Commercialization of Solar Energy in India-Potential and Prospects

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Abstract. The present paper will investigate whether India should adopt a policy of developing and commercializing solar power since being a densely populated region in the sunny tropical belt, the subcontinent has the ideal combination of both high solar insulation and therefore a big potential consumer base density.

It will also be highlighted whether India can make renewable resources such as solar the backbone of its economy by 2050, reining in its long-term carbon emissions without compromising its economic growth potential.

India's energy sector has a mix of all the resources available including solar power. The dominance of coal in the energy sector is likely to continue in future. Other renewable such as wind, geothermal, solar and hydroelectricity represent a 2 percent share of the Indian fuel mix. Nuclear holds a one percent share. The total potential for renewable power generation in the country as on 31.03.12 is estimated at 89774 MW. This includes wind power potential of 49130 MW (54.73%), SHP (small-hydro power) potential of 15399 MW (17.15%), Biomass power potential of 17,538 MW (19.54%), 5000 MW (5.57%) from bagasse-based cogeneration in sugar mills and U&I [URBAN & INDUSTRIAL WASTE) & SOLAR – 114.74 MW. The installed capacity of solar power grid [in MW] as on 30.3.2012 in States/UTs reveals that Gujarat has the highest share of 604.89, followed by Rajasthan 197.65, Maharashtra 20, Tamil Nadu 15.05 and Odisha 12.00.

India has the potential to generate 35MW per square km using solar photovoltaic and solar thermal energy. In July 2009, India unveiled a $19 billion plan, Jawaharlal Nehru National Solar Mission, to produce 20,000 MW of solar power by 2020. By January 2014 the installed grid connected solar power had increased to 2,208.36 MW, and India expects to install an additional 10,000 MW by 2017 and a total of 20,000 MW by 2020. Installation of off-grid/ decentralized Solar Photovoltaic i.e. Street Lighting System [SLS], Home Lighting System [HLS], and Solar Lantern [SL] in Numbers reveals that Uttar Pradesh has the highest numbers – SLS 100,406, HLS 185,388 and SL 61,932, followed by Haryana SLS 22,018, HLS 50,275 and SL 93,853, West Bengal SLS 8726, HLS 135,067 and SL 17,662, Uttaranchal SLS 8568, HLS 91,307and SL 64,023 and Delhi SLS 301, HLS [nil] and SL 4,807.

India currently has around 1.2 million solar home lighting systems and 3.2 million solar lanterns sold/distributed. By 2012, a total of 4,600,000 solar lanterns and 861,654 solar powered home lights had been installed. 20 million solar lamps are expected by 2022. By 30 September 2006, a total of 7,068 solar PV water pumping systems had been installed, and by March 2012, 7,771 had been installed. Bangalore has the largest deployment of roof top solar water heaters in India. These heaters generate an energy equivalent of 200 MW. Out of 1,221.26 MW Solar

Cookers installed as on 31.03.2012, 824.09 MW were installed in Gujarat and 222.9 MW in Rajasthan.

The government of India is promoting the use of solar energy through various strategies. In the latest budget for 2010/11, the government has announced an allocation of 1000 crore towards the Jawaharlal Nehru National Solar Mission and the establishment of a clean energy fund. The present paper will investigate whether India should adopt a policy of developing and commercializing solar power since being a densely populated region in the sunny tropical belt, the subcontinent has the ideal combination of both high solar insulation and therefore a big potential consumer base density. It will also be highlighted whether India can make renewable resources such as the environmental friendly solar the backbone of its economy by 2050, without compromising its economic growth potential.

Keywords: Solar power grid, Solar photovoltaic, Solar lamps, Solar cookers, clean energy fund

1 Introduction and Motivation of the Study

In India, the Sun, considered as the god of energy and life-force, is worshiped for well-being, prosperity and progress from time immemorial. Now the very survival of the mankind requires conversion of the energy of Sun god into solar power. India must adopt a policy of developing and commercializing solar power since being a densely populated region in the sunny tropical belt, the subcontinent has the ideal combination of both high solar insulation and therefore a big potential consumer base density.

Surya or Sun God or God of energy: Surya is the Sun God and 8 hymns are dedicated to Surya in Rig-Veda. The Sun is worshipped in no less than five forms as:

- Surya
- Savitri, representing the quickening power of the sun
- Mitra, famous in Iran than in India where he is associated with Varuna
- Pushan, symbolizing the power of the sun in its effects on the growth of herbs and vegetation
- Vishnu, representing the swift-moving sun in the Rigveda, though later he is worshipped as an independent god.

