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PROSPECTS OF SOLAR ENERGY IN NORTH EASTERN REGION OF INDIA

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ABSTRACT

Solar energy plays a vital role in economic development of a country. Energy is regarded as a prime element in the generation of wealth and a significant factor in economic development of a country. Economic use of energy resources like solar, wind etc. can be the prime factor in development. Limited fossil resources and environmental problems associated with them have emphasized the need for new sustainable energy supply options that use renewable energies. Solar thermal power generation systems, also known as Solar Thermal Electricity (STE) generating systems are emerging as renewable energy technologies and can be developed as viable option for electricity generation in future.

With recent developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. Solar energy could be made financially viable with government tax incentives and rebates. Most of the developed countries are switching over to solar energy as one of the prime renewable energy source. The current architectural designs make provision for photovoltaic cells and necessary circuitry while making building plans. The National Solar Mission is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge. This paper discusses the technology options, their current status and opportunities and challenges in developing solar thermal power plants in the context of India. Addition to that it includes the feasibility analysis of hybrid system in Guwahati.

I. INTRODUCTION

In recent years availability of power in India has increased and improved but demand has consistently outstripped supply and substantial energy and peak shortages prevailed in 2009-10. In order to meet the deficit between demand and supply, 25000 MW to 35000 MW of power is being produced by diesel generation system. In the past, the selection of an energy resource for electricity generation was dominated by finding the least expensive power generating plant. Although such an approach is essential, there is growing concern about other aspects of power generation such as social, environmental and technological benefits and consequences of the energy source selection.

1.1 Solar thermal power generation technologies

Solar Thermal Power systems use concentrated solar radiation as a high temperature energy source to produce electricity using thermal route. Since the average operating temperature of stationary non-concentrating collectors is low (max up to 120^0C) as compared to the desirable input temperatures of heat engines (above 300^0C), the concentrating collectors are used for such applications. These technologies are appropriate for

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applications where direct solar radiation is high. In the basic process of conversion of solar into heat energy, an incident solar irradiance is collected and concentrated by concentrating solar collectors or mirrors, and generated heat is used to heat the thermic fluids such as heat transfer oils, air or water/steam, depending on the plant design. This acts as heat carrier and as storage media. The hot thermic fluid is used to generate steam or hot gases, which are then used to operate a heat engine. In these systems, the efficiency of the collector reduces marginally with increasing operating temperature, whereas the efficiency of the heat engine increases with the increase in its operating temperature [1]

II. SCENARIO OF ELECTRICITY GENERATION

From the scenario of world electricity generation, it is clear that thermal generation plays huge role in production as compared to other, that is, renewable sources. Other sources include solar, wind, geothermal, combustible renewable and waste and heat.

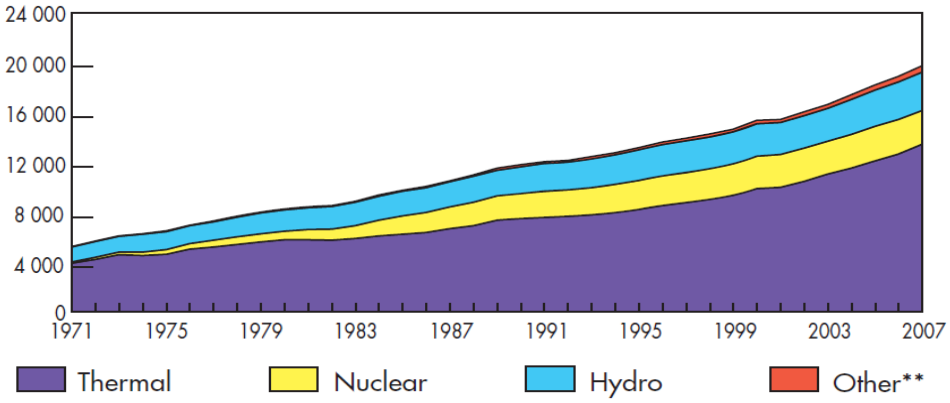

Fig1: World electricity generation by fuel (TWh)[4]

In order to improve power generation capacity economically and environmentally, new renewable power plants have to be implemented reducing the dependence on coal, gas and oil. In 2007, the usage of gas and coal is increased as compared to the use in 1973. On the other hand use of oil decreased by a sizable amount during the above mentioned period. Oil usage is reduced from 24.5% in 1973 to 5.6% in 2007. [2]

