

Sustainable Energy Generation



Indian Railways
Lifeline to the nation...



**NATIONAL ACADEMY
OF INDIAN RAILWAYS**
Ministry of Railways - Government of India

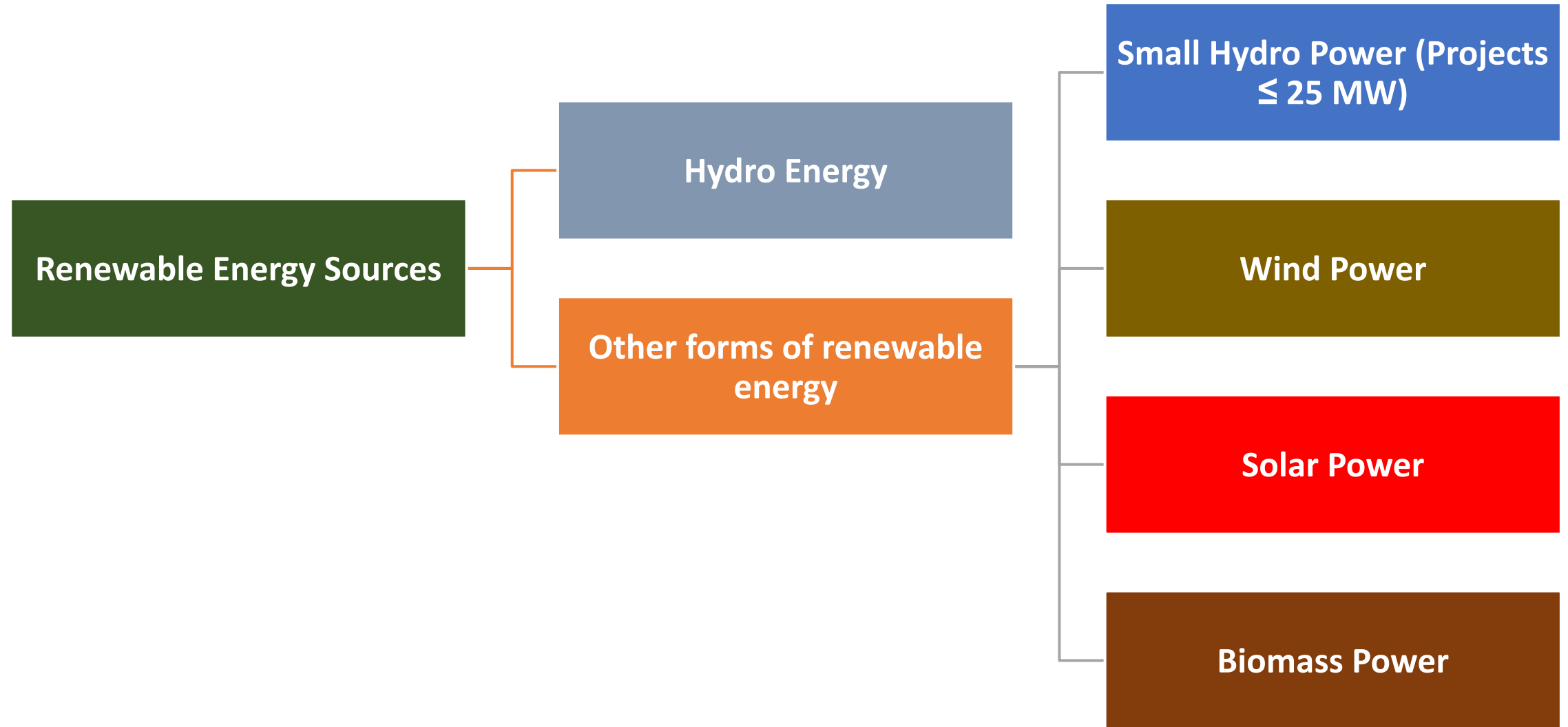
Dr. Prasad Modak

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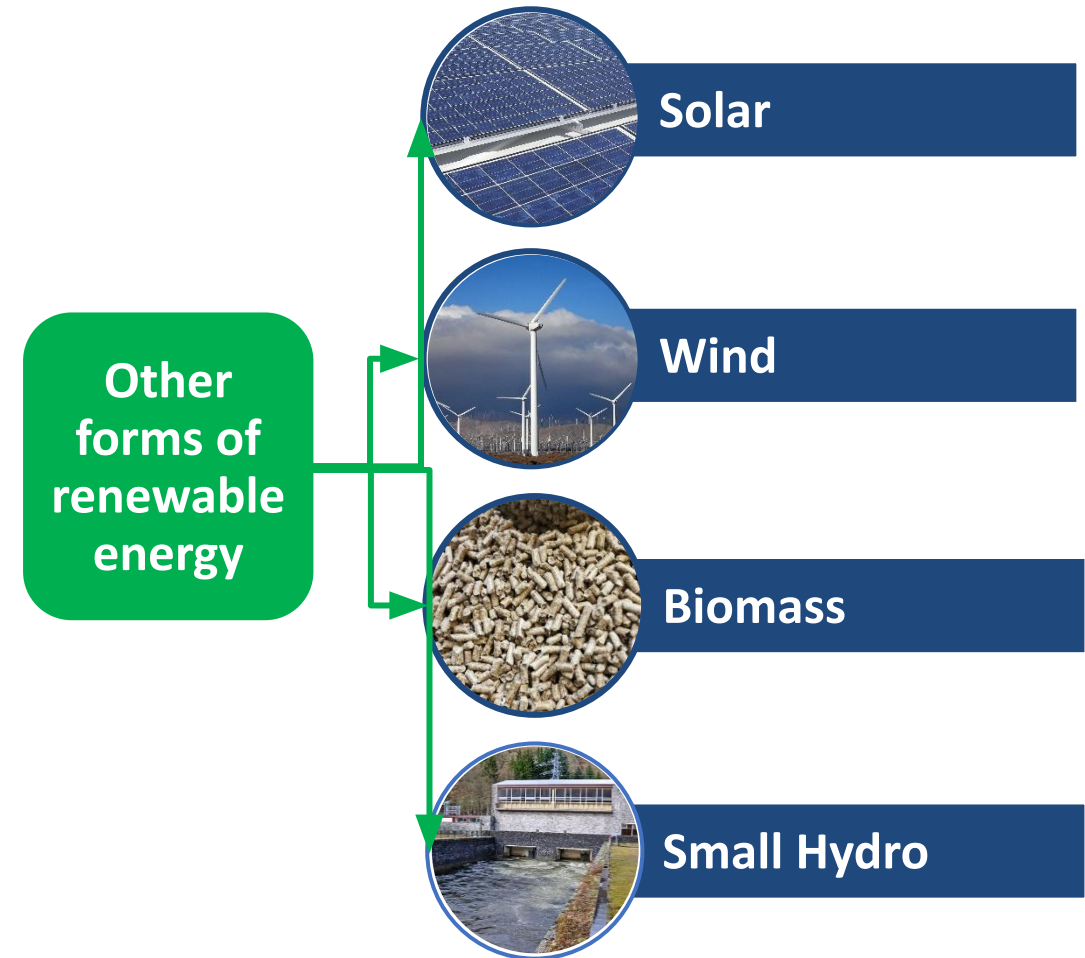
Renewable Energy Sources

