

Optimum Utilization of Solar Energy in Domestic Sector in India

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Abstract: India is endowed with abundance of solar radiation. The country receives solar radiation equivalent to more than 5, 000 trillion kWh/year, which is far more than its total annual energy requirement. The radiation available could be utilized for thermal as well as for photovoltaic applications. Solar thermal technologies have already found ready acceptance in a variety of decentralized applications in domestic, industrial and commercial sectors of the country. The most widely acceptable application is the solar water heating technology. However, solar steam generating and air heating technologies and energy efficient solar buildings are also attracting attention in urban and industrial areas. Among solar photovoltaic technologies, there are several important devices such as solar lanterns, solar home systems, solar street lights, solar pumps, solar power packs and roof top SPV systems. They could be useful both in rural and urban areas for the purpose of reducing the burden on conventional fuels. As the dependence on conventional fuels is decreased, the environmental pollution will go down. Significant among renewable energy sources is solar energy which is fortunately all pervasive, readily available almost throughout the year in India and non-depleting. In this study, primary focus has been given to optimum utilization of solar energy in domestic sector in such activities as cooking, lighting, water and air heating, drying, etc. Increased use of solar energy will also have health benefits; in particular women will be saved from drudgery and ailments.

Key words: Optimum utilization, solar energy, domestic sector, conventional fuels, pollution, environment,

1 Introduction

Energy is an essential requirement for human life. Energy can best be described as one of the major components for building a modern society. Apart from energy, a clean and healthy environment is also necessary. All the basic components in our environment are continuously recycled. The primary input in recycling processes is solar energy. The whole system of the cycles remains in a dynamic equilibrium and is sensitive to minor and major changes. Pollution can be defined as the presence of any unwanted material which leads to disturbance in the natural equilibrium.

gases whose presence in the environment pollutes the air. It also causes unrecoverable effects of global warming and other severe consequences. At present the share of energy in domestic sector in India is 24% [1]. To reduce the environmental pollution by green house gases it is strongly recommended to use alternative energy sources particularly in domestic sector. One of the most abundant renewable energy sources is solar energy which is never exhausted, readily available and produces no emission. In present scenario electric power has become a basic need of human life same as the need of air, water and food.

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Such disturbances are created by the excess of any one kind of activity and leaves irreversible changes in the environment. For example excess use of fossil fuel generates green house

We cannot think of a future without electrical power because all of our requirements from cooling to cleaning and transportation to industries depend solely on electric power. It is true that all the major advancement in human life coincide with rate of energy consumption increase. Therefore energy is required to raise the development of country in general and society in particular. About 68 percent of the

population in India, over 830 million, is still living in rural areas. They are trying to meet their energy requirements in a sustainable manner. But this continues to be a challenge for the country. One must gauge actual achievements in the context of conventional power capacity. It is quite likely that these will be higher than visualized [2]. To fulfill the energy requirement and to keep pollution free environment the share of renewable energy should be optimum. But the basic questions should be in mind before recommending the use of renewable energy.

- i. How much energy is available in the environment?
- ii. For what purpose can the harnessed renewable energy be used?
- iii. Is it economical in comparison to other sources?

2 The Power Scenario in India

The growth of national demand for electric power in India is likely to be around 10 % over the span of next 15 years. This would require about 30,000 MW of capacity addition every double by the year 2020 with reference to the present installed capacity of about 2, 55,700 MW. year over that period [3]. Demand is expected to It has been estimated that the present

power shortage results in an annual loss of production of about 2 % of the national income. In its May 2014 report, India's Central Electricity Authority anticipated, for 2014-15 fiscal year, a base load energy deficit and peaking shortage of 5.4% and 2% respectively. [4]. It is obvious that, fossil fuels will continue to be major energy sources, and will continue to play a critical role in the economy. India will be compelled to rely in large measure on vast coal reservoirs as a source of power generation. At the same time it will need to develop programs and policies that will reduce dependence on fossil fuels in order to achieve sustainable economic growth and environmental stability. The per capita energy consumption is extremely low in India as compared to that in developed countries. The average electricity consumption per capita in India is too low as compared to developed countries; it is just 970kWh per person per year. This is almost four times lower than China which is one notch higher on the list with 4,000 kWh. The world average is 2,782 kWh [5]. The electricity installed capacity in India from different sources is shown in Figure 1.

