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SOLAR ENGERGY IN INDIA: STRATEGIES, POLICIES AND FUTURE POTENTIAL

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ABSTRACT

Renewable Energy Sources and technologies have potential to provide solutions to the Longstanding Energy Problems being faced by the developing countries like India. Solar Energy can be an Important Part of India's plan not only to add new capacity but also to Increase energy security. Address environmental concerns and lead the massive market for renewable Energy. Solar thermal electricity (STE) also known as concentrating solar power (CSP) are Emerging Renewable Energy technologies and can be developed as future potential option. for electricity Generation in India.

In this paper, efforts have been made to summarize the availability, current status, strategies, Promotion policies major achievements and future Potential of Solar energy option in India.

KEYWORDS: *concentrating solar power (CSP) , Solar thermal electricity (STE).*

1. INTRODUCTION

Power sector is one of the key sectors contributing significantly to the growth of country's economy. Power sector needs a more useful role to be played in defining, formulating and implementing the research projects with close involvement of all utilities such that the benefit reaches the ultimate consumer [1]. During the nineties decade, many electric utilities throughout the world have forced to change their way of operation and business, from vertically integrated mechanism to open market system. The increase in energy consumption, particularly in the past several decades, has raised fears of exhausting the globes reserves of petroleum and other resources in the future. The huge consumption of fossil fuels has caused visible damage to the environment in various forms.

Every year human activity dumps roughly 8 billion metric tonnes of carbon into the atmosphere, 6.5 billion tonnes from fossil fuels and 1.5 billion from deforestation [2]. India also has followed the global change in power sector by establishment of the Regulatory Commissions in 1998 under the Electricity Regulatory Commissions Act 1998 (Central Law) to promote competition, efficiency and economy in the activities of the electricity industry and applied restructuring to Orissa state electricity board firstly and after that to many other states [3].

India's need to increase energy provision for its population and fast growing economy poses a formidable challenge which is perceived as both a great opportunity as well as a necessity for the country to increase the share of renewables in the overall energy mix. At present India is sixth largest country in the world in electricity generation, having aggregate capacity of 177 GWs out of which 65% is from thermal, 21% from hydro, 3% from nuclear and the rest about 11% is from renewable energy sources [4]. Although Over

the years, Indian power sector has experienced a five-time increased in its installed capacity—a jump from 30,000 MW in 1981 to over 176,990.40 MW [4] by 30 June 2011 but still there is a huge gap in generation and demand in India hence need to be establish more generation plants preferably to be come from renewable sources by governmental as well as various private participation.

Electricity generation from renewable is assuming increasing importance in the context of large negative environmental externalities caused by electricity generation from fossil fuels based energy. Managing environmental and its social impacts have been drawing considerable attention in policy-making, project development, and operations [5]. There is increasing environmental concern about the contribution of coal-fired power generation to air emissions, mainly due to the poor quality of Indian coal with an average ash content of 40% or high ash content. Indian coal based generation also coupled with low conversion efficiencies. The 33% of coal based plants generates large amounts of ash with other environmental harmful emission of gases such as carbon dioxide (CO2), sulphur dioxide (SO2), and nitrogen oxides (NOx). The future economic development trajectory is likely to result in rapid and accelerated growth in energy demand and the growing energy consumption from conventional sources of energy is likely to leads increasing emissions of gases, compounding the pollution problems and increasing Green House Gas (GHG) emissions [7].

Development of renewable energy sources, which are indigenous and distributed and have low marginal costs of generation, can increase energy security by diversifying supply, reducing import dependence, and mitigating fuel price volatility. Accelerating the use of renewable energy is also indispensable if India is to meet its commitments to reduce its carbon intensity. The power sector contributes nearly half of the country's carbon emissions.

At the same time there is a need to provide energy access to rural areas and reduce import dependence on fossil fuels. India's approach is to meet its energy needs in a responsible, sustainable and eco-friendly manner.

The solar photovoltaic is a very important power source for meeting rural electricity demand in this region of the country. Thermal energy is required to fulfill several purposes in the domestic, agricultural, industrial, and commercial sectors of the economy.

India is growing towards huge solar energy day by day. As of June 2011, solar power in India had reached a cumulative generation capacity of approximately 39.6 MW. This is approximately 0.002% of JNNSM's 2022 target of 22 GW [5]. While this will be implemented in three stages, the first stage would involve setting up 1100 MW of grid solar power and 200 MW capacities of off-grid solar applications utilizing both solar thermal and photovoltaic technologies, by March 2013 [14].

