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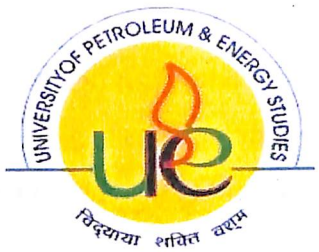

INDIA's SOLAR ENERGY PROSPECTS, POTENTIAL: A STUDY IN LIGHT OF THE GIVEN REGULATORY REGIME, INVESTMENT POTENTIAL AND MARKET, PROMPTING A NEED TO REFORM AND LIBERALISE.

By

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A Dissertation Report submitted in partial fulfillment of the requirements for LL.M. (Energy Laws Specialization)

COLLEGE OF LEGAL STUDIES
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DEHRADUN

19/12/15

19/12/15

APPENDIX-II

Acknowledgment

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DANNY MALWAL

LLM (Energy Law) (2014-2015)

500041921

APPENDIX-III

A Declaration by the Guide

This is to certify that Mr. Danny Malwal, a student of LLM (Energy Law Specialization) with SAP Id. 500041921 of University of Petroleum and Energy Studies has successfully completed this dissertation report on *"India's solar energy prospects, potential: a study in light of the given regulatory regime, investment potential and market, prompting a need to reform and liberalise."* under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by him and the same has not been submitted in any other University or Institution for award of any degree.

In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfilment for the degree of LLM.

Signature

(Mr. SUJITH P SURENDRAN)
Faculty (College of Legal Studies)
University of Petroleum and Energy Studies

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LIST OF ACRONYMS

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3	CFL	:	Compact Fluorescent Lamp
4	CLFR	:	Compound Linear Fresnel Reflectors
5	CSP	:	Concentrated Solar Power
6	DC	:	Direct current
7	DHW	:	Domestic Hot Water
8	DMRC	:	Delhi Metro Rail Corporation
9	DNES	:	Department of Non-conventional Energy Sources
10	DRE	:	Decentralized Renewable Enterprises
11	EIA	:	Environmental Impact Assessment
12	EIB	:	European Investment Bank
13	EPC	:	Engineering, Procurement, Construction
14	ETC	:	Evacuated Tube Collectors
15	FIT	:	Feed in Tariff
16	FPC	:	Flat Plate Collectors
17	GDP	:	Gross Domestic Product
18	GHG	:	Green House Gas
19	IEA	:	International Energy Agency
20	IEGC	:	Indian Electricity Grid Code
21	IIT	:	Indian Institute of Technology
22	INDC	:	Intended Nationally Determined Contributions
23	IREDA	:	Indian Renewable Energy Development Agency Limited
24	JICA	:	Japan International Cooperation Agency

25	JNNSM	:	Jawaharlal Nehru National Solar Mission
26	LFR	:	Linear Fresnel Reflector
27	LFRSC	:	Linear Fresnel Reflector Solar Concentrator
28	MNRE	:	Ministry of New and Renewable Resources
29	MoEFCC	:	Ministry of Environment, Forest and Climate Change
30	MOP	:	Ministry of Power
31	NABARD	:	National Bank for Agriculture and Rural Development
32	NAPCC	:	National Action Plan on Climate Change
33	NCEF	:	National Clean Energy Fund
34	NGO	:	Non Governmental Organization
35	NIB	:	Nordic Investment Bank
36	NTPC	:	National Thermal Power Corporation Ltd.
37	ONGC	:	Oil & Natural Gas Commission
38	PCO	:	Public Call Office
39	PPA	:	Power Purchase Agreement
40	PSL	:	Priority Sector Lending
41	PV	:	Photo Voltaic
42	RBI	:	Reserve Bank of India
43	REC	:	Renewable Energy Certificate
44	REDA	:	Rajasthan Energy Development Agency
45	RPO	:	Renewable Purchase Obligations
46	RESCO	:	Renewable Energy Service Providing Companies

47	RSPCL	:	Rajasthan State Power Corporation Ltd.
48	SEC	:	Solar Energy Centre
49	SECI	:	Solar Energy Corporation of India
50	SERC	:	State Energy Regulatory Commission
51	SHS	:	Space Heating Systems
52	SNA	:	State Nodal Agencies
53	SPV	:	Solar Photovoltaic
54	STE	:	Solar Thermal Electricity
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56	TRAI	:	Telecom Regulatory Authority of India
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ABSTRACT

This paper reviews the solar energy in the context of the applications to which the solar energy can be put to use. The prevailing energy scenario as presently exists in India and the potential it holds for the use of solar energy to augment the need of its burgeoning population which is generating the demand and supply gaps. In India context, the use of solar energy and its application to meet the different energy requirements assume great importance given the fact that India is greatly dependent on the conventional fuel and source of energy which are depleting. The Solar Energy on the other is readily available and is not exhaustible in nature.