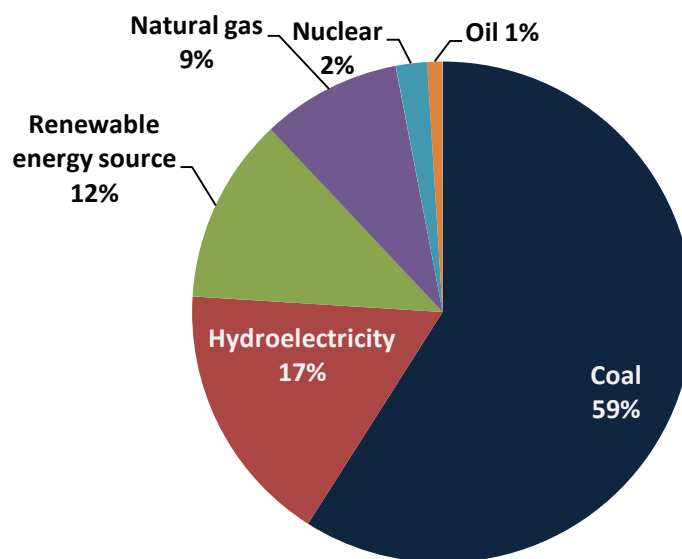


Figure1: Electricity installed capacity in India by source

3 Renewable Energy Scenario in India

Industrialization, urbanization, population growth, economic growth, improvement in per capita consumption of electricity, depletion of coal reserves, increasing import of coal, crude oil and other energy sources and the rising concern over climate change have put India in a critical position. It has to take a tough stance to strike a balance between economic development and environmental sustainability. One of the primary challenges for India would be to alter its existing energy mix (which is dominated by coal) to greater share of cleaner and sustainable sources of energy. India is blessed with an abundance of sunlight, water and biomass. Vigorous efforts during the past two decades are now bearing fruit as people in all walks of life are more aware of the benefits of renewable energy, especially decentralized energy which is required in villages and in urban or semi-urban centres. India has the world's largest programme for renewable energy. India has set a target of achieving overall renewable energy installed capacity of 41,400 MW by 2017 and 72,400 MW by 2022. To achieve this target, India will have to add 40,130.39 MW of renewable energy installed capacity. To achieve a target of 72,000 MW of installed capacity for renewable energy India will have to invest around US\$ 46.22 billion. Almost similar investment will be made in upgrading the transmission and distribution (T&D) infrastructure and renovating old renewable plants. NOVONOUS estimates that India will have to invest US\$ 83.35 billion in the renewable energy sector till 2022 [6]. According to the India Renewable Energy Status Report 2014 released at the ongoing Green Summit 2014 in Bangalore, the total renewable energy potential from various sources in India is

2,49,200 MW [7]. The total Renewable Energy Potential and Installed Capacity in India (as on 31 Dec 2014) is shown in Table1 [8].

Table 1: Total Renewable Energy Potential and Installed Capacity in India

Source	Potential (MW)	Installed capacity (MW)
Wind Power	102,700	22,465
Solar Power (PV)	100,000	3,062
Small Hydro Power	20,000	3,990
Biomass Power	17,500	1,365
Bagasse Cogeneration	5,000	2,800
Waste to Power	4,000	107
Total	2,49,200	33,789

4 Renewable Energy Sources

Following are the types of renewable energy sources so far in India:

1. Solar energy
2. Wind energy
3. Biomass
4. Biogas
5. Small hydro power

5 Role of Renewable Energy in India

Renewable energy sources are indigenous and contribute towards reduction in dependence on fossil fuels. Renewable energy also provides

national energy security at a time when decreasing global reserves of fossil fuels threatens the long-term sustainability of the Indian economy as well as global economy.

Renewable energy sources assume special significance in a developing country like India, when viewed in the context of the geographic diversity and size of the country. Since the RES are diffused and decentralized, they are appropriate as local energy sources, to meet the ever expanding and diversified energy needs.