Renewable Energy Sources



Advantages of Renewable Energy Sources

- ▶ Practically inexhaustible sources of energy. Abundance of potential...
- ▶ Can be harnessed with minimal environmental impact
- ▶ Contribute to reducing the dependence on depletable conventional energy resources
- ▶ Promote decentralization of energy systems
- ▶ Most ecologically sound solution for the effective reduction of GHG emissions and for combating of climate change



Renewable Energy Technologies

Renewable Energy Technologies

Solar Electricity Generation

Solar Photovoltaic (PV)

Concentrated Solar Power (CSP)

Wind Energy Technology

Vertical-axis wind turbines

Horizontal-axis turbines

Biomass Energy

Biogas Plants

Biomass Briquetting

Biomass Gasifiers

Bio-fuels

Solar Electricity Generation



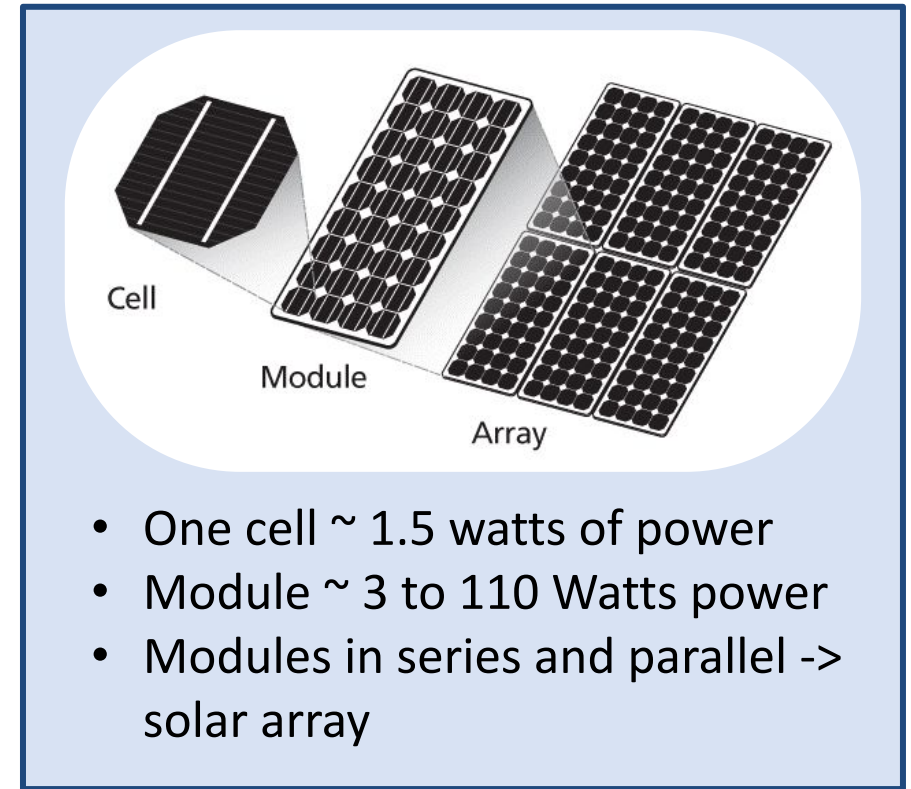
**Solar
Photovoltaic (PV)
Technologies**



**Concentrated Solar
Power Technologies
(CSP)**

Solar Photovoltaic Technology

- ▶ Solar Photovoltaic (PV) cells are made of silicon; releases electrons when exposed to light.
- ▶ **PV tracking systems** facilitates the system to follow the sun as it moves through the sky -> improves output by up to 40%
- ▶ **Back-up systems** include connecting the system to the utility grid or storing excess electricity in batteries for use at night or on cloudy days



Concentrated Solar Power (CSP)

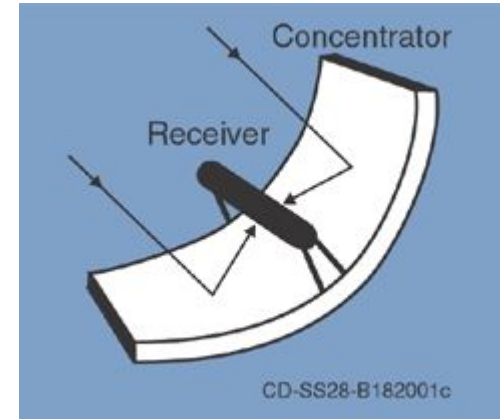
- ▶ use mirrors to focus sunlight and convert it into heat to create steam to drive a turbine that generates electrical power
- ▶ require large areas for solar radiation collection when used to produce electricity at commercial scale
- ▶ CSP Technologies:
 - ▶ Trough Systems
 - ▶ Power Tower Systems
 - ▶ Dish Engine Systems



CSP Technologies

▶ Trough Systems

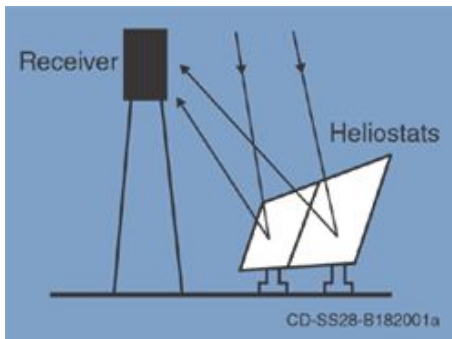
- ▶ parabolic reflectors/focusing mirrors that have oil-filled pipes running along their focal point
- ▶ Oil heated up to 400°C to boil water, which makes steam to run conventional steam turbines and generators



Source: <http://solareis.anl.gov>

▶ Power Tower Systems

- ▶ use many large, flat heliostats (mirrors) to track the sun and focus its rays onto a receiver
- ▶ concentrated sunlight heats a fluid (molten salt) to 560°C to make steam for electricity generation
- ▶ Molten salt has good heat retention and can be stored for later use