2. SOLAR THERMAL POWER PLANTS

Solar thermal power plants (STE) produce electricity in much the same way as conventional power stations. STE to generate bulk electricity is one of the technologies best suited to helping to mitigate climate change in an affordable way, as well as reducing the consumption of fossil fuels and its produce electric power by converting the sun's energy into high temperature heat using various mirror or lens configurations [11]. STE plants are considered to have a minimum life of 20 years. According to some estimates, India can have a STE installed base of 4–5 GW by 2020. A large amount of Indian STE output is consumed in Delhi, Haryana, and Punjab, drawing upon supply sites in both Rajasthan and Jammu and Kashmir.

Population centers in Gujarat are also well positioned to extract power from Rajasthan [12].

4. SOLAR ENERGY STATUS AND CURRENT SCENARIO IN INDIA

Solar energy is the energy derived from the sun through the form of radiation. India is endowed with rich solar energy resource. The average intensity of solar radiation received on India is 200 MW/km square (megawatt per kilometer square) with 250–300 sunny days in a year. Solar is an important, although currently underutilized, energy resource in India with the potential to offer an improved power supply (especially in remote areas) and increase the security of India's energy supply. Solar energy intensity varies

geographically with Western Rajasthan receiving the highest annual radiation energy and the north-eastern regions receiving the least. India has a good level of solar radiation, receiving the solar energy equivalent of more than 5000 trillion kWh/year. Depending on the location, the daily incidence ranges from 4 to 7 kWh/m2, with the hours of sunshine ranging from 2300 to 3200 per year.

The annual global radiation varies from 1600 to 2200 kWh/m2, which is comparable with radiation received in the tropical and sub-tropical regions. The equivalent energy potential is about 6000 million GWh of energy per year. Solar radiation levels in different parts of the country are given in Fig. 2. It can be observed that although the highest annual global radiation is received in Rajasthan, northern Gujarat and parts of Ladakh region, the parts of Andhra Pradesh, Maharashtra, and Madhya Pradesh also receive fairly large amount of radiation as compared to many parts of the world especially Japan, Europe and the US where development and deployment of solar technologies is maximum [8]. India's installed solar power capacity of 39.6 MW at the end of June 2010 was based entirely on PV technology with approximately 20% of the capacity being used for off-grid applications [5]. Development of alternate energy has been part of India's strategy for expanding energy supply and meeting decentralized energy needs of the rural sector. The strategy is administered through India's Ministry of New Renewable Energy (MNRE), Energy development agencies in the various States and the Indian Renewable Energy Development Agency Limited (IREDA) [9]. These strategies is being achieved through research and devolvement, demonstration projects, government subsidy programs, and also private sector projects and to promote the maximum utilization of all forms of solar power as well as to increase the share of renewable energy in the Indian market.

7. GOVERNMENT INITIATIVES TO PROMOTE SOLAR ENERGY IN INDIA

There are several electricity policies in the last few years have talked about the need and priority to promote renewable energy. Foremost amongst them is the Electricity Act (2003) which delicensed stand-alone generation and distribution systems in rural areas [18,19]. The National Rural Electrification Policy, 2005 [20] and National Rural Electrification Policy, 2006 also stresses the need for urgent electrification [21]. The New Tariff Policy (2006) stated that a minimum percentage of energy, as specified by the Regulatory Commission, is to be purchased from such sources [22]. The details of directive released by Indian government to promote renewable energy are discussed in later sections.

7.1. Electricity Act 2003

In this act provides that cogeneration and generation of electricity from renewable sources would be promoted by the State Electricity Regulatory Commissions (SERCs) by providing suitable measures for connectivity with grid and sale of electricity to any person and also by specifying, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee. Such percentage for purchase of power from these sources should be made applicable for the promotional tariffs to be determined by the SERCs at the earliest.

Progressively the share of electricity from renewable energy sources would need to be increased as prescribed by SERCs. Such purchase by distribution companies shall be through competitive bidding process. Considering the fact that it will take some time before renewable technologies compete, in terms of cost, with conventional sources, the commission may determine an appropriate differential in prices to promote these technologies [18].

Moreover with advent of SERCs in various states with restructured power sector every state has set Renewable portfolio obligation (RPO/RPS) in their respective state. With such type RE policy and the corresponding regulatory environment provide a framework for the pricing signals and projected viability and sustainability of renewables. The sections of EA-2003 which emphasis for promotion of renewable in India are give below:

(a) Section 86 (1) (e)—"The State Commission shall discharge the following functions, namely: promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures

for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total Consumptionof electricity in the area of a distribution license".