In this perspective, there are numerous possibilities for meeting the basic energy needs particularly of the rural poor. Thus, the increased use of RES/technology is necessitated by the following:

- Inability of the conventional system to meet growing energy demand in an equitable and sustainable manner.
- Need to efficiently and economically utilize the energy needs of all citizens, particularly the rural poor.
- Large-scale impact of conventional energy production and consumption on the physical and human environment.

Renewable energy technologies enjoy the benefit of little or zero pollution during their operation. Our primary focus in the present study is solar energy. The basic solar energy programs are the following:

5.1 Solar Energy Program

Energy from sun has many features which makes its use versatile. First and the best features are its widespread distribution, pollution free nature and virtually inexhaustible supply. India receives solar energy equivalent to 5, 000 trillion kWh/year, which is far more than the total energy consumption of the country. The daily average solar energy incident varies from

4-7 kWh/sq. m. depending upon the location. There are 250-300 sunny days in most parts of the country. If 1 percent of the total land area available in country is used to generate electricity from this radiation at a net efficiency of 1 percent, it will produce around 3, 00,000 MW of power, which is sufficient to meet the country's energy demand [3].

5.2 Solar Thermal Energy Program

A solar thermal device receives and captures the thermal energy available in solar radiation. The energy thus obtained can be used to meet the requirements of energy in different temperature ranges. The heat is used directly or further converted into mechanical or electrical energy. Following are the three main temperature ranges considered for applying solar thermal energy:

- a. Low Grade thermal energy: This covers a range below 100 °C. The most common applications of this energy are water heating, air heating, drying and desalination.
- b. Medium grade thermal energy: It lies in the temperature range of 100 to 300 °C. Its major applications are cooking, steam generation for industrial use, refrigeration, water pumping and power generation.
- c. High grade thermal energy: Energy above temperature 300 °C fall under this category. Main application is in power generation.

Solar thermal energy is now finding ready acceptance for a variety of applications, and a fair degree of technical and commercial viability has been attained. About 4.47 million m² of collector area has so far been installed in the country ranging from domestic water heaters of 50-100 liters capacity in about 80,000 homes to industrial and commercial system of up to 2,40,000 liters of hot water per day. Bangalore has the largest deployment of rooftop solar water heaters in India. These heaters generate an

energy equivalent of 200 MW. Bangalore is also the first city in the country to put in place an incentive mechanism by providing a rebate of Rs. 50 on monthly electricity bills for residents using roof-top thermal systems. The Shri Sai Baba Sansthan Trust has world's largest solar steam system. It was constructed at the Shirdi shrine at an estimated cost of Rs.1.33 crore, Rs.58.4 lakh of which was paid as a subsidy by the renewable energy ministry. The system is used to cook 50,000 meals per day for pilgrims visiting the shrine, resulting in annual savings of 100,000 kg of cooking gas. It has been designed to generate steam for cooking even in the absence of electricity. It may also run the feed water pump for circulating water in the system [3].

6 Application of Solar Energy

India is in sunny belt of the world. Solar energy is available abundantly in India and can be utilized for both thermal and electrical application in domestic sector. The solar energy is mostly applicable in the following systems [7]:

6.1 Water Heating Systems

Solar water heating is an important area of application of solar energy. A solar water heater can be used in homes, hotels, hospitals and offices; it is usually a replacement of electric geyser. Wider use of solar heaters, therefore, not only saves substantial amount of electricity but also contributes significantly to reduction in peak load demand. It has been estimated that installation of 1000 solar water heaters (2000 sq. meter collector area) can contribute to peak load saving of 1 MW. Large solar water heating system used in hostels, hospitals, dairies contributes to substantial saving of electricity and commercial fuels and also results in environmental benefits. Delhi Govt. has made the use of solar water heating system mandatory

in any commercial building having an area of about 500 sq. meters. Thirty five solar water heater systems have been installed in schools and colleges of Delhi so far and fifty more will be installed this year. A typical solar water heating system is shown in Figure 2.