Undoubtedly, the sun, either as the actual Creator, or as an emblem of the great energizing force in Nature, has been worshipped by every nation of the world. India's total renewable power installed capacity as on October 31, 2014, has reached 33 giga watt (GW). Wind energy accounts for 70 per cent of the installed capacity at 22.1 GW followed by biomass

power-4.2 per cent, small hydro power-3.9 GW and solar power 2.8 GW. There are 1.1 million households using solar energy and over 10,000 remote and inaccessible hamlets have been provided with basic electricity services through distributed renewable power systems.

India has the potential to generate 35MW per square km using solar photovoltaic and solar thermal energy. In July 2009, India unveiled a $19 billion plan, Jawaharlal Nehru National Solar Mission, to produce 20,000 MW of solar power by 2020. By January 2014 the installed grid connected solar power had increased to 2,208.36 MW, and India expects to install an additional 10,000 MW by 2017 and a total of 20,000 MW by 2020.

The 12th five year plan has projected 33 per cent installed capacity of power in 2030 from renewable energy sources. India has ambitious plans to scale up renewable energy to 165 MW; of this solar energy will be 100 GW by 2019-20. It has proposed 25 solar parks in India and 100,000 solar pumps for irrigation and drinking water. It has also provided for incentives in investment and a ten -year tax holiday. It is world number five in solar water heating systems, number two in biogas plants and number one in bagasse co-generation. The government of India is promoting the use of solar energy through various strategies. In the budget for 2010/11, the government announced an allocation of 1000 crore towards the Jawaharlal Nehru National Solar Mission and the establishment of a clean energy fund.

The present paper will investigate whether India should adopt a policy of developing solar power as a dominant component of the renewable energy mix, since being a densely populated region in the sunny tropical belt, the subcontinent has the ideal combination of both high solar insulation and therefore a big potential consumer base density. It will also be highlighted whether India can make renewable resources such as solar the backbone of its economy by 2050, reining in its long-term carbon emissions without compromising its economic growth potential.

2. Overview of the Literature

Many articles appeared on the future of Solar energy in India such as “Can India’s Future Needs of Electricity be met byRenewable Energy Resources?[1], MNRE Presentation on “Business Models and Current Trends” workshop on “Challenges and Issues in Solar RPO ” Compliance/RECs[2]; Clouds over Solar[3].

Eshita Mukherjee, from Institute for Defence Studies and Analyses, in his article Shining Not so Bright: Solar Energy in India[4] has raised the question: " can solar energy be the next big thing? The major challenges impacting the progress of solar energy today are the land needed for installation, project development, high cost of solar PV technology, energy storage, and high initial costs. Though these have been addressed on paper, implementation remains pending."

Annie Philip in his article Filling the Gaps:Rooftop Solar Projects in India[5], has advocated small-*scale rooftop solar projects to address the ever-increasing domestic energy requirements.* Rahul Tongia & Vikram Mehta edited book " Blowing Hard or Shining Bright? Making Renewable Power Sustainable in India[6]", deals with questions that the ministry is currently grappling with, especially keeping in mind the ambitious targets for solar power (100,000 MW by 2022, a 60+% compound annual growth rate). Improved policies can help harness RE, and experience from other countries shows that a larger share of RE is feasible, though with effort and investment in grid management.

The book entitled Renewable Energy and Sustainable Development, 2015 and edited by Sandip A. Kale, Durai Prabhakaran Raghavalu Thirumalai and K. Prabakar [7] presents theoretical and experimental analysis, case studies and models in renewable energy systems issues related to Solar Energy with chapters such as Solar Greenhouse Technology. According to Ramachandra TV, Subramanian DK. , Awareness on the environmental and health benefits of solar energy is essential to mobilize solar technologies in the fuel-wood based grass-root.economy of India.[8] According to Kirubi C, Jacobson A, Kammen DM, Mills A., Developing solar micro-grid systems in village level for meeting the electricity requirements of a cluster of families through financial support for energy service providers, proper fee- for-service models, and micro-finance for consumers could lead the way for decentralized rural electrification and management.[9] A case study in Sagar Dweep island by Chakrabarti S & Chakrabarti S[10] extols the improvement in education, income generation, social life and health of the people benefited by decentralized solar electrification.

3. Research Methodology and Sources of Data

This Research article is mainly based on the interpretation of data of Annual Reports, 2009-10, 2010-11, 2011-12, 2012-13, 2013-14 and 2014-15 of Ministry of Non and Renewable Energy, Government of India. Literatures available on development of solar energy in India were

also reviewed. An attempt has also been made to do a comparative study of the data available. This paper not only attempts to view the development of solar energy in India but also investigates the prospects for its commercialization.