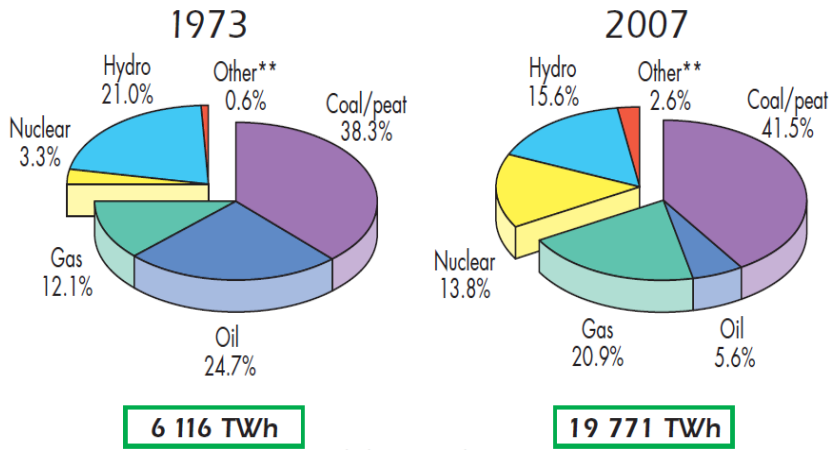

Fig 2: Fuel shares of electricity generation[4]

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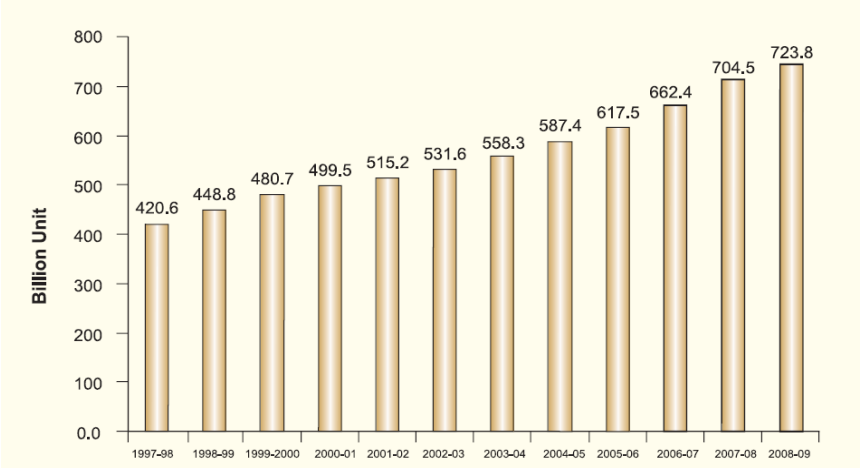

Fig3: Power generation of India

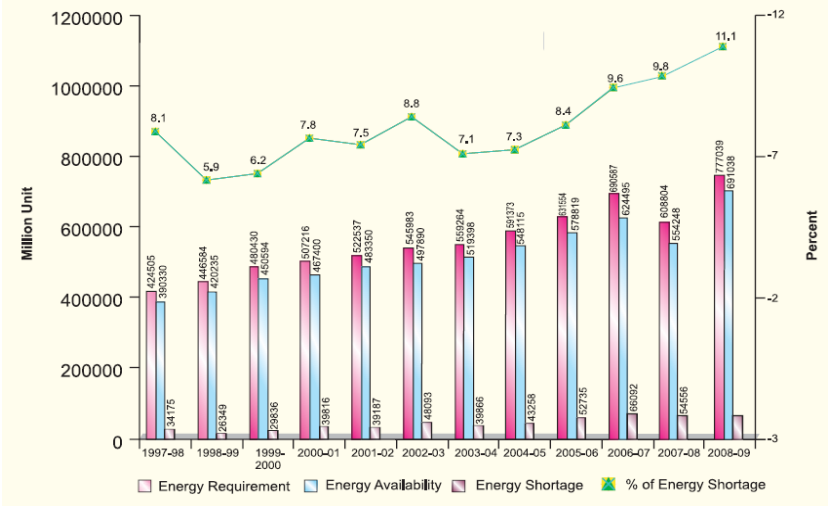

Fig4: Power supply positions energy

The most useful way of harnessing solar energy is by directly converting it into electricity by means of solar photo-voltaic cells. The photo-voltaic effect is defined as the generation of an electromotive force as a result of the absorption of ionising radiation. [3].

2.1. The Energy Scenario

The comparison of India with other regions of the world with regard to Total Primary Energy Supply which has been normalized with respect to GDP and population for the year 2008 is shown in the table 1. It can be seen that per capita consumption of energy in India is one of the lowest in the world. India consumed 540 kgoe in 2008 compared to 1803 kgoe by the world, 4560 kgoe by OECD countries, 1600 kgoe by China.