Figure 2: Solar water heating system

6.2 Solar Cooker

Solar cooker appears extremely suitable for our country especially in rural areas with multidimensional benefits. A solar cooker cooks food with the help of solar energy and can save a substantial amount of cooking fuel. It is mainly suitable for cooking through boiling. The cooking temperature is about 100 °C. The heat required for physical and chemical changes involved in cooking is small compared to the sensible heat of increasing food temperature and required for meeting heat losses that normally occur in cooking. On a clear sunny day an oven of size 50×50×10 cm³ takes 2-3 hours to cook lunch for a family of 5-7 members. A community type parabolic concentrating solar cooker developed by ULOG Group of

Switzerland is being promoted by an NGO in Gujarat and has met with moderate success. This cooker is designed to direct the solar heat to a secondary reflector inside the kitchen which focuses the heat to the bottom of a cooking pot. This cooker costs about of Rs. 50000 and it is also possible to fry, bake and roast food. More than 50 such cookers have been deployed under a project sponsored by Sardar Patel Renewable Energy Research Institute and Gujarat Energy Development Agency. Box type and parabolic solar cookers are shown in Figure 3.



Figure 3(a): Box type solar cooker



Figure 3 (b): Parabolic solar cookers

Advantages of solar cooker are the following:

- As solar cooker does not consume any conventional fuel, it saves fossil fuels, which are otherwise required to cook the food.
- It does not emit any smoke or smell and hence does not pollute the environment. There is thus no chance of causing illness.
- It does not require constant attention while cooking and hence saves time which can be utilized for some other productive work.
- As it is a slow cooking device, it preserves the nutritional value of food.
- It can be used for cooking three to four items at a time.
- There is no possibility of causing accidents like catching of fire, bursting of gas cylinder, electrical shock, etc. and hence is safe to handle.
- It does not have sophisticated components and hence is easy to operate.
- It keeps cooked food hot for four to five hours.
- It saves cost.

6.3 Solar Photovoltaic System

Solar energy may be utilized via photovoltaic route. It converts sun light in to electricity which can then be used for variety of purposes such as lightning, pumping, communication and refrigeration, without causing any pollution. Solar photovoltaic is a key program, particularly for decentralized applications in rural and remote areas. Photovoltaic is a simple, reliable and environmentally benign technology which is immediately available to provide electricity to widely dispersed households and farms. By the end of March 2013 the installed grid connected Photovoltaics had increased to 1686.44 MW, and India expects to install an additional 10,000 MW by 2017 and a total of 20,000 MW by

2022. In recent years, major market oriented programs have also been launched for popularization of solar water pumps and solar lantern. There are regions in which conventional grid electricity may not be easily provided as it involves long distribution lines. In such regions, solar energy can be easily be harnessed by using Solar Photovoltaics. A 40 MW photovoltaic system is installed in Dhirubhai Ambani Solar Park, Rajasthan and it is working since April 2012.

7 Impact of Renewable Energy

There is a visible impact of renewable energy in the Indian energy scenario over the last three decades. A part from contributing about 13.6% to national electricity generation installed capacity, renewable energy based applications have benefited millions of Indians in villages by meeting their needs of cooking and lighting, etc. The social and economic benefits include reduction in drudgery among rural women engaged in the collection of fuel wood from long distances and cooking in smoky kitchens. Risks of contracting lung and eye ailments, is minimized. There is an incentive of employment generation at village level and ultimately there is improvement in the standard of living.

8 Renewable Energy Development in India

8.1 General Background

India has a huge population and its economy growing fast. Its energy industry is facing dual pressure at the moment, of economic development and environmental protection. Therefore, it will be of great significance to upgrade energy production by using clean and renewable energy resources, establishing a sustainable energy system for promoting the national economy and improving environment.

Renewable energy is characterized by low carbon and no carbon emissions, which creates

minimum environmental pollution. It is not only the foundation of further energy systems, but also a necessary supplement to existing supply. By using renewable energy sources we can improve people's living standards (especially in remote and rural areas) as well as improve the environment. Indian government has paid continuous attention and given priority to the development and utilization of renewable energy in the following ways;

- Firstly, Govt. of India has emphasized the importance of the development and utilization of renewable energy from the past two decades.
- Secondly, India has already adapted the strategy of sustainable development in which renewable energy development is one of the important points.
- Thirdly, the development program of renewable energy has been formulated to carry out and promote the national renewable energy development plan in 1992.
- Fourthly, application of renewable energy has been recognized as an important component of energy development strategy in India.

