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Off-Grid Energy Technologies Used in Rural Areas of India

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Abstract

Energy scenario in India is changing with a greater pace. Growth rate of villages has increased, likewise their energy demand. With the awareness of the decreasing natural resources, non conventional energy resources are gaining lots of interest in sparsely separated areas. The rural areas of India are having the huge scarcity of energy because of limited energy resources and Grid connectivity is not feasible due to economic factors and geographical situations. So we require to establish the off grid system for the benefit of the mass. Off-grid System's commissioning and operation done as indigenous unit, and free from grid related problems like frequency and voltage regulations and they provides flexible operation because their emphasis is on extraction of energy and conversion into useful work. This paper discusses the potential use of off-grid energy technologies as an alternative for grid extension. Off-grid Energy systems provide the solutions to the basic energy needs in the rural areas of India. These indigenously build plants are not connected to any electrical utility and can be connected with the micro grid for the better reliable operation. Due to small size their demand and load management would be easy. Off-grid system utilizes the solar thermal radiation, wind energy, geothermal energy, tidal wave, Biomass etc. There is numerous numbers of applications where we can use this energy and decrease the dependence on conventional grid.

Keywords: *off grid, biomass energy, solar PV panels, wind energy, small hydropower etc*

1. Introduction

Energy is the primary and most universal measure of all kinds of work by human beings and nature. Whatever happens in the world is only the expression of flow of energy in either of its forms. The electricity requirement of the world is increasing at an alarming rate due to industrial growth, increased and extensive use of electrical gadgets. Electricity is used not only for lighting and household purposes, but it also has application in water pumping, threshing, milking and hoisting grain for storage [1-2].

The present mismatch between energy generation and consumption, depletion of sources of conventional energy are serious in nature. Unless a long term planning is done to handle these issues and commercially viable and environment friendly alternative technologies are developed, it will spell a doom. If appropriately applied individually or in combination, renewable energy sources have the potential to be cost effective sources for some of the rural loads. However, such sources are usually site specific (e.g. hydro), appear in low concentration (e.g. wind and solar), and hence require capital intensive equipment to convert into more usable forms of energy (e.g. electricity) [3-5].

India has huge prospects in developing energy through alternate sources. What is lacking at present is the focused desire and serious efforts in research and development.

1.1. Understanding the Energy Problem

It is a matter of shame for all of us that even 65 years after independence, 60% of all rural households in India do not have electricity and use kerosene for cooking, lighting and heating. Wood-fuel supplies 80% of the cooking energy needs. Kerosene fuel is mainly used for lighting and heating. Utilization of these resources places pressure on tree-forests and subjects individuals to pollution due to inhalation of smoke and fumes in households [2].

Even for those rural areas, which are electrified, there is tremendous shortage of power supply. Thus, it is not uncommon for these areas to have 10-12 hours of blackouts every day.

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Because of tremendous shortage of electricity, industrial growth and general life in the country is seriously affected. Moreover, with any problems in the national grid, rural areas are affected the most, since, the state electricity board provide urban areas with electricity on priority basis [3].

1.2. Off-Grid Alternative Technologies

Renewable energy technologies have substantial potential to provide reliable and secure energy supply as an alternative to grid extension. The major barrier for large scale deployment of renewable and its utilization for rural electrification is large capital investment and therefore higher cost of electricity generation making it unviable in comparison to subsidized grid tariffs. Also there exists obvious risk of these renewable off-grid installations becoming redundant once grid reaches. Therefore there is a need to develop policy and regulatory interventions that would address these risks [4].

The following sections lay out the available off-grid technologies, analyzes their advantages and disadvantages, and helps understand the different end-uses each technology can meet.

2. Biomass as Sourse of Energy

Biomass is plentifully available in the rural regions. The rural people use biomass mainly as a major source of energy in cooking food, which constitutes almost 50% of the total energy consumption. Biogas is produced from trees, crops, animal and human waste through a process known as anaerobic digestion, done with organic matter. Some of the advantages of biogas are that it can be produced at low cost, and that the technology to make biogas can be produced locally as well. Furthermore, as Practical Action states, “small-scale biogas production in rural areas is now a well-established technology,” particularly China and India (Practical Action 2006). Other modern uses of biomass are also great alternatives for replacement of traditional technologies for cooking, especially in India [1].