The authors are sure that this indicative work must propel the future researchers to unravel the fine tunes of this process of development paving the way for its commercialization.

4. Hypothesis and Comparative Interpretation of Census Data

The government of India is promoting the use of solar energy through various strategies. In the budget for 2010/11, the government announced an allocation of 1000 crore towards the Jawaharlal Nehru National Solar Mission and the establishment of a clean energy fund. Government has allocated Rs 500 crore in Budget 2014 to push ultra-modern solar power projects in Rajasthan, Tamil Nadu and Ladakh. The funds may be routed through Solar Energy Corporation of India as seed capital. Solar power panels will become cheaper as solar power gear makers will have to pay lower tax. This will give a boost to not only solar power project developers but also the government's programme to set up one lakh solar powered irrigation pumps.

Total Budget support for Plan in Main Budget 2014-15 is higher by an amount of `19,678 crore in comparison to Interim Budget. The additional amount in Main Budget 2014-15 is targeted towards specific sectors of the economy viz. Agriculture, Capacity Creation in the areas of Education and Health, Railways, National Highways, Rural Roads, Clean energy, improvement of irrigation, river conservation and renewable and development of handloom sector. State Wise Solar Installations in India as of January 31, 2014: Total 2208 MW[11]

- Gujarat: 860 MW
- Rajasthan: 667 MW
- Maharashtra: 238 MW
- Madhya Pradesh: 195 MW
- Andhra Pradesh: 93 MW
- Others: 155 MW

State wise Installed capacity of Solar Projects as on 15.12.2014: Total: 3002.66 MW[12]

- Gujarat: 929.05 MW
- Rajasthan: 839.5 MW
- Madhya Pradesh: 353.58 MW
- Maharashtra: 286.9 MW
- Andhra Pradesh: 233.86 MW
- Tamil Nadu: 104.2
- Karnataka: 67
- Punjab: 55.77
- Orissa: 31.5
- UP: 29.51

Therefore, we see an increase of 794.66 MW from January 2014 to December 2014. In order to encourage the development of solar energy, many states have notified the State Solar Policies:

YEAR	STATES
2009	Gujarat
2011	Rajasthan, Karnataka
2012	Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Tamil Nadu
2013	Jharkhand, J&K, Kerala, Orissa, Uttrakhand, Uttar Pradesh

Solar Insolation[13] in:India[14]

i. The Gangetic plains (Trans, Middle and Upper) Plateau (Central, Western and Southern) region, Western dry region, Gujarat Plains and hill region as well as the West Coast plains and Ghat region receive annual Global insolation above 5kWh/m2/day*. These zones include Karnataka, Gujarat, Andhra Pradesh, Maharashtra, Madhya Pradesh, Rajasthan, Tamil Nadu, Haryana, Punjab, Kerala, Bihar, UttarPradesh and Chattisgarh.

ii. The Eastern part of Ladakh region (Jammu & Kashmir) and minor parts of Himachal Pradesh, Uttarakand and Sikkim which are located in the Himalayan belt also receive similar average Global insolation annually.

iii. The Eastern Himalayan states of Arunachal Pradesh, Nagaland and Assam receive annual average global insolation below 4kWh/m2/day.

Although India is one of the best recipients of solar energy due to its favorable location in the solar belt(40◦S to40◦N), a meager aggregate of 66 MWp (Megawatt peak)solar applications (80%of which are solar lanterns, home/street lighting systems and solar water pumps)are installed in the country. This includes a total of 12.28n MWp grid connected and 2.92 MWp off grid Solar Power Plants (SSPs). Installation of off-grid/ decentralized Solar Photovoltaic i.e. Street Lighting System [SLS], Home Lighting System[HLS], and Solar Lantern [SL] in Numbers reveals that Uttar Pradesh has the highest numbers – SLS 100,406, HLS 185,388 and SL 61,932, followed by Haryana SLS 22,018, HLS 50,275 and SL 93,853, West Bengal SLS 8726, HLS 135,067 and SL 17,662, Uttranchal SLS 8568, HLS 91,307and SL 64,023 and Delhi SLS 301, HLS [nil] and SL 4,807.

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The Jawaharlal Nehru National Solar Mission was launched on the 11th January, 2010 . The Mission has set the ambitious target of deploying 20,000 MW of grid connected solar power by 2022 is aimed at reducing the cost of solar power generation in the country through (i) long term policy; (ii) large scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022. Mission will create an enabling policy framework to achieve this objective and make India a global leader in solar energy. The under mentioned factors have facilitated the way for the development as well as commercialization of solar energy in India:

i. increasing costs of fossil fuels,
ii. price volatility of fossil fuels,
iii. concerns about environment,
iv. decreasing costs and technology improvements in the solar industry itself, and

v. Government Support

vi. State subsidies.