8.2 Policy, Planning and Coordination for Renewable Energy

Ministry of New and Renewable Energy (MNRE) is a ministry of Government of India. The ministry was established as the Ministry of Non-Conventional Energy Sources in 1992. It adopted its current name in October 2006. The Ministry is mainly responsible for research and development, intellectual property protection, and international cooperation, promotion, and coordination in renewable energy sources such as wind power, small hydro, biogas, and solar power. The broad aim of the Ministry is to develop and deploy new and renewable energy

for supplementing the energy requirements of India.

8.3 Renewable Energy Policy

The MNRE is in process of preparing a comprehensive Renewable energy policy and supporting legislation. The main objective of the policy includes – Augmentation of grid electricity supply, Energy for rural development, substitutes of fossil fuels for decentralized applications. The policy is also addressing issues related to institutional arrangements, financial resource mobilization, promotion of industry

and human resources development necessary for large scale utilization of solar energy in the country.

Planning and coordination division is focal point for planning and executing all activities of the Ministry. The planning division of the Ministry prepares annual and five year plans for properly managing all the activities in a scheduled and stepwise manner.

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8.4 Renewable Energy Generation

Table 2 shows the energy Generation/saving and number of projects from new and renewable energy sources during 9th, 10th and 11th five year plan [8-11].

S.NO.	SOURCE	9 th PLAN	10 th PLAN	11 th PLAN	TOTAL
1.	Power from Biomass	368 MW	750 MW	1546 MW	2664 MW
2	Power from Wind	1667 MW	4415 MW	6074 MW	12156 MW
3	Power from Solar	500 MW	700 MW	500 MW	1700 MW
4	Power from Small Hydro	600 MW	520 MW	1371 MW	2491 MW
5	Improved Chullhas (Nos.)	55 Million	78 Million	70 Million	203 Million
6	Biogas Plants* (Nos.)	0.7 Million	0.16 Million	0.18 Million	0.41 Million
7	Energy Plantation** (ha)	1.5 Million	4.6 Million	3.0 Million	9.1 Million
8	Sewage Sludge	30 MW	40 MW	55 MW	125 MW
9	Solar Thermal Systems	12 MTCR [#]	15 MTCR	18 MTCR	45 MTCR
10	Photovoltaic Pumps	9 MW	13 MW	12 MW	34 MW

11	Wind Pumps	30 MW	45 MW	40 MW	115 MW
12	Small battery chargers and stand alone systems	6 MW	15 MW	14 MW	35 MW
13	Energy from distillery	86 MW	126 MW	150 MW	362 MW
14	Energy from solid waste	96 MW	70 MW	120 MW	286 MW
	TOTAL	3392 MW	6694 MW	9984 MW	19970 MW

* 4 m³ average size.

** 2.5 million hectare with average 20 Tons/ha

Million Tons of coal replacement

9 Conclusion

Our requirement of energy is increasing day by day along with population it is possible to reduce the energy consumption, the only thing possible is to increase the energy efficiency. Increasing energy efficiency requires action on two fronts: rationalizing energy prices to incentivize energy efficiency and taking non-price initiatives to push the economy towards greater energy efficiency. To achieve the goal of “Energy for All”, if the required energy is generated from fossil fuels the level of green house gases and other pollutants will rise very high. To keep the environment pollution free and to fulfill the energy demands the use of renewable resources is a better choice. Continued emphasis has to be placed on renewable resources, especially on expanding the emerging area of solar thermal and solar photovoltaic. While a National Solar Mission plans for a capacity of 22,000 MW by 2022, C-WET estimated a technically feasible wind potential of 49,000 MW. These areas will need further study. The potential for such generation is clearly higher than current estimates of about 50 GW. Government is also promoting the use of solar utilities by providing heavy subsidy on the cost of various solar appliances for rural as well as urban areas. Finally one may say that promotion of renewable resources of energy particularly solar energy leads to cleaner and greener environment is highly beneficial, health

benefits (particularly for women) and reduction in conventional fuel as well as fossil fuel dependence.

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