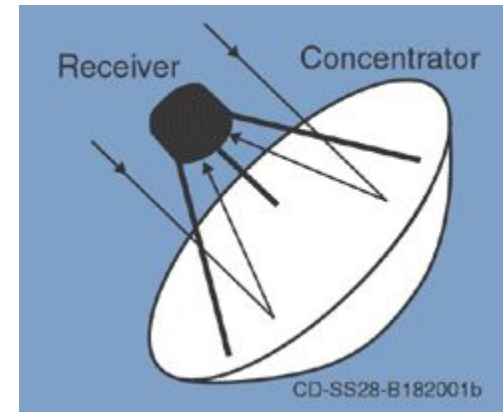
Source: <http://solareis.anl.gov>



CSP Technologies

▶ Dish Engine Systems

- ▶ Use large mirrored dishes to focus and concentrate sunlight onto a receiver.
- ▶ receiver is integrated into a high-efficiency "external" combustion engine, which contains hydrogen or helium gas in pipes that run along the outside of the engine's four piston cylinders and open into the cylinders
- ▶ the gas in the tubes are heated to very high temperatures, which causes hot gas to expand inside the cylinders, which drives the pistons to turn a crankshaft that drives an electric generator



Source: <http://solareis.anl.gov>

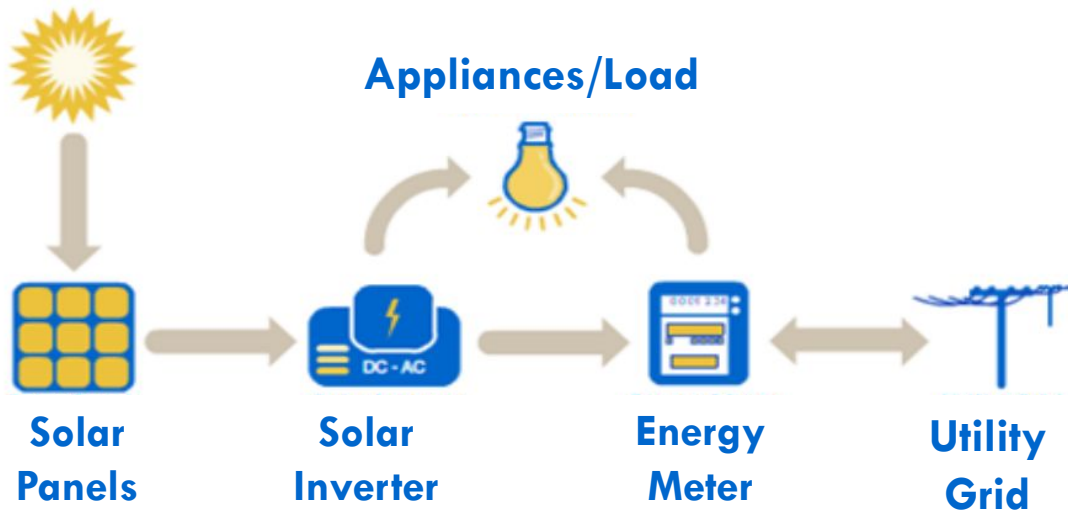


Solar Applications

► Rooftop Solar

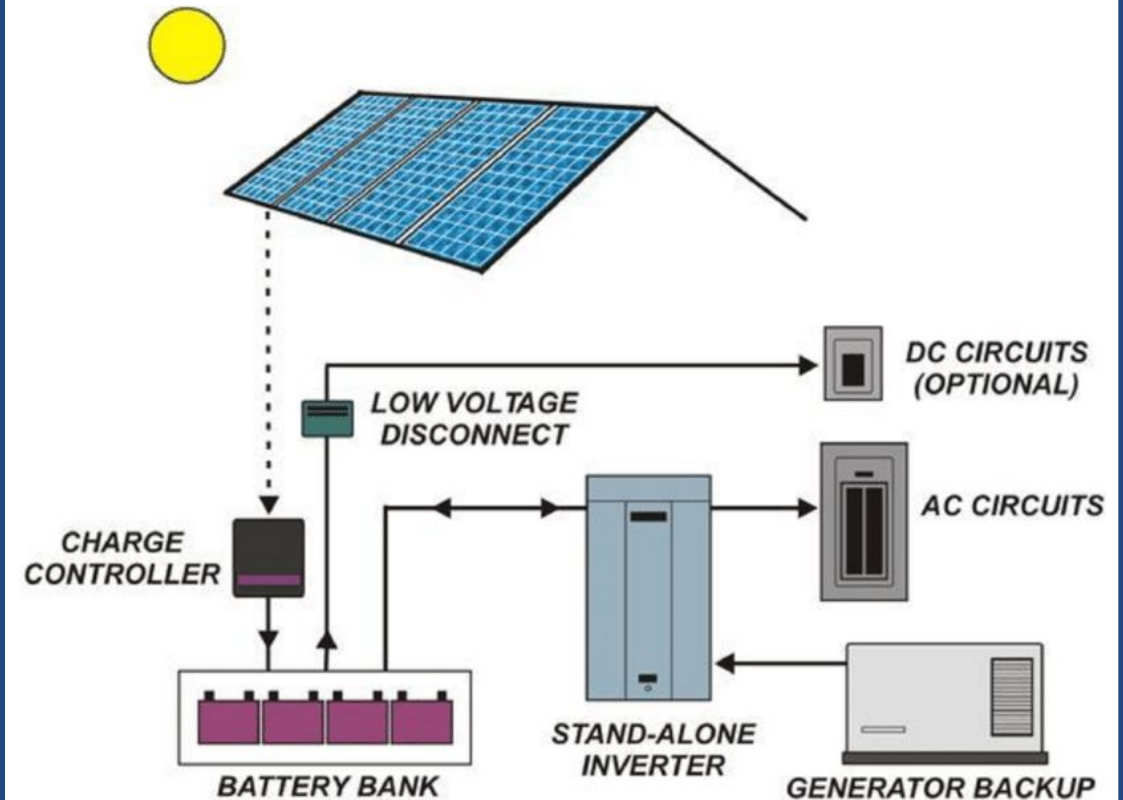
- solar panels are installed in the roof of any kind of building
- two types; i) with storage facility using battery (off-grid) and, ii) grid connected

Grid Connected Solar Rooftop System



Source: <https://solarrooftop.gov.in/pdf/faq.pdf>

Off-Grid Solar Rooftop System



Source: https://www.researchgate.net/figure/Off-grid-PV-System-Schematic_fig2_322738988