But there is also a third dimension to use biomass as a fuel, and that is the pollution arising due to burning of biomass. Generally, we do not consider the pollution caused by cooking fires very seriously, but according to statistics published by the World Health Organization, annually about 500,000 women and children die prematurely in India due to air pollution caused by cooking fires in rural households. Considering the fact that almost 60% of our population is rural, giving the rural women a cleanly burning biofuel is a major task, which is unfortunately not tackled by any of our major research centers [2-3].

Technological advancement in biomass energy is derived from two spheres-biomass energy production practices and energy conversion technologies. Improvements in soil preparation, planting, cultivation methods, species matching, bio-genetics and pest, disease and fire control have contributed to reduction in production cost of biomass energy. Technological advancements in biomass energy conversion comes from three sources-enhanced efficiency of end-use technologies [4].

The designing of the cooking devices should be done in such a way that they burn the biomass more cleanly, so that the pollution caused by them is reduced. This is achieved by providing the fuel with sufficient air, so that it burns completely, reducing automatically the carbon monoxide and the particular matter in the fuel gases. Another strategy is to design a stove in such a way that wastage of heat is to be avoided. This results in higher fuel use efficiency, requiring the user to burn less fuel. Pollution is naturally reduced if the amount of fuel is reduced. Both the strategies are combined in modern improved cook stoves. To improve the efficiency of the stoves, standardization of fuel is also required. The easiest way of standardizing woody biomass is to cut it into uniform, small pieces called chips [5].

Modern biomass has potential to penetrate in four segments - i) process heat applications in industries generating biomass waste, ii) cooking energy in domestic and commercial sectors (through charcoal and briquettes), iii) electricity generation and iv) transportation sector with liquid fuels. Economic reforms have opened the doors for competition in energy and electricity sectors in India. Future of biomass energy lies in its use with modern technologies. Biogas can also be used as fuel in internal combustion engines. The CNG technology that is currently available in India can be used in either ways as bigas or an automotive fuel [1], [2], [4].

An International Energy Agency report states that “because biomass with continue to dominate energy demand in developing countries in the foreseeable future, the development of more efficient biomass technologies is vita for alleviating poverty, creating employment and expanding rural markets” [5].

3. Solar PV Panels

Solar Photovoltaic (PV) Panels have recently become a popular solution to target energy problems in disconnected areas. Solar electric, or photovoltaic (PV), systems convert sunlight directly into electricity. They can power an electrical appliance directly or store energy in a battery. In areas with no utility lines, PV systems are often cheaper and require less maintenance than diesel generators, wind turbines, or batteries alone. This is different from hydropower, for instance, where a minimum size is required and there are expansionary limits based on the size of the river and the capacity of the turbine. Another advantage of PV panels is that most of them have proven to be reliable, durable, require low maintenance, and last up to 30 years. The main problems with PV panels are the high capital cost (as well as installation cost), the need of a battery, which has to be replaced every four to five years thus increasing operating costs, and the fact that they cannot be produced locally and that spares are expensive [1], [3-5].

PV is best suited for remote site applications that have small to moderate power requirements, or small power consuming applications even where the grid is in existence. Some common PV applications in rural areas are as follows:

Water Pumping: Photovoltaic (PV) water pumping systems may be the most cost effective water pumping option in locations where there is no existing power line. PV powered pumping systems are excellent for small to medium scale pumping needs (e.g., livestock tanks) and rarely exceed applications requiring more than a 2 hp motor. PV pumping systems main advantages are that no fuel is required and little maintenance is needed. PV power systems run pumps directly when the sun is shining, so they work hardest in the hot summer months when they are needed most [2].

