

# Theoretical Review of Renewable Energy for Rural Applications

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## Abstract

This paper gives a detailed theoretical review of various types of renewable energy for rural applications. This paper provides an overview of renewable energy to increase electricity production in rural areas. Renewable energy technologies have long been subject to international debate and action as a means of expanding access to electricity by means of off grid or grid extension program. Similarly, there are variety of components which supplies electricity in off grid or rural areas like PV modules, small wind turbines, towers, small hydro turbines, winds and solar pumps, inverters, and variety of decentralized systems have also been developed and used to run various house hold appliances, micro grid and mini grid are also used for off grid power electricity generation.

## 1. Introduction

We now realize that the electricity is slowly becoming the basic need of humans, but in rural areas about 63% of houses do not have electricity. Around 80,000 of un-electrified villages exist in India. Grid based power supply is not possible in some rural areas and it is not feasible in around 20,000 villages. Even in electrified villages there is a power cut for 10 to 15 hours daily. Now a day's we have decentralized alternatives to conventional grid extension that are technically and financially viable, even in remote rural areas. Renewable energy technologies are an important subset of the decentralized alternatives.

Electricity is one of the prerequisites for significant sustainable economic growth of rural areas. There exists a wide variety of renewable resources like solar, biomass, wind, tidal and hydro power. As we know that the significance of all these resources depends upon the location, climate, weather and other miscellaneous factors. In this paper we are covering the theoretical aspects of renewable energy in the field of rural application. Renewable resources are not completely exhaustible that's why they are called it renewable.

## 2. Status of Various Renewable Resources

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### 2.1 Solar Energy

As we know sun is the free and abundant source of energy. Its potential is high in India and it comes in the solar belt region for utilizing the world solar potential. India receives solar energy in the region of 5 to 7 kwh/m<sup>2</sup> for 300 to 330 days in a year. This energy is sufficient to setup 20 MW power plants per square km land area. Solar energy is utilized by two different methods first one is by solar thermal process and the one is by solar photovoltaic method. In first process we use the sun's heat for various household applications like cooking, drying etc. In solar photovoltaic process sun's heat is utilizes to produce electricity for lighting the houses, buildings and to run various electric appliances.

Over 18 lakhs solar photovoltaic system are installed or distributed. The target of solar mission by 2022 as per MNRE is to provide 20000 MW grid supplies, 2000 MW of off-grid, 20 millions house hold covered by solar lighting. For achieving this they decide some objectives like to develop man power, support research and development, development of eco system for industry. The various application of solar photo voltaic are home and community lightings, village street lightings, village power plants, water pumping systems, vaccine refrigeration and also for playing TV sets and radio receivers. And other applications are battery charger for defense

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applications, railways and telecommunications. In Solar thermal process, solar energy is converted into thermal energy with the help of solar collectors and solar receivers. Solar thermal devices are of three types.

1. Low-grade heating devices up to the temperature of 100 °C
2. Medium grade heating devices up to the temperature range of 100 °C - 300 °C
3. High grade heating devices above temperature of 300 °C

Low grade devices are used in air heaters, solar cookers, water heaters and for various domestic and industrial applications. Solar water heater comprises of two main parts solar collector and solar tank. These systems are either active or passive systems. Its applications are in bathing, washing, sterilizing, pasteurizing etc. Solar cooker is a substitute for saving fossil fuels; it saves wood and electrical energy and a pollution free method of cooking except in rainy, winter and cloudy season. There are two types of solar cooker; box type solar cooker and parabolic concentrating solar cooker. Box type solar cooker is widely used in rural areas for cooking. Parabolic concentrating types are also widely used and frying and baking is also possible. In photo voltaic method, the name itself stands for solar electric. This is the most powerful tool for electrification of rural areas. Solar photovoltaic pumping sets are most commonly used for irrigation. It requires no fuel, easy to operate and maintain. Suitable to irrigate about five acre land: Recent initiatives taken in the area of solar photovoltaic research and development are discussed below:

1. Development of poly silicon material.
2. 20-22% efficiency single crystal silicon cell.
3. 3)10-12% efficiency nano crystalline thin film modules.
4. 10-15% efficiency CIGS cells.
5. 5)10-12% efficiency dye sensitized cells.
6. 6)5% efficiency organic-inorganic hetero junction cells.

In solar thermal, second generation technology developed using selective coating absorbers, number of modes developed for solar box type and concentrating dish cookers, scheffler cooker for indoor cooking for large kitchens are developed. Concentrator technologies for industrial process heat application and steam generation is in progress.