(b) Section 61 (h)—"The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely: the promotion of cogeneration and generation of electricity from renewable sources of energy".

7.2. National Electricity Policy 2005

The National Electricity Policy 2005 stipulates that progressively the share of electricity from non-conventional sources would need to be increased; such purchase by distribution companies shall be through competitive bidding process; considering the fact that it will take some time before non-conventional technologies compete, in terms of cost, with conventional sources, the commission may determine an appropriate deferential in prices to promote these technologies [19].

7.3. National Tariff Policy 2006

As per the National Tariff Policy 2006 the State Electricity Regulatory Commissions (SCRC) to specify a Renewable energy Purchase Obligation (RPO/RPS) by distribution licensees in a time-bound manner. The Policy announced in January 2006 has the important provision for renewable promotion such as in pursuant to provisions of section 86 (**1**) (**e**) of the E' Act 2003, the Appropriate Commission shall fix a minimum percentage for purchase of energy from renewable sources taking into account availability of such resources in the region and its impact on retail tariffs. Such percentages for purchase of energy should be made applicable for the tariffs to be determined by the SERCs. It will take some time before nonconventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission. Such procurement by Distribution Licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the E' Act 2003 within suppliers offering energy from same type of non-conventional sources. In the long-term, these technologies would need to compete with other sources in terms of full costs of generation. The Central Commission should lay down guide lines with in three months of its establishment for pricing nonfarm power, especially from non-conventional sources, to be followed in cases where such procurement is not through competitive bidding [21,22].

7.4. National Rural Electrification Policies (NREP), 2006

The goals of NREP-2006, include provision of access to electricity to all households by the completion of year 2009, quality and reliable power supply at reasonable rates, and minimum lifeline consumption of one unit/household/day as a merit good by year 2012 [17]. For villages/habitations where grid connectivity would not be feasible or not cost effective, off-grid solutions based on stand-alone renewable based systems may be taken up for supply of electricity. Where these also are not feasible and if only alternative is to use isolated lighting technologies like solar photovoltaic, these may be adopted. However, such remote villages may not be designated as electrified. State governments have to be prepared and notify a rural electrification plan in their respective states, which should map and detail the electrification delivery mechanism. The plan may be linked to and integrated with district development plans. The plan should also be intimated to the appropriate commission.

Moreover, Gram Panchayat shall involve in it and issue the first certificate at the time of the village becoming eligible for declaration as electrified. Subsequently, the Gram Panchayat shall certify and confirm the electrified status of the village as on 31st March each year [23,24].

7.5. Initiatives to promote solar PV in India

The NREP-2006 policy aims at providing access to electricity to all households in the country and a minimum 'lifeline' level of consumption of 1 unit (kWh) per household per day. The policy also mentions that

off-grid solar PV solutions may be deployed where the supply of grid electricity is infeasible. The policy also mentions that off-grid solar PV solutions may be deployed where the supply of grid electricity is infeasible [25].

7.6. Semiconductor Policy (2007)

The Semiconductor Policy is meant to encourage semiconductor and ecosystem manufacturing, of which solar PV is also a component. It offers a capital subsidy of 20% for manufacturing plants in SEZs and 25% for manufacturing plants outside of Special Economic Zones (SEZs). The subsidy is however, based on the condition that the net present value (NPV) of the investment is at least US $212 mn (Rs. 10,000 mn at 1 US$ = Rs. 47) [25].

7.7. Solar PV generation based incentive

MNRE formed guidelines for generation based incentives for grid connected solar (both thermal and PV) plants in January 2008. The scheme was extended to all existing registered companies, Central and State power generation companies and public/private sector PV power project developers. The scheme promoted grid connected power plants in excess of 1 MW of capacity at a single location. The scheme was limited to 5 MW per developer across India and a maximum of 10 MW per state.

According to this scheme, MNRE offered to provide, through IREDA, a generation-based incentive of a maximum of Rs. 12/kWh to eligible projects, which are commissioned by December 31 2009, that project. Apart from the Central Government, several State Governments have also taken [5,17].

7.8. State level initiatives

The State Electricity Boards and respective agencies for renewable energy at the state level, play a key role in implementation at a state level. Independent of these national efforts, states are promoting solar power. Gujarat, for example, is promoting the installation of 350 MW solar PV by 2011. It offers a feed-in tariff of Rs. 15/kWh for the first 12 years and Rs. 5/kWh for the following 13 years [26].