Solar Applications

► Solar Park

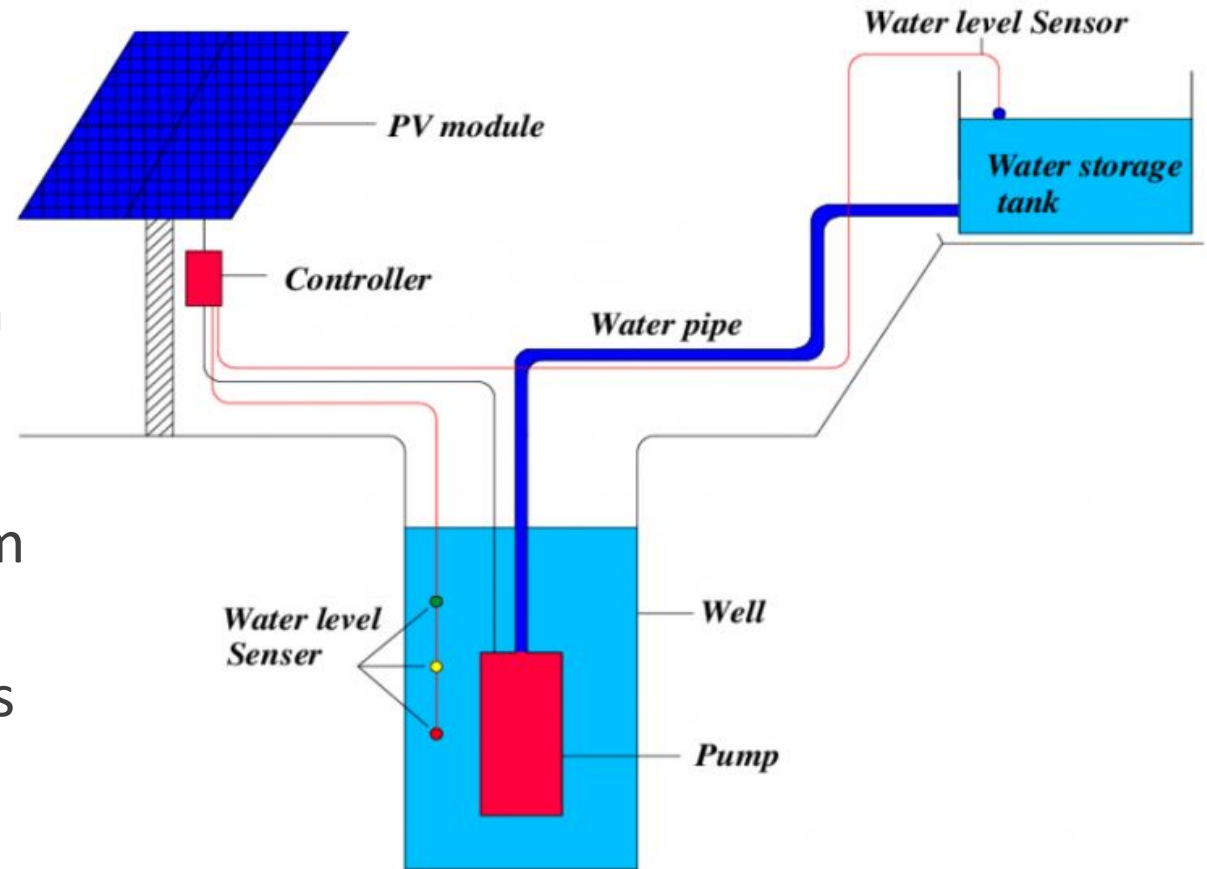
- Concentrated zone of development of solar power generation projects
- Characterized by well developed infrastructure for maintenance
- India has over 34 solar parks
- India has 2 of the worlds largest solar parks; Bhadla Solar Park (2,245 MW), Rajasthan and Pavagada Solar Park (2,050 MW)



Solar Applications

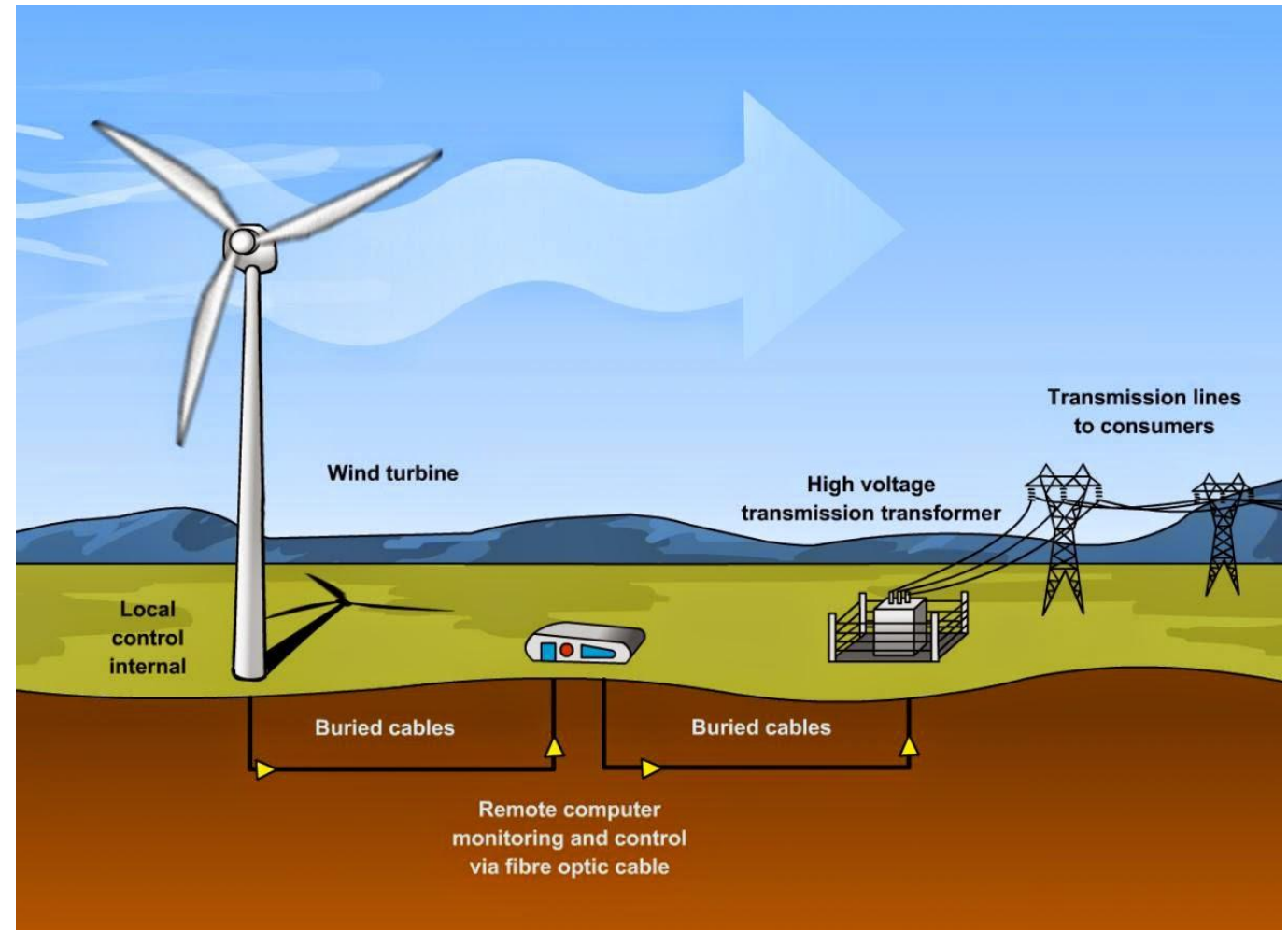
► Solar Pumps

- Conversion of solar energy to electricity for running the pumping system
- About 62,000 pumps in operation across the country. Majority installed through programs such as MNRE's Solar Pumping Program for Irrigation and Drinking Water, State nodal agencies and schemes which included financial support (such as NABARD)



