or Solar PV** is a semiconductor device which coverts sunlight directly into electricity. A solar PV panel, when exposed to sunlight generates voltages and current at its output terminal. The quantum of electricity depends on the intensity of the sunlight.
- Photovoltaic system comprises the following components:
  - ✓PV Modules
  - ✓Inverters & Charge Controllers
  - ✓Mounting structure
  - ✓Balance of System Components

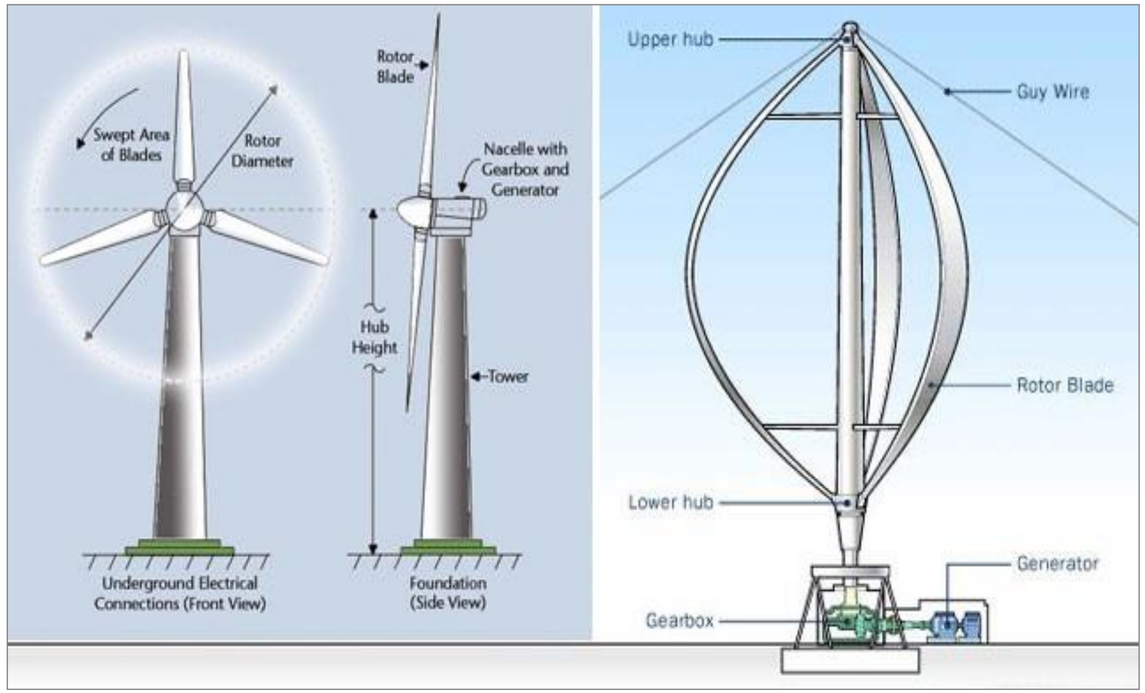
WIND ENERGY

5 Wind Energy

- The non-conventional energy sources, wind energy is proved as the most matured source and popular all over the world for clean and safe production of electricity.
- Earth's commercially viable wind power potential is estimated to be 72 TW (72000000 MW) which is four times more than the world's present total energy demand.
- India ranks fourth in the world in terms of cumulative installed capacity (34046 MW as of 2018) after China, USA and Germany.
- Three key factors affect the amount of energy a turbine can harness from the wind: wind speed, air density, and swept area.
- Energy in the wind is given by the following relation:

$$\text{Power in the Wind} = \frac{1}{2}\rho A V^3$$

5 Wind Energy

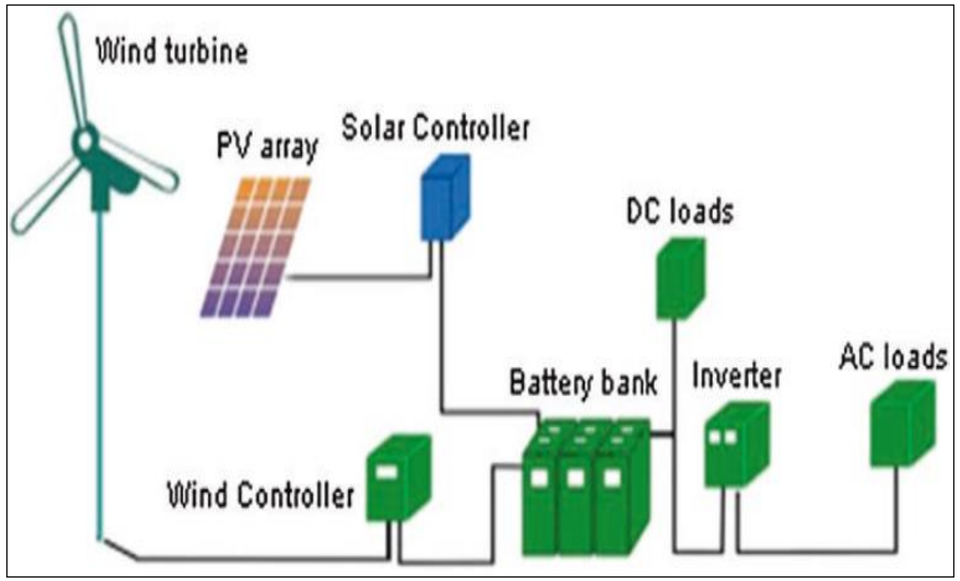


Horizontal Axis Wind Turbine **Vertical Axis Wind Turbine**

- Where,
  ρ = Air Density kg/m3
  Swept Area (A) = πR2 (m2) Area of the circle swept by the rotor
  V = Wind Velocity m/s
  Kinetic Energy =½ mV2

- **Types of Wind Turbines** are categorized into two basic types namely the horizontal-axis and the vertical-axis design.

5 Small Wind-Solar Hybrid System



- The combination of renewable energy sources, wind & solar are used for generating power called as wind–solar hybrid system. This system is designed using solar panels and small wind turbines generators for generating electricity.A wind-solar plant will be recognized as hybrid plant if the rated power capacity of one resource is at least 25% of the rated power capacity of other resource.

- A hybrid project reduces this variation and power can be generated from a plant almost 15–18 hours/day apart from optimally utilizing the infrastructure including land and transmission system.

BIO-ENERGY

6 Bio-energy

- Biomass is basically ‘fresh’ carbon from plants and animals, while coal, oil and natural gas are more like ‘old’ carbon from plants and animals.
- Biomass is formed on a relatively short time-scale via photosynthesis from CO_2 and water.
- The CO_2 is released during combustion, and can then be bound by the next generation of plants.
- Biomass can be considered as a ‘carbon neutral’ fuel.
- In contrast to other energy sources, biomass can be converted into solid, liquid and gaseous fuels.
- Energy from biomass can be extracted by
    - Direct combustion
    - Co-firing, gasification
    - Bio-methanation or digestion

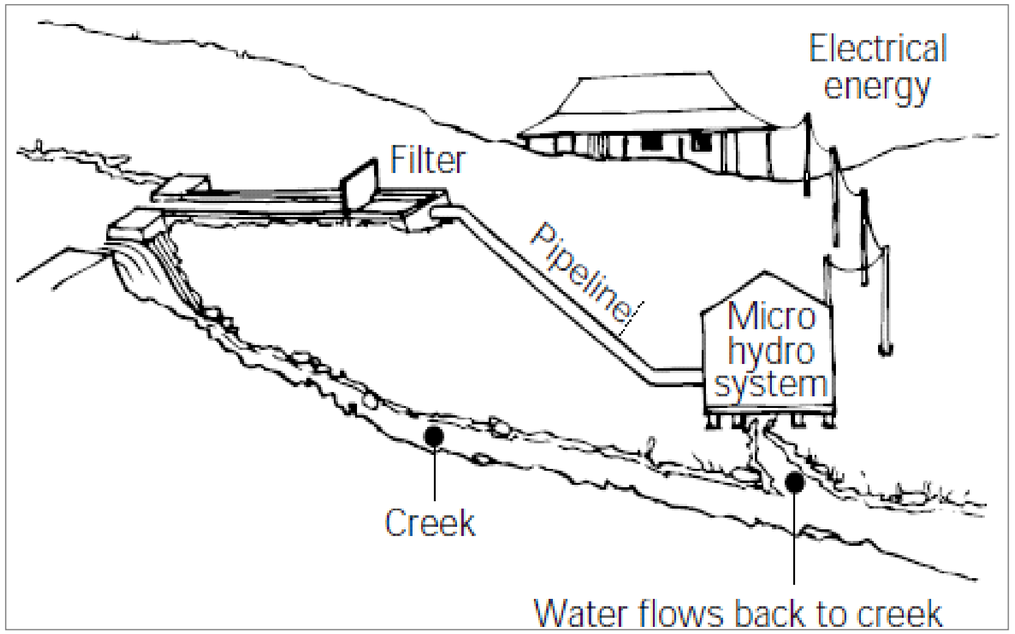
6 Bio-energy

- **Typical Composition of Biogas:**
  - ✓Methane – 55 to 70%
  - ✓Carbon dioxide – 15 to 40%
  - ✓H2S – 1000 to 35,000 ppm
  - ✓Humidity – 100%
  - ✓Calorific Value – 4500 to 6500 KCal /m3

- **Application:** H_2S quantity has to be reduced to less than 200 ppm using a scrubber before use. The biogas can be burnt directly as a fuel for cooking or heating, or it can used in DG set for producing electricity.