**Table: 1.** Temperature Range Required for Different Domestic/Agricultural Applications

Agricultural applications	System type	Temperature, daily heat delivery range
Cleaning, sanitation	Solar water heating, (flat plate units)	40° C to 70° C
Production of high value fruits, spices, exotic house plants etc.	Green houses	20°C to 30°C
Crop drying (coffee, tea fruit )	Hot air systems, solar tents and dryers	40° C to 70° C
Poultry processing	Solar hot water	40°C - 100°C
Coffee drying and processing	Coffee husks are used as fuel for biomass furnaces for various applications	100 - 700 kW thermal
Water pumping (irrigation, live stock watering)	Bio fueled power generators	-

### 3. Hydro Power

Hydro power is the most useful and cheapest source of energy. For rural applications we can utilize the small hydro power up to a great extent. Potential of small hydro power is 15,000 MW in India. Micro up to 100 KW and mini hydro up to 101 KW to 1000 KW can provide power for various applications. The MNES has launched a scheme for portable micro hydro sets for rural areas. These sets have zero maintenance cost and can provide electricity to small sets of villages. Small hydro power is beneficial in various aspects. Its equipment efficiency is greater than 85%, capacity utilization factor is as high as 95%. To improve its use research and development and testing is going on. For this, real time digital simulator set up at AHEC, IIT Roorkee has been installed. Turbine model testing set up is also installed at AHEC. Onsite project testing facility is also created. It is beneficial for rural applications. Ministry of non conventional energy sources is focused on the following issues:

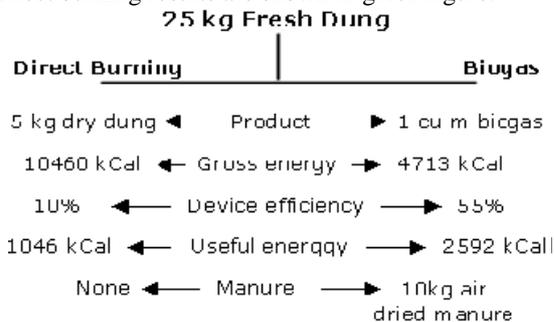
1. Nationwide resource assessment.
2. Setting up of commercial projects.
3. Renovation and modernization.
4. Industry based research and development.
5. Development and up-gradation of water mills.

#### 4. Biomass

Biomass is a renewable energy resource derived from the waste of human and natural processes. It derives from various resources like wood, agricultural crops, raw material of forest and other local available residues. It does not add carbon dioxide to the atmosphere. Biomass is the second most important source of energy after coal, oil and natural gas. The potential of biomass is 16000 MW in India. The potential of bagasse cogeneration is 5000 MW. Biomass combustion, biomass cogeneration and biomass gasification are the important technologies of bio energy. Biomass gasification is useful tool for rural needs as we know that biomass is available in huge amount in village. So we have to utilize this for electricity generation and other aspects of villagers.

Generally biomass gasification is the conversion of woody and non woody biomass like rice husk, cotton stalks, wood chips etc to obtained producer gas. It is the key energy source of energy for sustainable development. It offers high energy efficiency as compared to direct burning.

Bio energy is used for various applications like cooking, pumping, power generation etc. the biogas contain 60% methane and 40% carbon dioxide. Biomass is used by different techniques like biomass briquetting, gasification and cogeneration. It is the process of densifying the loose waste agro product into a solidified biomass of high density. It is eco-friendly and also known as bio-coal. These materials are easily briquetted like jute stick, ground nut shell. Tobacco dust, rice husk, pine needle, saw dust etc. Biomass briquettes can be directly used as fuel in chulhas, furnaces and in gasifier. Main advantages of this briquetting are high calorific value and low ash content. No poisonous gases are present like sulphur and phosphorus fumes. This results in complete combustion, ease of handling, transportation and storage because of uniform size. Biomass offering high energy efficiency in the form of bio gas than by direct burning results are shown in given figure.



**Fig: 1.** Comparison of biomass energy in the form of biogas than by direct burning

The conversion efficiency of gasification process is 60 to 70%. Gasification of biomass will save at least 50% in fuel consumption. Gasifiers are also used for irrigation purpose for electrical power generation up to 500 KW. The government of India is also implementing power generating plants in villages through MNES and IREDA.

High efficiency wood burning stoves reduce cooking time, health hazards, fire wood. It reduces more than 50% fuel wood consumption. It also provides rural employment opportunities for villagers. With an estimated production of about 460 million tonnes of agricultural waste like agricultural residues to meet energy needs every year, Biomass is capable of supplementing the coal to the tune of about 260 million tonnes. This can result in a saving of about Rs. 250 billion, every year.

**Table: 2.** Potential of Various Agro Field / Industrial Residues Waste

Type of Agro residues	Quantity(Million Tonnes / annum)
Straws of various pulses & cereals	225.50
bagasse	31.00
Rice husk	10.00
Ground nut shell	11.10
Stalks	02.00
Various oil stalks	04.50
others	65.90
total	350.00

#### 5. Waste to Energy Technology

Various technologies are developed to produce power by the treatment of urban, rural and industrial waste. It is estimated that more than 1000 MW power is generated from the waste in India by adopting these technologies. Some processes of solid waste treatment are discussed below.

- Incineration:** It is a process of controlled combustion for burning of wastes and residues. The heat generated during this process is utilized for production of steam and electricity generation.
- Pelletisation:** It is a process of generation of fuel pellets from solid waste. It also known as refuse derived fuel (RDF). 100 ton of solid waste can be utilized to generate 30 tonnes of fuel pellets per day. Calorific value of fuel pellets are about 3500 to 4000 kcal/kg and can be used for various applications and electricity generation also.