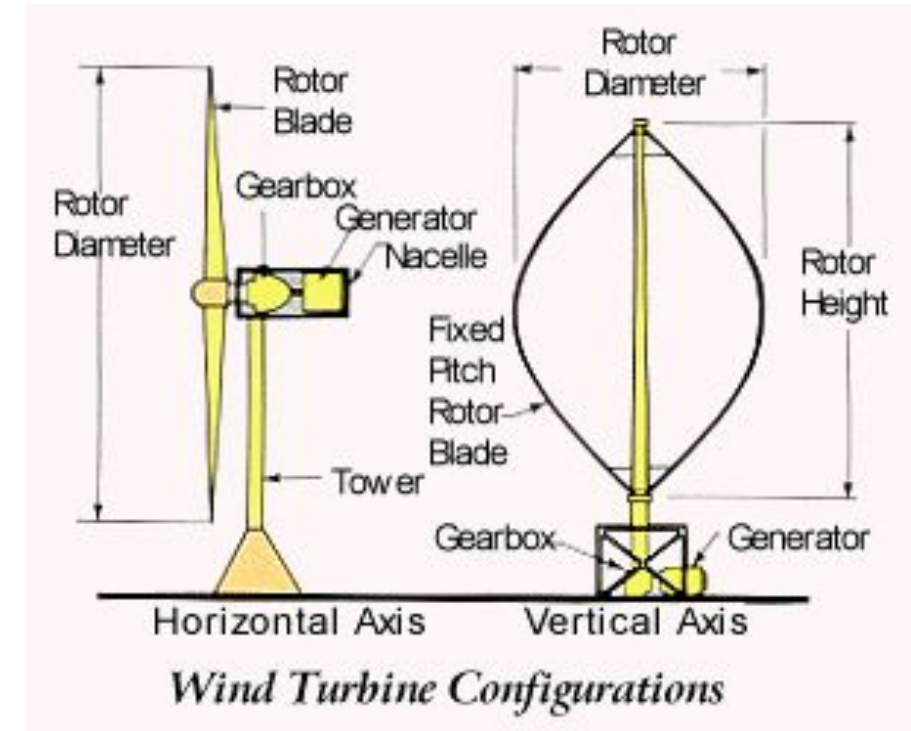
Wind Energy

- ▶ Kinetic energy of the wind is captured by the turbine blades
- ▶ Rotation of the blades spins a shaft that leads to the hub of the rotor of the generator which produces electricity



Wind Energy Technology

- ▶ Wind electric generator converts kinetic energy available in wind to electrical energy by using rotor, gear box and generator
- ▶ Wind Turbine Configuration
 - ▶ Vertical-axis wind turbines
 - ▶ Horizontal-axis turbines



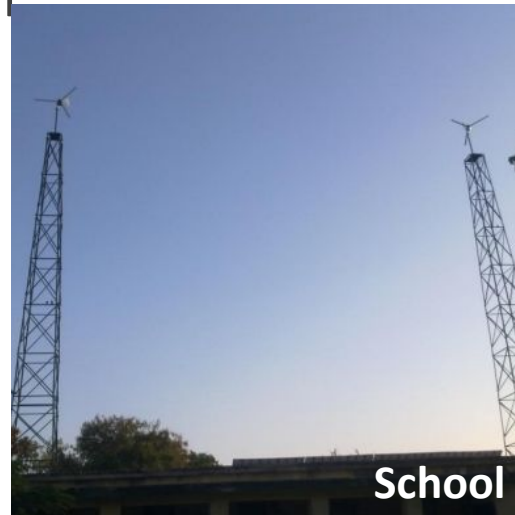
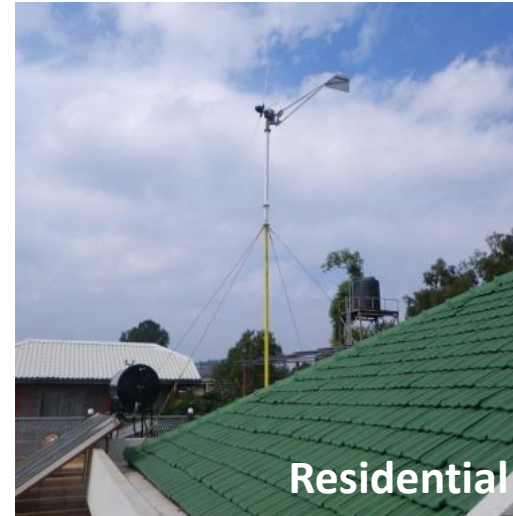
Wind Turbines

- ▶ Blades are made of reinforced carbon-fibre plastics or glass plastics
- ▶ Small wind turbines that can power a single home may have a capacity of 10 kW.
- ▶ The largest wind turbines in operation have electricity generating capacities of up to 10,000 kW, and larger turbines are in development



Wind Energy Application

- ▶ Off-Grid Applications: residential, rural, industrial
- ▶ Wind turbines suitable for residential or village scale range from 500 W to 50 kW
- ▶ Potential market sectors for remote locations include Rural market sectors, Railways, Defence



Wind Energy Application

- ▶ Micro wind turbines
 - ▶ Capacity ≤ 100 kWh
 - ▶ Ideal for remote locations
 - ▶ Can be implemented on tall towers, skyscrapers, communication towers (especially in remote locations)
 - ▶ Micro wind turbines for remote water pumping by driving an electrical submersible pump directly



Wind Energy Application

- ▶ Wind Farms
 - ▶ Also called wind power stations or wind parks
 - ▶ Wind farms may be offshore or onshore
 - ▶ Mountain passes are ideal locations for onshore wind farms



Hybrid Applications

- ▶ PV-Solar / Wind Hybrid Energy System
 - ▶ Hybrid systems found to be ideal instead of backup diesel generator sets for applications (Nema et al., 2010) such as homes in remote locations, GSM towers etc.