It augurs well for India since its lies in the tropical zone and has abundant sunshine for most part of the year. India presently is at an evolving stage in its growth story and therefore a viable energy strategy is critical for sustaining this growth and to have a development which is environmentally sustainable. In this era of global cooperation, as India works towards meeting its requirements under global commitment for emission norms it is imperative that a prospective scenario of development is visualized. This paper examine the role solar energy can play in development of India, the regulatory regimes facilitating such growth and use of solar energy as well as the challenges, constraints and issues faced by the solar sector, aspects which needs consideration and the needs for reform to develop the solar sector in India. Having examined the prevailing scenario related to Solar Energy in India it is can well be mentioned that India is poised for having a leading role in the world, it is just matter of time.

INDIA's SOLAR ENERGY PROSPECTS, POTENTIAL: A STUDY IN LIGHT OF THE GIVEN REGULATORY REGIME, INVESTMENT POTENTIAL AND MARKET, PROMPTING A NEED TO REFORM AND LIBERALISE.

1. INTRODUCTION

Solar Energy as a clean energy resource has tremendous potential which needs to be tapped with the use of devices and latest emerging technology. It is helping in curbing the emission and is therefore having a good environmental effect in the long term perspective. There has been spurt in the application of the solar technology in different areas. Solar energy systems are more easily available for usage in residential as well as for different industrial usage. The advent of technology in the field of solar applications is further adding the advantage of minimum maintenance. The solar energy sector could be made more effective and financially viable by the government so as to further add and accelerate the growth.

In the context of developing countries, which are endowed with this nature's bounty, there is an added advantage in the form of saving of precious foreign exchange which goes in the procurement of the fossil fuels. This is giving a thrust and required impetus to the developing countries to switch to solar energy, which is one of the major renewable energy sources.

In the context of India, the need to harness solar energy is all the more important as this requirement is emanating from the ever increasing population. This population with the change in the lifestyle and standard of living owing to higher disposal income is putting more pressure on the traditional depleting resources.

Today globalization, industrialization and development are the buzz words however; it is a well known fact that without the energy requirement being met nothing of these is possible to be given effect. The geo political situation is adding to an unstable energy market as a result thereof it is essential that the dependency thereon is reduced.

Indian government had taken a major initiative in the form of The National Solar Mission through which both the Central and the State Governments aim for the promotion of ecologically sustainable growth in the energy sector while at the same time addressing the challenge of India's energy security and this has also taken to be a major step from India's end to meet the global efforts to meet the challenges of the climate change. The main aim or focus of the National Solar Mission is to place India as a global leader in the solar energy sector. This is intended to be done with the help of creating policies providing for the conditions which would facilitate and quicken the process of adoption and penetration of solar energy usage through various application, appliances and devices.

The main focus for the time being is to create and enable an environment both at the centralized and decentralized level. The National Action Plan on Climate Change also points out:

> *"India is a tropical country, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has great potential as future energy source. It also has the advantage of permitting the decentralized distribution of energy, thereby empowering people at the grassroots level".*

This study is aimed at exploring and understanding through the material available through various sources especially with more focus on the material available on the internet so as to gain an understanding on the solar energy and its application, the factors which influence or have a bearing on the growth and development of usage of solar energy. The potential of solar energy in India and the prospects of its usage in India, the opportunities it offer for investments, the market available for the growth of different applications have been examined.

This study also delves into an evaluation of the solar energy sector in India, its potential, the challenges for the growth of solar energy sector in India, incentives, policy initiatives taken by the government, prevailing regulatory regimes; the actions which can be taken for promoting the growth and development of the solar energy sector so as to meet the demand of energy in future, need for facilitating the investments in India and also the need for reforming and liberalizing the related market.

Chapter 1 gives the general introduction of the study carried out on the various aspect of solar energy and its related aspects. It gives a brief on the subject matter of this dissertation. It mentions about the topic on which the study or evolution has been carried out and the methodology adopted in doing so.