SMALL SCALE HYDROPOWER

7 Small-scale Hydropower



- Small-scale or micro hydro units convert the energy of flowing water into electrical energy. With a suitable water source, micro hydro is the most cost effective form of renewable electricity.
- They create less environmental impact than conventional hydro units because the natural flow of the river is only partially blocked.
- The major advantages of small–scale hydro are their high reliability and high efficiency. Efficiency ranges from 70–75%, which means that 70–75% of the potential energy can be converted to electricity.

7 Small-scale Hydropower

- Power generated by hydropower station :

  $P = \eta \rho Q g h$

- Where,

  P = power (W)

  η = efficiency of hydropower station

  ρ = density of water (kg/m3)

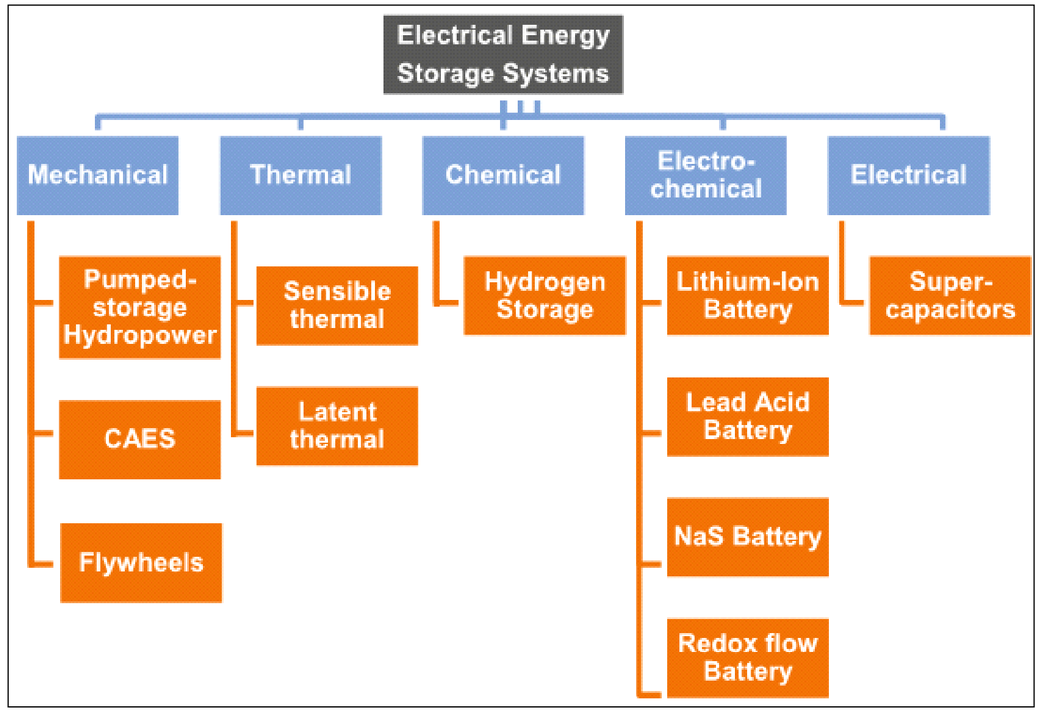
  Q = flow rate of water (m3/s)

  g = acceleration due to gravity (m/s2)

  h = height difference between the top reservoir and bottom reservoir, or Head (m

ELECTRICAL ENERGY STORAGE (EES)

8 Electrical Energy Storage (EES)



- Nearly 160 GW of wind and solar energy by 2020, there is a need for storage applications to address the issues of variability, unpredictability and location dependency of these renewable energy sources.
- Recent developments in storage technologies and developments, electricity can be stored in megawatt scale.
- Energy storage technologies are broadly classified into mechanical, electrochemical, chemical, electrical and thermal energy storage systems as shown in Figure.

GRID INTEGRATION FOR MITIGATION OF CLIMATIC CHANGE

9 RE-EE Integration

- India is endowed with abundant renewable energy (RE) resources that currently supply about 5 percent of the country's grid electricity, with potential to enable a low-carbon growth path.
- the following two key questions if the country is to integrate its RE resources into the power grid at an accelerated scale.
  a) How can the issue of intermittence of RE resources and the need for load balancing be addressed?
  b) What are the emerging global best practices that countries are following to integrate their variable RE sources into the grid at a significant scale?
- Efforts are underway to address some of the aforementioned issues of large-scale integration of RE into the power grid in India.
- They range from analysis and planning, policy and regulatory reforms, new infrastructure, and the application of utility driven demand response and efficiency programs.
- Key initiatives like Smart Grid Roadmap and pilot projects in its distribution utilities, the reform of the electricity Grid Code.

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