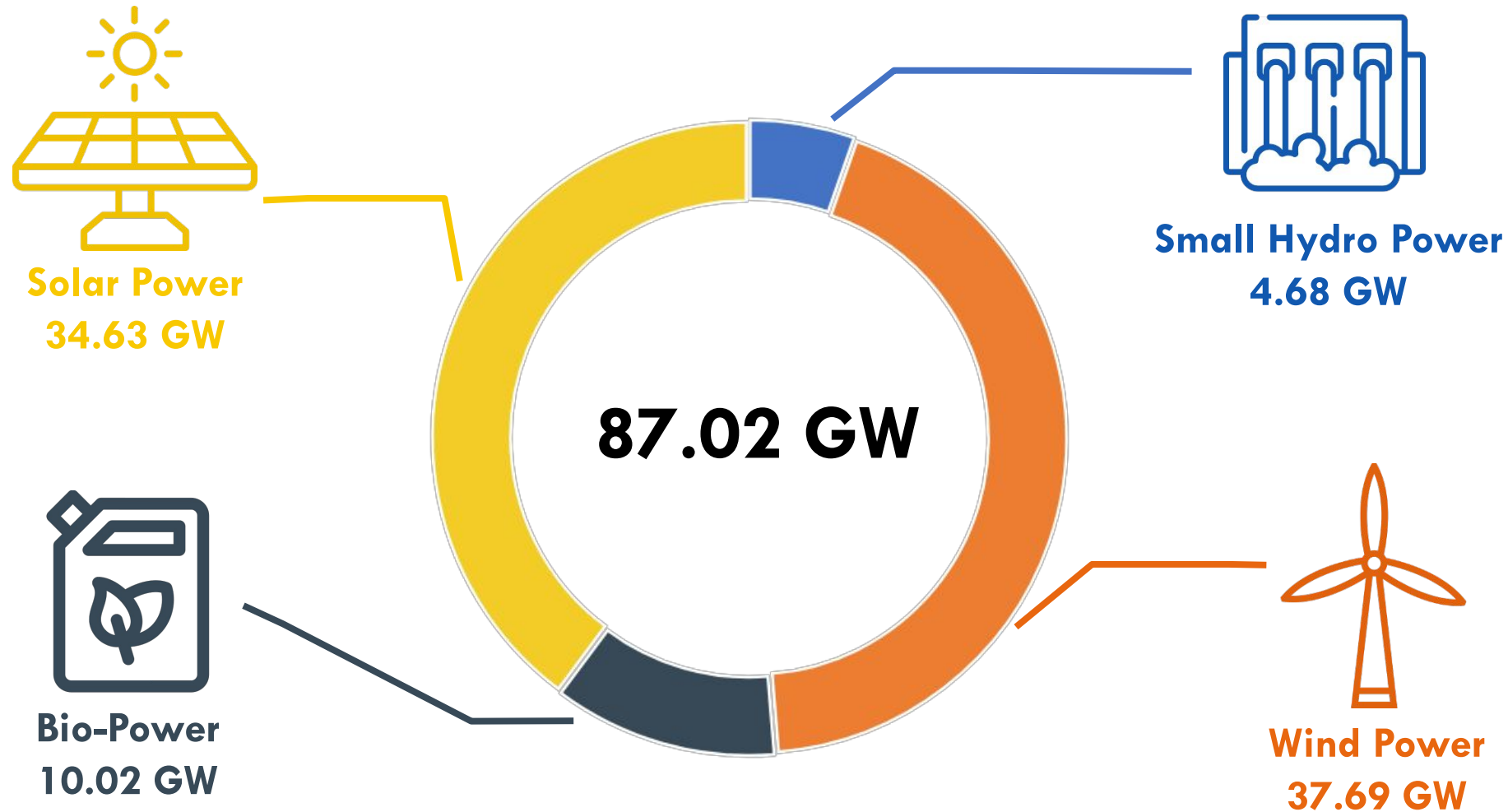


Image source:

<https://www.lavancha.in/solar-wind-energy-hybrid-system/hybrid-power-plant/>

Renewable Energy in India

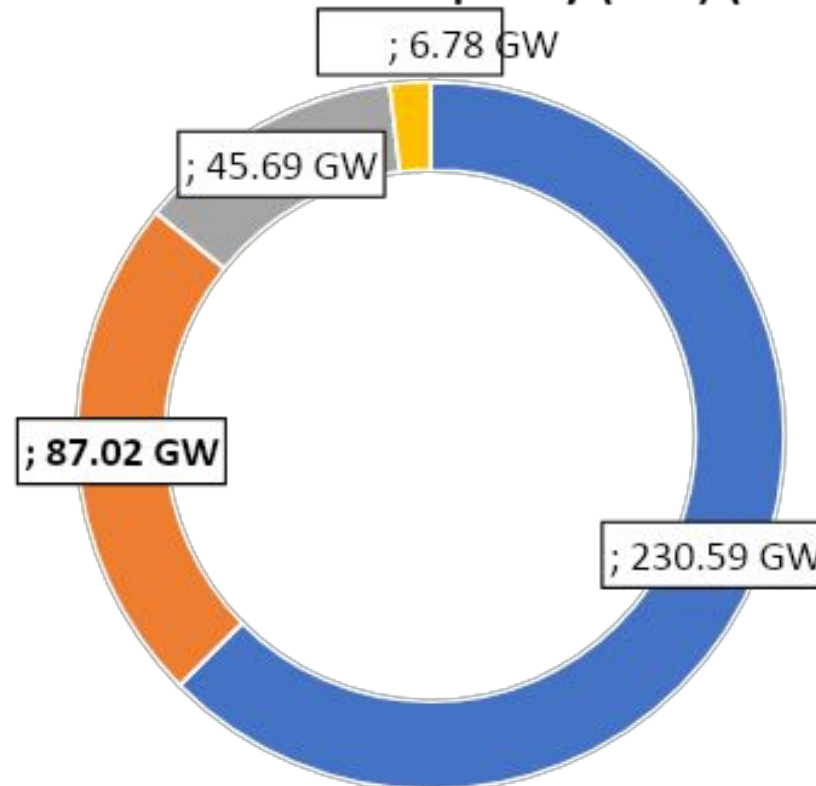
Renewable Energy in India by Source



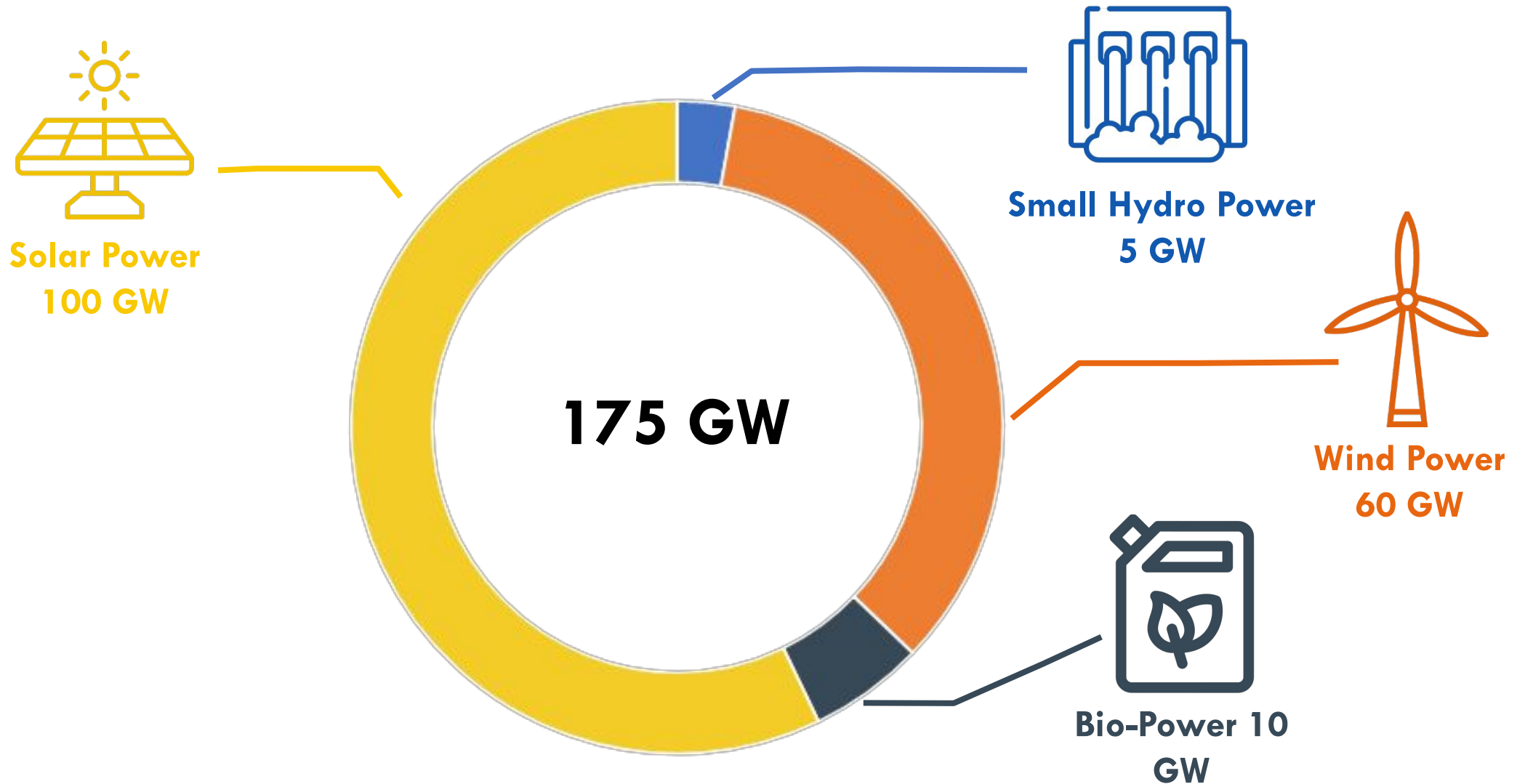
Present Capacity of Renewable Energy in India

- ▶ As of March 31 2020, renewable energy capacity stands at 87.02 GW. This is around 23% of the total installed capacity

Source-wise Installed capacity (GW) (2019-20)



India's Renewable Energy Target (2022)



Government Schemes for Renewable Energy

- ▶ Development of Solar Parks and Ultra-Mega Solar Power Projects
 - ▶ To facilitate the solar project developers to set up projects in a plug and play model [up to 2020-21]
 - ▶ For setting up of Solar Parks and Ultra Mega Solar Power Projects
 - ▶ Target - 40,000 MW
 - ▶ 39 solar parks of aggregate capacity 22,879 MW have been approved to 17 States up to December 2019.

Government Schemes for Renewable Energy

- ▶ Rooftop PV And Small Solar Power Generation Programme (RPSSGP)
 - ▶ **91.8 MW from 72 projects in 13 States commissioned**
 - ▶ Ministry provides Generation Based Incentives (GBI) applicable for 25 year is payable to the distribution utility
- ▶ Phase II of the Grid connected rooftop solar programme approved with a target for achieving a cumulative capacity of 40,000 MW RTS Projects by the year 2022 in February 2019

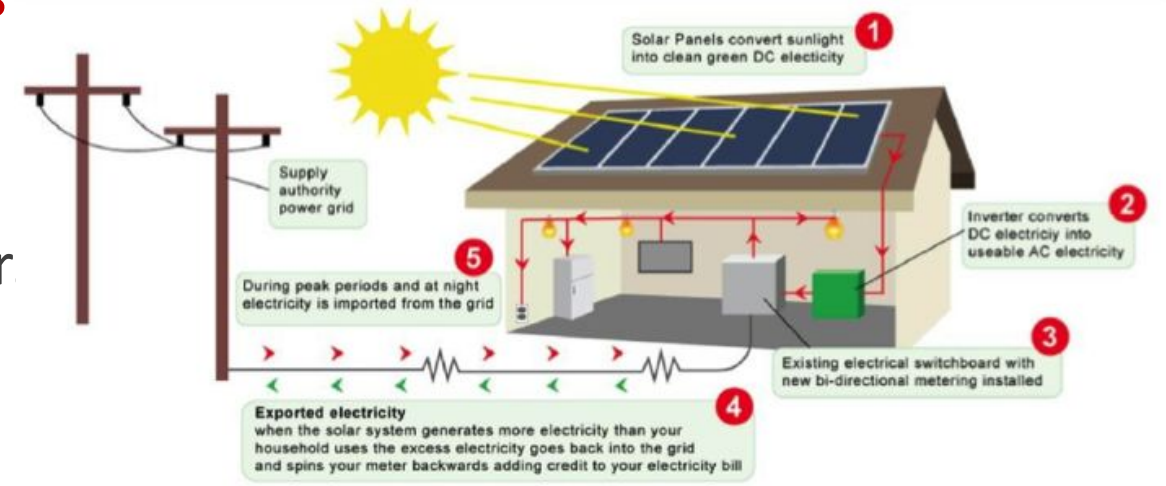


Image source:

<https://www.ireda.com/content/73/Apply-for-Rooftop-Solar-PV-Program>

Renewable Energy Tariffs

- ▶ The year 2017 witnessed record-low winning tariffs of INR 2.44 per kWh (USD 0.04) and INR 2.43 per kWh (USD 0.04) for utility-scale solar and wind energy generation tariffs, respectively. This is two thirds of the cost of domestic coal-sourced thermal tariffs, and half that of imported thermal power costs.