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Countries/ Regions	Population (millions)	GDP Per Capita (PPP) 2000USD	TPES Per Capita (kgoe)	TPES/GDP (kgoe-2000USD)	Elec. Cons/capita (kwh)	Kwh/ $-2000 PPP
World	6688	9549	1803	0.19	2782	0.29
OECD	1190	27620	4560	0.17	8486	0.31
Middle East	199	8191	2990	0.37	3384	0.41
Former USSR	285	8996	3650	0.41	4660	0.52
Non OECD Europe	53	10471	2010	0.19	3378	0.32
China	1333	8311	1600	0.19	2471	0.30
Asia***	2183	4013	650	0.16	719	0.18
Latin America	462	8522	1240	0.15	1956	0.23
Africa	984	2540	670	0.26	571	0.22
India	1139.97	3781	540	0.14	566	0.15

(Source: 2010 Key World Energy Statistics: IEA)

*** Asia excludes China but includes India

Table 1: World scenario

The electricity consumption per capita for India is just 566 KWh and is far below most other countries or regions in the world. Even though 85% of villages are considered electrified, around 57% of the rural households and 12% of urban households, i.e. 84 million households in the country, do not have access to electricity. Electricity consumption in India is expected to rise to around 2280 BkWh by 2021-22 and around 4500 BkWh by 2031-32 [5].

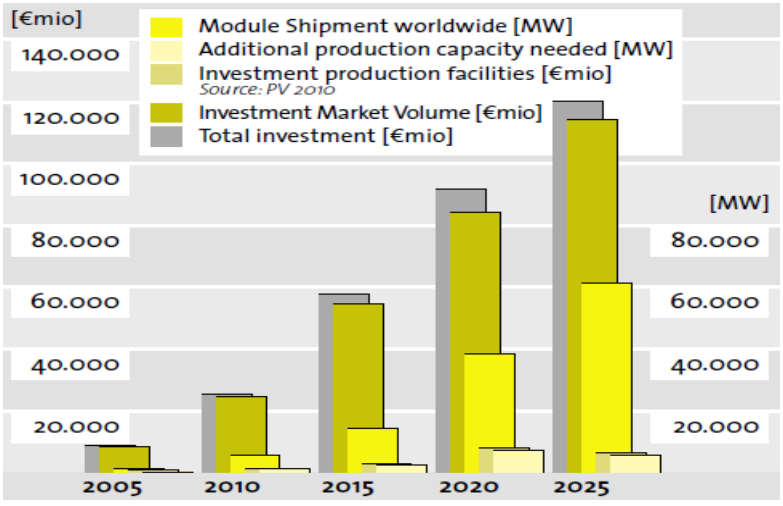

Fig5: Global Investment in new PV production facilities. [2]

From Fig5 it will be predicted that in the near future solar is the prime source for power extraction. Along with power production it also improves the environment by reducing CO gas emission which is forecasted in Fig 6. In environmental terms, it would have reduced annual CO_2 emission by 353 million tonnes. This reduction is equivalent to the emissions from 150 coal fired power plants.

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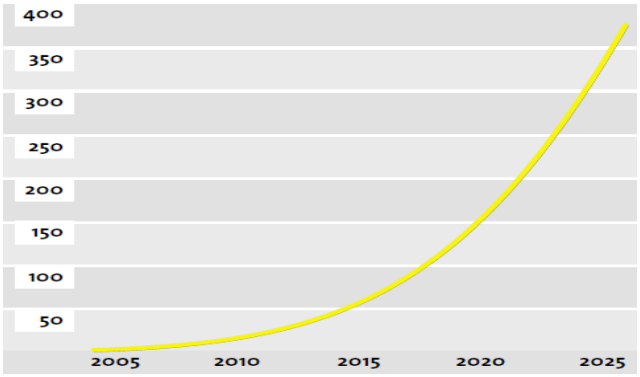

Fig6: Annual Global CO_2 savings in millions of tonnes. [2]

2.2. Solar energy scenario in India

The installed capacity and respected estimated generation of different existing renewable sources in the year 2013 are tabulated in Fig A. As discussed earlier, it is observed that the use of solar power is not notable as compared to wind and biomass.

	Installed Capacity (MW)	Estimated Capacity Factor	Estimated Generation (GWh)
Wind	18635	14%	22854
Biomass	1264	70%	7751
Bagasse Cogeneration	2301	60%	12094
Small Hydro	3552	40%	12446
Waste to Energy	96	50%	420
Solar PV	1447	20%	2535
Total	27295	25%	58101

Table 2: Renewable Scenario in India [6]

2.2.1. Solar thermal power generation program of India

Different programs have been installed and operated in India taking solar power as major source. Some of them are listed below.