Chapter 2 of this study mentions about the solar energy and the type of its application. The usage and the benefits of using the solar energy, the pros and cons associated, factors having the bearing on the usage of solar energy and the prevailing energy scenario.

Chapter 3 delves into the energy potential that India has and which can be put to use by seeking more investments from the domestic and foreign investors. The conditions supporting or facilitating this potential of India.

Chapter 4 examines the various regulatory regime and institutional structure available and supporting the energy sector. It also touches upon the relevant policies framed by the Government of India which are aimed at increasing the penetration of the solar energy usage in India.

Chapter 5 deals with the investment potential and different markets which exist for the use of solar related application. There exists enormous scope for India to exploit solar energy owing to there being big supply demand gap existing in the solar sector and its very less penetration as compare to the opportunities that exist. This chapter reflects on the market size and the conditions or factors which are inhibitors or developer.

Chapter 6 concerns the issue related to the challenges and concerns being confronted in the solar sector in India. This chapter touches upon the issues which are hampering or impacting the growth of solar energy in India like the availability of land, political scenario and lack of finance.

Chapter 7 mentions some of the suggestions which if implemented would be very effective in paving way for the further development of the solar energy sector and would address some of the concerns presently being confronted by this sector.

Main purpose of this study was to gain an insight as to where and how India is placed. It is important for India to be self reliant in meeting its energy requirement. This assumes greater significance in view of the ever changing geo political situation especially in the Middle East.

Limitation of the study

This study is based on the secondary sources accessed and most of the same has been through the use of internet. The major portion of the study is based on the resources accessible and found on various websites including that of the governmental bodies. There have been considerable time constraints and other issues which afforded very less time for carrying out the further research into the subject matter.

Methodology adopted

The use of secondary sources has been used extensively and exclusively for carrying out this study and research relating to the topic forming the subject matter of this dissertation. The main reason for this has been the constraint relating to time. The main emphasis has been to make the use of internet to the maximum.

2. SOLAR ENERGY AND ITS APPLICATIONS

Solar energy is radiant light and heat from the Sun harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture and artificial photosynthesis. This energy is the form of solar radiation. It is most readily available source of energy which offers enormous potential to be tapped for the purpose of energy generation.

Energy through solar radiation can be used in two ways:

(i) thermal route; or

(ii) photovoltaic ('PV') route.

It is an important non-conventional source of energy since it is non-polluting in nature and is helps in reducing the green house effect. It is considered to be renewable as it does not destroy the environment and the technology that is used for the generation of solar power does not produce smoke and air pollutants. Energy in the form of radiation is converted using electricity using PV panels. Countries experiencing Intense sunlight, the PV panels convert the solar radiation and helps in generation of electricity.

This availability of radiation can be put to use and utilized for thermal as well as for photovoltaic applications. Solar thermal technologies have already found ready acceptance for 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 some devices/ systems such as solar lanterns, solar home systems, solar street lights, solar pumps, solar power

packs, roof top SPV systems etc. which could be useful both in rural and urban areas for the purpose of reducing burden on conventional fuels[1]

2.1 APPLICATIONS OF SOLAR ENERGY

Solar energy can be put to different use and has numerous applications. Some of which are mentioned below:

2.1.1 *Solar Thermal Electricity* (STE)

Such generating systems have of late started emerging as one of the renewable energy technologies which is being considered as a feasible option for the generation of electricity to meet the future requirements.

Solar thermal technology makes use of the sun's energy instead of fossil fuels to generate low-cost, thermal energy which is also suitable environmentally. Such energy is used to heat water or other fluids and is different from the photovoltaic systems which generate electricity. Solar thermal power is considered to be the most cost-effective solar technology if taken on a large scale. It is ahead of other PV systems, and it can also be ahead of the cost of electricity from fossil fuels. It has high negative environmental impact and is low cost option as compared to coal which is prominently and majorly used in India for the generation of power.
Three main types of solar thermal power systems are:

(i) ***Parabolic troughs*** – Under this system, a parabolic trough collector has a long parabolic-shaped reflector which concentrates the focus of the rays of the sun on the on the receiver pipe, which is based at the parabola. The fluid which circulates through pipes transfers its heat to water in order to generate high-pressure steam which is super heated.