Alternate Fuels

Alternate Fuels

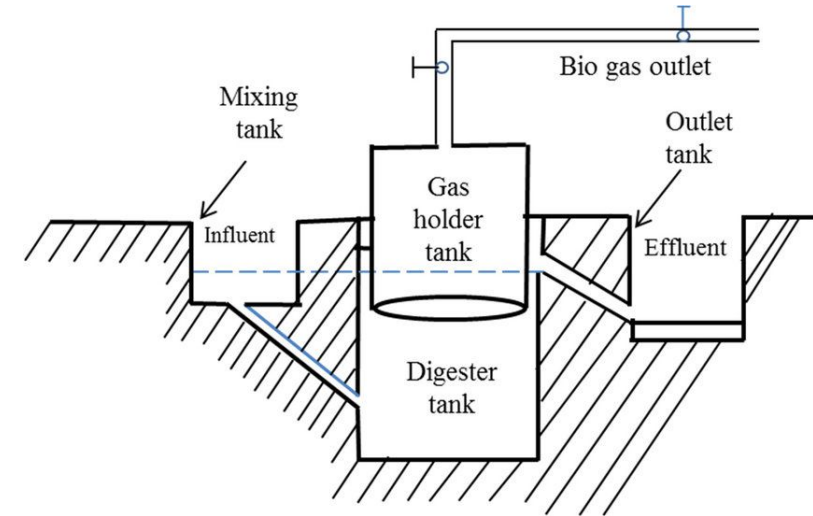
- ▶ Derived from the carbonaceous waste of various human and natural activities,
 - ▶ By-products from the wood industry, agricultural crops, raw material from the forest, household wastes etc.
- ▶ Biomass offers **higher energy efficiency** through form of Biogas than by direct burning
- ▶ In India, Biomass fuels account for about one-third of the total fuel used; used in over 90% of rural households and 15% of the urban household



Types of Alternate Fuels

▶ Biogas

- ▶ naturally produced from the decomposition of organic waste in an anaerobic (absent of oxygen) environment
- ▶ primarily a mixture of methane and carbon dioxide
- ▶ Composition of biogas depends on the composition of the substrates fed and the rate of digestion



▶ Biomass Briquettes

- ▶ densifying loose agro-waste into a highly dense solidified biomass
- ▶ high calorific value with low ash content, absence of polluting gases like sulphur, phosphorus fumes and fly ash
- ▶ can replace almost all conventional fuels like coal, firewood and lignite in for general applications like heating, steam generation etc

Types of Alternate Fuels

▶ Ethanol

- ▶ Fuels produced from materials that have sugar such as sugar cane, sugar beet, sweet sorghum, etc
- ▶ Flexible-fuel vehicles; run on mixtures of gasoline and up to 85% ethanol

▶ Biodiesel

- ▶ Derived from non-edible vegetable oil, acid oil, used cooking oil, animal fat and bio oil, algal feedstock, etc.
- ▶ Methyl or ethyl ester of fatty acids
- ▶ Extracted and refined into fuel for diesel engines and buses

▶ Drop-in fuels:

- ▶ Fuels derived from biomass, agri-residues, MSW, plastic wastes, industrial wastes, etc.



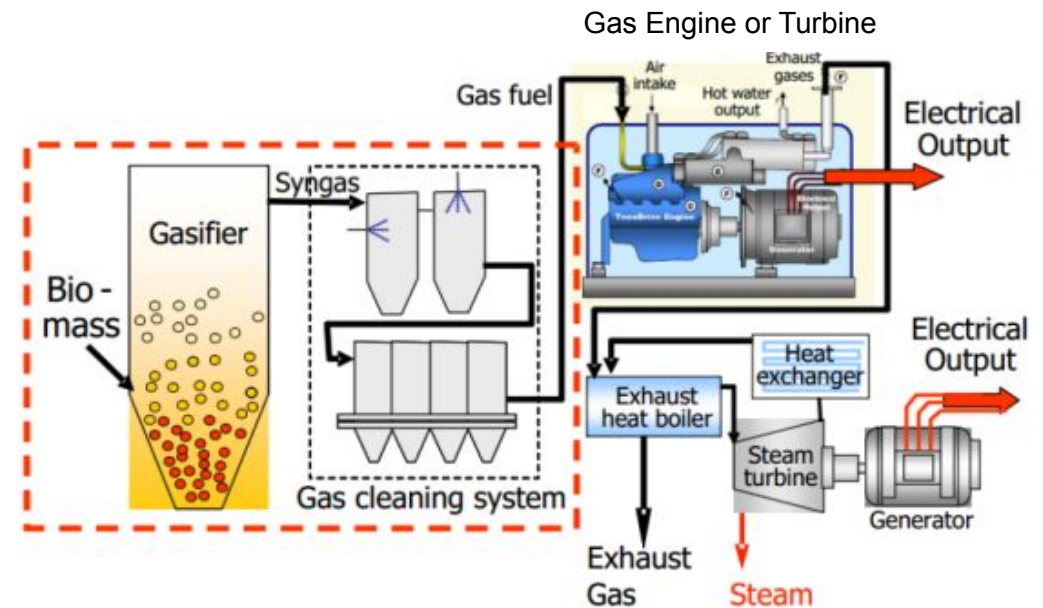
National Policy on Biofuels - 2018

- ▶ A derivative of renewable biomass resources such as plastic, municipal solid waste (MSW), forestry residues, agricultural wastes, surplus food grains, etc.
- ▶ Besides environmental benefits, adoption of biofuels can significantly improve farmers' income, generate employment opportunities, reduce imports, augment waste to wealth creation, etc.
- ▶ Target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel to be achieved by 2030
- ▶ Proposed measures
 - ▶ Ethanol Blended Petrol (EBP) Programme - ethanol produced from various types of feedstocks would be blended with petrol
 - ▶ Biodiesel Blending Programme - biodiesel would be blended with diesel
 - ▶ Drop-in fuels derived from MSW, different types of industrial wastes, biomass, etc. to be emphasized
 - ▶ Second-generation (2G) ethanol technologies would be developed and commercialized

Bio Energy Technologies

► Biomass Gasifiers

- Convert the solid biomass into a combustible gas mixture (producer gas) which consists of mainly CO, H₂, N₂ gas and methane, with low calorific value (1000–1200 kcal/Nm³)
- On substitution, can result in savings of at least 50% in fuel consumption
- Gas needs to be cleaned in venture scrubbers in a gas cleaning system before being utilized
- Gasifier when connected with an electric generator equipped with a **gas engine or turbine** can generate electricity



Efficiency of the gasification ~ 60-70%

Thank you



Ministry of Environment, Forest
and Climate Change



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