Prevailing tariffs for solar power across Indian states are shown in Table 6.

7.9. Research & development (R&D) initiatives

For technology development, the R&D strategy would comprise five categories, viz.

- Basic research having a long term perspective for the development of innovative and new materials, processes and applications.
- Applied research aimed at improvement the existing processes, materials and the technology for enhanced performance, durability and cost competitiveness of thesystems/ devices.
- Technology validation and demonstration projects aimed at field evaluation of different configurations, including hybrids with conventional power systems for obtaining feedback on performance, operability and costs.
- Development of R&D infrastructure in private public partnership mode, and
- Support for incubation and start ups, a 3-tier R&D institutional framework, including high level research council, National Center of Excellence and a network of centers of excellence.

10. MAJOR ACHIEVEMENTS IN SOLAR SECTOR

India's major achievements on solar energy development can be summarized as follows:

- 3600 remote villages/hamlets, including those in Sunderbans, Bastar, Ladakh and the North East electrified through solar energy.
- Largest solar–steam cooking system for 15,000 persons/day set up at Tirupati Tirumala Devasthanam.
- 7 lakh m−2 collector area solar water heating systems installed.
- 30 MW capacity Solar Photovoltaic products exported to various developed and developing countries.
- Solar Energy Center set up for development of solar energy systems and devices at Gurgaon in Haryana.

- A new architecture has been designed for the 1000 MW projects.
- The tariff for current year for PV is Rs.17.91 per unit and Rs. 15.31 per unit for solar thermal power. NTPC Vidyut Vyapar Nigam (NVVN) has issued request for selection of new grid power projects of 620 MW capacities. About 450 applications to set up 5000 MW capacities have been received.

11. FUTURE OF SOLAR ENERGY IN INDIA

India, faced with twin challenges on energy and environmental front, has no option but to work towards increasing the role of renewable in the future energy systems. The objective of the JNNSM is to establish India as a global leader in Solar Energy, by creating the policy conditions for its diffusion across the country as quickly as possible.

- New project developers for 100 MW capacity of grid (below 33 kV) connected solar projects (of 100 kW to 2 MW capacities each) have also been selected. It is expected that 150–200 MW of solar power will be installed in the country by December 2011.
- To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.
- To ramp up capacity of grid-connected solar power generation to 1000 MW within three years by 2013; an additional 3000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff. This capacity can be more than doubled – reaching 10,000 MW installed power by 2017 or more, based on the enhanced and enabled international finance and technology transfer. The ambitious target for 2022 of 20,000 MW or more, will be dependent on the 'learning' of the first two phases, which if successful, could lead to conditions of grid-competitive solar power. The transition could be appropriately up scaled, based on availability of international finance and technology.
- To create favorable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
- To promote programs for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022.
- To achieve 15 million m2 solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022.
- JNNSM Mission has set a target of 1000 MW by 2017, reaching million households. To meet this target, the Mission plans to provide solar lighting systems to over 10,000 villages and hamlets and also to set up stand alone rural solar power plants in special category States and areas such as Lakshadweep, Andaman & Nicobar Islands and the Ladakh region of Jammu & Kashmir.
- The State Government of Andhra Pradesh is developing a solar farm cluster called solar city on a 10,000 acre land at Kadiri in Anantapur district. Solar city is expected to attract investments worth Rs. 3000 crore in the first phase. Four firms (Sun borne, Lance Solar, AES Solar and Titan Energy) have signed a memorandum of understanding with the State to set up their units there. These companies will be the anchor units in solar city and have a combined capacity of 2000 MW.
- Karnataka Power Corporation Ltd. has implemented two projects each of 3 MWp capacity and has awarded a third project of same capacity recently. The solar plants, located in Kola and Chickadee districts, have been implemented under the Arunodaya scheme for ensuring assured power supply to rural areas, especially irrigation pump sets. These PV power plants are intended as tail end support/powering of irrigation pumps.

13. CONCLUSIONS

India has a severe electricity shortage. It needs massive additions in capacity to meet the demand of its rapidly growing economy. Development of solar energy, which is indigenous and distributed and has low marginal cost of generation, can increase energy security by diversifying supply, reducing import dependence, and mitigating fuel price volatility. Solar energy development in India can also be an important tool for spurring regional economic development, particularly for many underdeveloped states, which have the greatest potential for developing solar power systems which is unlimited and clean source of energy. It

can provide secure electricity supply to foster domestic industrial development. So it can be concluded that photovoltaic power systems will have an important share in the electricity of the future not only in India, but all over world.

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