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- 3. **Pyrolysis:** In pyrolysis process combustible matter is allowed for drying and then it is shredded in a hammer mill. The final product includes gas which is known as producer gas and it is utilized for generation of electricity.
- 4. **Bio methanation:** In this process organic matter of solid waste is segregated and after this the end product is fed to the bio reactor. Here in anaerobic condition and in the presence of methanogenic bacteria, fermentation takes place and biogas is produced and this can be utilized in biogas engines for generation of electricity.

**Table: 3.** Energy Based Estimated Potential of Renewable Energy

Energy Source	Estimated Potential
Solar energy	20 MW per sq km
Small hydro	10,000 MW
Bio energy	17,000 MW
Draught animal power	30,000 MW
Biogas plants	12 Million plants
Improved wood burning stoves	120 Million stoves
Bagasse based cogeneration	3500 MW
Wind energy	20,000 MW

**6. Wind Energy**

Wind energy is utilizing the wind power for electricity generation or for other applications. It is not a new form of energy; we are using this since centuries. If we discuss it from technical point of view; the air always flows from hotter region to colder regions. Due to these air flows, windmill and wind turbine produce power. Wind energy system requires minimum 15km/h speed of wind but it is not good, 22km/h is moderate and 29km/h is excellent. India ranks fifth in the world in wind power generation with installed capacity as on 31.oct.09. India ministry of renewable energy is offering new incentives for grid connected renewable wind power generation. Wind electricity producers are now receives a incentive of 0.50 rupees per unit of electricity.

**6.1 Advantages Of Wind Power**

- 1. It is environment friendly, safe and clean energy resource.
- 2. Low gestation period as compared to other conventional resources.
- 3. No fuel consumption hence low operating costs and its maintenance cost is also low.
- 4. Equipment erection and commissioning requires less time.

**Table: 4.** Potential of Wind Power in India

State	Potential in MW	Installed in MW
Andhra Pradesh	8968	122
Gujarat	10645	1433
Karnataka	11531	1184
Kerala	1171	23
Madhya Pradesh	1019	188
Maharashtra	4584	1838
Orissa	255	-
Rajasthan	4858	671
Tamil nadu	5530	4124
Total	48561	10891

Pollution saving with an average output of 4000 kWh per year through wind power generation is given below:

- Sulphur dioxide (SO<sub>2</sub>) = 2 to 3.2 tonnes
- Nitrogen oxide (NO<sub>x</sub>) = 1.2 to 2.4 tonnes
- Carbon dioxide (CO<sub>2</sub>) = 300 to 500 tonnes
- Particulates = 150 to 180 kg

**Table: 5.** Estimated Potential Capacities From Renewable Energy Resources (In Gws)

Resource	2005	2010	2015	2020	2030	2040	2050
Wind	04	12	29	69	143	200	224
Photovoltaic	0	0	02	10	118	486	1093
biomass	0	01	04	08	19	41	70
geothermal	0	0	0	02	06	18	30
Solar thermal	0	0	0.5	03	23	70	151
Ocean energy	0	0	0	01	03	05	11
Total	4	13	35.5	93	312	820	1579

**7. Discussion**

As we go through the review about renewable energy resources, we find that these are the key points discussed here. we know that the fossil fuel are on the verge of depletion the need is to save the fossil fuel reserve and use more and more of renewable energy resource. The villages or rural areas where grid supply is not possible, in those places we can use solar photovoltaic and biomass for energy generation. The renewable energy resources are pollution free, environment friendly and non toxic for human life. As

there are number of villages deprived of electricity,

Solar panels are also used for lighting and agricultural residues are used as source of biomass. The cost of electricity generation through renewable resources is less as compared to the supply grids. Improved technologies in the field of renewable energy are shifted from the traditional large scale centralized power production network to more feasible decentralized system.

In some of the cases the renewable system and hybrid system are more reliable, environment friendly, more cost effective than fossil fuel system alone.

The combined application of biomass based cogeneration and wind electric power generation are used for large and small scale rural applications and it is safe from environmental and economic point of view.

If we put light from health care point of view, In some rural areas we provided photo voltaic system which supplies power for vaccine refrigerator, oxygen concentrator, nebulizer, centrifuges, microscopes and lights in health clinics. In some rural health clinics have reliable two-way regional communication via VHF radio and electricity provided by single 30W PV

solar panels are installed there for fulfilling the need. module. Solar water distillation and pasteurization are done for biological contaminated water. In solar pasteurization water or milk containers are placed in solar cooker. The temperature required for pasteurization is easily achieves here. Solar distillation is also a beneficial process and it makes water bacteria free and also free from various chemical contaminations and making it drinkable for healthy life. This is also helpful in providing lighting for various educational activities.

## 8. Conclusion

From the above review we conclude that the scope of renewable energy in the country is quite high. We can utilize this to improve the living standard of rural people. We can utilize these energy resources to easily supply the electricity to off-grid rural areas with minimum expenditure. It is also beneficial from various points like health, cost, power supply etc. There are various places where biomass is available in huge quantity and which is sufficient for rural needs. Power generation through renewable resources is economic and useful for rural areas

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