(1) In India the first Solar Thermal Power Plant of 50kW capacity has been installed by MNES following the parabolic trough collector technology (line focussing) at Gwalpahari, Gurgaon, which was commissioned in 1989 and operated till 1990, after which the plant was shut down due to lack of spares. The plant is being revived with development of components such as mirrors, tracking system etc.

(2) A Solar Thermal Power Plant of 140MW at Mathania in Rajasthan has been proposed and sanctioned by the Government in Rajasthan. The project configuration of 140MW Integrated Solar Combined Cycle Power Plant involves a 35MW solar power generating system and a 105MW conventional power component and the GEF has approved a grant of US$ 40 million for the project. The Government of Germany has agreed to provide a soft loan of DM 116.8 million and a commercial loan of DM 133.2 million for the project.

(3) In addition a commercial power plant based on Solar Chimney technology was also studied in North-Western part of Rajasthan. The project was to be implemented in five stages. In the 1st stage the power output

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shall be 1.75MW, which shall be enhanced to 35MW, 70MW, 126.3MW and 200MW in subsequent stages. The height of the solar chimney, which would initially be 300m, shall be increased gradually to 1000m. Cost of electricity through this plant is expected to be Rs. 2.25 / kWh. However, due to security and other reasons the project was dropped.

(4) BHEL limited, an Indian company in power equipments manufacturing, had built a solar dish based power plant in 1990's as a part of research and development program of then the Ministry of Non-conventional Energy Sources. The project was partly funded by the US Government. Six dishes were used in this plant.

III. GROWTH OF SOLAR POWER IN INDIA

Solar energy plays an important role in developing economic growth of India. Recently, Ex-Prime Minister Manmohan Singh acknowledge that solar energy will transform rural India as it is used in an increasing trends and also launched a National Solar Mission in 2010. In 2009, the solar power generation is 12 MW and within two years it is increased to 190 MW in 2011. By March 2013, it is expected to grow fivefold to 1,000 MW, but the country has a long way to go to reach its goal of increasing solar-power generation to 20 gigawatts by 2020. Across India, there are still thousands of villages with plenty of sun but not enough power [7].

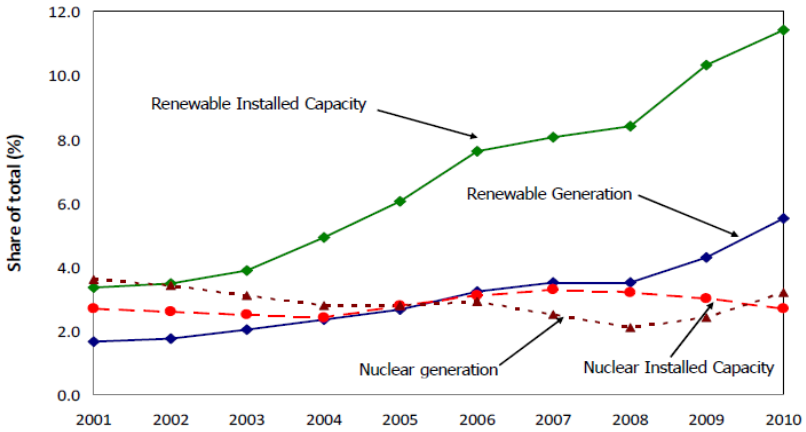

Fig7: Renewable share in power in India

Among the various renewable energy resources, India possesses a very large solar energy potential; most parts of the country are blessed with good amounts of sunshine. There are about 300 clear sunny days in a year in most parts of country. The average solar radiation incident over India varies from 4 kWh/day to 7 kWh/day. The solar radiation received over the Indian land area is estimated to be about 5,000 trillion kWh/year. In June, 2008, a National Action Plan on Climate Change was announced, which included eight major national missions with the one on solar energy being the centre piece. This mission envisages a major step up in the utilization of solar energy for power generation and other purposes. The Jawaharlal Nehru National Solar Mission (JNNSM) was launched by the Prime Minister of India in January 2010, with a target of 20,000 MW grid solar power (based on solar thermal power generating systems and solar photovoltaic (SPV) technologies), 2000 MW of Offgrid capacity including 20 million solar lighting systems and 20 million sq.m. solar thermal collector area by 2022. The Mission will be implemented in three phases. The first phase will be of three years (up to March, 2013), the second up to March 2017 and the third phase will continue until March, 2022.