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[1] <http://mnre.gov.in/schemes/decentralized-systems/solar-systems/> (*Accessed on 25th October, 2015)*

This steam is used to generate electricity through a conventional steam turbine. Power plants using this system may even use fossil fuels in order to supplement the solar output when there is low solar energy.

(ii) *Solar dish* - This system uses concentrating solar collectors which are pointed towards sun and they concentrate the solar energy of the sun at the main focal point of the dish. The concentration ratio of the solar dish is far more than the solar trough. Generated energy can be collected through number of installation and converted into electricity.

(iii) *Solar Power Tower* – In such a system, solar power tower or central receiver is used to generate electricity with have the focus of the concentrated solar energy. This is done on a heat exchanger which is mounted on a tower. This system uses number of flat sub facing mirrors to reflect and concentrate the energy of the sun onto a central receiver tower. This technology though has a limited as it can be put to use and is feasible economically only if the project is on a large scale. It can prove to be very promising if this technology is used for grid-connected power plants which are large in scale.

(iv) *Compound Linear Fresnel Reflectors* (CLFR)

It is also referred to as a concentrating linear Fresnel reflector. It is a specific type of linear Fresnel reflector (LFR) technology. Linear Fresnel reflectors use long, thin segments of mirrors to focus sunlight onto a fixed absorber located at a common focal point of the reflectors. These mirrors are capable of concentrating the sun's energy to approximately 30 times its normal.[2]

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[2] <http://www.sciencedirect.com/science/article/pii/S0038092X03002962> *Dey, C.J. (2004). "Heat transfer aspect of an elevated linear absorber". Solar Energy. 76 (2004): 243–249 (Accessed on 2nd November, 2015)*

Linear Fresnel reflectors, as shown Fig 1 use long, thin segments of mirrors to focus sunlight onto a fixed absorber located at a common focal point of the reflectors. A secondary concentrator is used to reflect the rays within the accepting angle. This concentrated energy is transferred through the absorber into thermic fluid. Through a heat exchanger energy is extracted to use to generate power or other commercial applications.

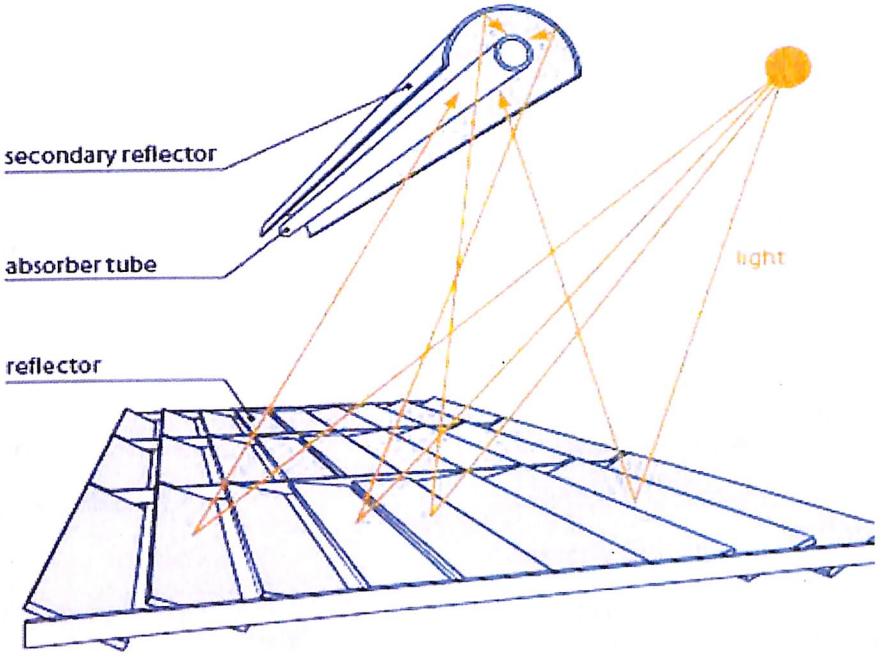

Figure 1. Fresnel Reflector Principle

Rooftop Linear Fresnel Reflector Solar Concentrator (LFRSC) is modular in type and can be interconnected number of units depending on the requirement. They can be connected in parallel-series to achieve given temperature and mass flow rate[3].