A Comparative analysis of India and other major Solar Energy Producing Countries[15]

Ranking	Country	Installed PV [MW]
1	Germany	32,411
2	Italy	16,361
3	China	8,300
4	USA	7,777
5	Japan	6,914
6	Spain	5,166
7	France	4,003
8	Belgium	2,650
9	Australia	2,650
10	Czech Republic	2,072
11	UK	1,829
12	India	1,205

Now if we compare the above mentioned countries on the basis of Total Solar Power Capacity [MW] Per Million People, we find India lagging behind: Germany: 398.63 MW; Italy: 267.07 MW; Belgium: 253.87 MW; Czech Republic: 203.59 MW; Spain: 109.81 MW; Australia: 109.56 MW; France: 60.99; MW Japan: 54.28 MW; UK: 29.01 MW; USA: 24.78 MW; China: 6.18 MW and India: 1.00 MW.

Moreover, if we compare these countries on the basis of Total Solar Power Capacity [MW] Per $ 1 Billion GDP, we again find India lagging behind: Czech Republic: 10.17 MW; Germany: 9.53 MW; Italy: 8.12 MW; Belgium: 5.47 MW; Spain: 3.82 MW; Australia: 1.56 MW; France: 1.48 MW; Japan: 1.16 MW; China: 1.00 MW; UK: 0.75 MW; India: 0.66 MW and USA 0.50 MW.

5. Conclusion and Suggestions

As a first step, Government of India must popularize solar energy through distributed installations of small-scale systems for producing electricity or hot water, typically on residential, commercial, or industrial building rooftops. Distributed solar electric (photovoltaic) systems and solar thermal water heaters offer some important advantages. Moreover, small-scale solar systems can be sited on existing buildings, eliminating the need for dedicated land to

produce energy and reducing, or at least not contributing to, the need for new transmission and distribution facilities. Social acceptance of solar power generation must.

Like US Energy Department, the Energy Department in India must also help entrepreneurs, small business owners and start-ups to bridge the gap between research and development and commercial deployment. MNRE in collaboration with German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has undertaken a project titled Commercialisation of solar energy in urban and industrial areas with Overall term: 2009 to 2016, the objective is to make solar energy commercially viable in urban and industrial areas. For this, work is going on to establish a better regulatory framework to encourage the use of rooftop PV installations, as these are one of the most important means of commercializing solar power systems.

Therefore, in order to realize the full potential of Solar energy in India, the thrust area would be conservation, collection and storage technologies. R&D is required not only to reduce the cost but also to make it people friendly and it is rightly said, to quote Engels, "if society has a technical need , that helps science forward more than ten universities." Conservation—R & D development—Cost Reduction- Social acceptance—Publicity and Role of Media [we find NO advertisement in TV]. Government must encourage the use of rooftop PV installations, as these are one of the most important means of commercializing solar power systems. Main barriers which prevent widespread solar energy utilization and its commercialization:

i. It requires significant surface area to collect an appreciable amount of energy. For example, a 200 MW thermal trough plant would require about 1,000 acres of land.
ii. Cost of producing energy in large-scale solar power plants is still high relative to other options.
iii. Solar resource's intermittency and cyclical nature pose challenges for integrating solar at a large scale into the existing energy infrastructure.
iv. Solar thermal electric technologies, such as central receiver and parabolic trough designs require a considerable amount of water for cooling.
v. Availability of adequate power transmission capacity,
vi. Availability of feasible back-up power sources and Conservation/ storage technologies,
vii. Inconsistent tax policy,

viii. Lack of incentives for utility participation,

ix. Absence of a conducive market place.

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11. *Source: CEEW, NRDC based on data from MNRE's "State wise Installed Capacity of Solar PV Projects under Various Scheme as on 31.01.2014,"*.
12. *Source: Ministry* of New and *Renewable Energy* (MNRE)
13. Insolation - The solar power density incident on a surface of stated area and orientation. It is commonly expressed as average irradiance in watts per square meter (W/m2) or kilowatt-hours per square meter per day(kW·h/(m2·day)) (or hours/day).]
14. Source: Hotspots of solar potential in India, T.V. Ramachandra a,b,c,∗, Rishabh Jain a, Gautham Krishnadasa a Energy &Wetlands Research Group, Centre for Ecological Sciences[CES], Indian Institute of Science, Bangalore, India b Centre for Sustainable Technologies Centre (astra), Indian Institute of Science, Bangalore, India c Centre for infrastructure, Sustainable Transportation and Urban Planning [CiSTUP], Indian Institute of Science, Bangalore].
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