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IV. BARRIERS FOR SOLAR POWER

Solar thermal power plants need detailed feasibility study and technology identification along with proper solar radiation resource assessment are the prime factors which decides the feasibilility of the plant. The current status of international technology and its availability and financial and commercial feasibility in the context of India is not clear. The delays in finalizing technology for Mathania plant have created a negative impression about the technology.

V. FEASIBILITY OF HYBRID SYSTEM IN NORTH EAST REGION

The normal incident solar radiation output on north east is in the range between 5-7 KW/hour/day. This intensity of solar radiation is enough for the production of solar power by using photovoltaic array. But the combined effect solar and wind power will not be able to play a vital rule in case of north east region. A practical approach has been taken to analyse the feasibility of this system in Guwahati.

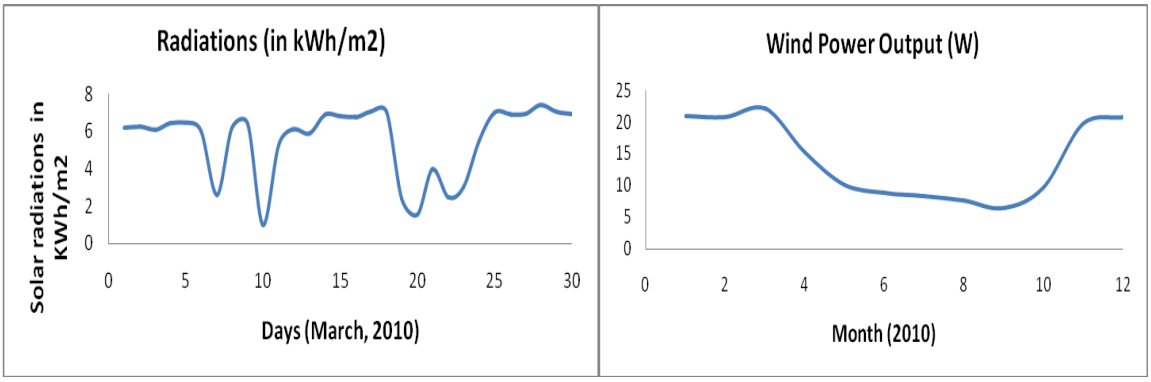

Fig8: Solar and Wind power output in Guwahati.

In the month of April 2010, the field study was performed and the findings are-

(i) Maximum solar power at irradiance is 13.13 W (for 1 hour) with open circuit voltage 22.12 volt.

(ii) Maximum wind power generation is 28.33 W (for 1 hour) with average wind speed 3 m/sec.

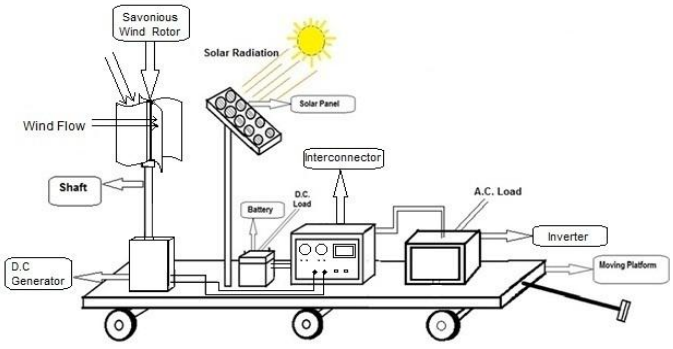

Fig9: Practical hybrid model developed for analysis

This study will conclude that although it is possible to obtain solar output in northeast region but due to insufficient wind speed in Guwahati, wind power is not a viable option. But utilizing hybrid model in hilly areas of Northeast and in riversides like Brahmaputra Barak where wind speed is maximum, power production is

possible, and if any organization is keen in adopting such power generation scheme then our model will prove to be a very efficient means of power generation.

VI. CONCLUSION

Potential use of solar plants should be increased for further economic development of the country especially in a country like India. Three major factors, resource assessment, technological appropriateness and economic feasibility are the basic requirements of project evaluation. In India, the solar radiation is available sufficiently over the country. Extraction of solar power should be increased in all respect which will reduce the dependence on non renewable sources. In long term, it will also reduce amount of CO_2 emission to the environment. Efficient use of hybrid systems in remote places will improve the economic stability of the nation. The solar tower power and point focusing dish type plants are being popular worldwide. In the pulp and paper industry, the moderate temperature is required for processing and solar energy can effectively generate this amount of heat. From this investigation, it is clear that efficient use of solar power in industrial activities will help in making India a 'Solar Power Nation'.

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