PV powered water pumping system is similar to any other pumping system, only the power source is solar energy; PV pumping systems have, as a minimum, a PV array, a motor, and a pump. Generally, batteries are not necessary because the water is stored in tanks or pumped to fields and used in the daytime. Larger pumping systems may include batteries, inverters, and tracking mounts to follow the sun.

When properly sized and installed, PV water pumps are very reliable and require little maintenance. The size and cost of a PV water pumping system depends on the quality of solar energy available at the site, the pumping depth, the water demand, and system purchase and installation costs.

Commercial Lighting: PV powered lighting systems are reliable and a low cost alternative widely used. Even when utility power is available nearby, using PV to charge batteries for lighting may be the cheapest option for outbuildings. The cost of a transformer and running wires to where the light is needed can add up. A simple PV system can operate low- or high-pressure sodium lights, as well as fluorescent and incandescent bulbs. Security, billboard sign, area, and outdoor lighting are all viable applications for PV [3].

Small motors: Electric motors with small power needs can be very handy in remote areas or in places where running an electrical line is a problem. PV-powered automatic gate openers use a 14” by 13” PV panel to charge the battery. PV is also used to run aeration fans in grain storage bins and to power automatic supplement feeders.

Ventilation: Certain agriculture enterprises such as chicken and turkey farms must have constant ventilation during the hot summer months. The body heat from thousands of birds in close proximity to each other can quickly kill them if electricity is lost. Since it operates when the sun makes the air the warmest, PV can be an ideal power source in this instance. It has extremely high value, since one episode of grid power loss, where the PV takes over and saves the birds, could pay for a large part of the system immediately. Since animal losses will be avoided, insurance companies may be willing to reduce premiums, thereby helping to pay for the system. PV powered ventilation can also help relieve peak power requirements on the grid, and makes use of direct current (DC) motors rather than conversion to alternating current (AC) which requires a costly inverter [1].

4. Wind Energy

India has been rated as one of the most promising countries for wind power development, with an estimated potential of 16,078 MW as on 31st March, 2011. Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical energy. When solar radiation enters the earth's atmosphere, different regions of the atmosphere are heated to different degrees because of earth curvature. This heating is higher at the equator and lowest at the poles. Since air tends to flow from warmer to cooler regions, this causes what we call winds, and it is these airflows that are harnessed in windmills and wind turbines to produce power [4].

One of the main advantages of wind turbine generators is that they can be used for both, a household system, or an integrated grid. In the same way as PV panels, the more windmills are installed, the more energy is generated. One of the problems with wind, however, is its intermittence, and thus they are not as reliable as other sources. Using wind for electricity might also be too expensive due to the high replacement costs of batteries. However, for other applications like mechanical energy for water pumping, wind can be extremely beneficial. One final advantage of wind power is that the larger part of the structure can be locally produced, with laminated wood, plastics and welded or galvanized steel for the tower, and thus communities would only have to import the generator and gearbox [3].

5. Small Hydropower

Small hydropower plants are generally of small capacities, of about 5kW to 100kW. They consists of a small channel that takes the water from a small river or creek to a settling basin and then to a forebay tank. At the forebay tank water is stored at a higher altitude so that it gets potential energy. The water is then fed into a tube or penstock that brings the water down to a power house in the form of mechanical power. This mechanical power can be used to run a turbine to generate electricity. Small Hydro Power is a reliable, mature and proven technology. It is non-polluting, and does not involve setting up of large dams or problems of deforestation, submergence and rehabilitation. Its main disadvantage is the high capital cost, as similar to other renewable energy sources. Small hydropower plants are particularly good for micro-grids, but they can also be used for mechanical power [2], [4], [5].

6. Conclusion

Based on cost considerations alone, grid extension is the most cost-effective system of supply for rural electrification. However, in cases where grid extension is not viable due to long distances or low returns, then renewable energy resources could be practical alternatives. Renewable energy sources offer an attractive alternative to the traditional rural supply sources because they are available in abundance in the rural areas, their implementation utilizes local human and material resources, and they are environmentally friendly. Renewable energy based supplies can also be configured to meet demands of scattered, remote and isolated loads, giving consumers complete ownership and control over the supplies.

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