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[3] *Source:* http://www.redrok.com/Lfrljeit.pdf *(Accessed on 12th November, 2015)*

The comparison between the different concentrated solar power (CSP) is mentioned herein below in **Table -I**

Table -I

Comparison of CSP Technologies[4]

	PARABOLIC TROUGH	**CENTRAL RECEIVER**	**PARABOLIC DISH**	**FRESNEL LINEAR REFLECTOR**
Applications	Grid-connected plants, medium to high process heat (Highest single unit solar capacity to date: 80 MWe. Total capacity built: over 500 MW and more than 10 GW under construction or proposed)	Grid-connected plants, high temperature process heat (Highest single unit solar capacity to date: 20 MWe under construction, Total capacity~50MW with at least 100MW under development)	Stand-alone, small off-grid power systems or clustered to larger grid connected dish parks (Highest single unit solar capacity to date: 100 kWe, Proposals for 100MW and 500 MW in Australia and US)	Grid connected plants, or steam generation to be used in conventional thermal power plants. (Highest single unit Solar capacity to date is 5MW in US, with 177 MW installation under development)

[4] <http://www.ripublication.com/irph/ijert_spl/ijertv6n3spl_04.pdf.> Aniket Dwivedi, Ajay Bari and Gaurav Dwivedi (2013) *Scope and Application of Solar Thermal Energy in India-A Review*, International Journal of Engineering Research and Technology. pp 318-319 *(Accessed on 10th November, 2015)*

Advantages	Commercially available over 16 billion kWh of operational experience; operating temperature potential up to 500°C (400°C commercially proven) • Commercially Proven annual net plant efficiency of 14% (solar radiation to net electric output) • Commercially proven investment and operating costs • Modularity • Good land-use factor • Lowest materials demand • Hybrid concept proven • Storage Capability	• Good mid-term prospects for high conversion efficiencies, operating temperature potential beyond 1,000°C (565°C proven at 10 MW scale) • Storage at high temperatures • Hybrid operation possible • Better suited for dry cooling concepts than troughs and Fresnel • Better options to use non-flat sites	• Very high conversion efficiencies – peak solar to net electric conversion over 30% • Modularity • Most effectively Integrate thermal storage a large plant • Operational experience of first Demonstration projects • Easily manufactured and mass-produced from available parts • No water requirements for cooling the cycle	• Readily available • Flat mirrors can be purchased and bent on site, lower manufacturing costs • Hybrid operation possible • Very high space efficiency around solar noon.

2.1.1.1 *Importance of Solar Thermal Technology*

The important of the solar thermal technology in business are being pushed forth and their usage importance lies in the fact that it lead to following benefits:

(i) ***Reduction in Utility bills*** - There is considerable reduction in the utility bills since the solar energy is used to heat fluids especially where the businesses have to pay for fuel required to heat large quantities of hot or liquid fluids. The use of the solar thermal technology leads to reduction in the operational costs involved and thus leads to substantial savings.

(ii) ***Reduction in Carbon Foot prints*** - Instead of using the fossil fuels, the use of solar thermal technology leads to reduction in carbon based greenhouse gases a business would emit into the atmosphere at the relevant site.

(iii) ***Compliance***: There are certain compliances which are mandated by the regulatory regimes from the government's end which necessitates the use by implementing the renewable energy technologies. By providing the return on investments, the solar thermal systems can help in meeting such requirements.

Solar water heating systems is one of the applications of the solar thermal technology. Solar water heating systems uses solar thermal collectors (panels) usually on a roof which absorbs solar energy. Through such collectors by way of a low energy pump, solar fluid is circulated which delivers heat to the water storage tank. The storage tanks pre feeds the water heating system when there is requirement of the hot water. So, either the boiler is not activated or even if it is activated then the same is for a lesser

time, this saves a dent on financials. The building owner is able to save a lot owing to lower bills which would have been otherwise since the heating would have used more energy. Solar thermal technology has its use in various commercial applications. Some of the solar thermal systems which are used include Domestic Hot Water (DHW) systems, Space Heating Systems (radiant), Swimming Pool/Hot Tub-Heating Systems. Further, there can also be the combination of these systems. Solar thermal technology has some advantages and advantages which are attached to its usage some of them are mentioned below in Table -II:

Table-II

ADVANTAGES	DIADVANTAGES
• This technology does not require fuels and is renewable in nature. • It is considered to be non-polluting in nature. It is carbon-free, except for the production and transportation involved. • It can be used to serve as a drop-in replacement for conventional fuels in order to make steam • The operating costs involved are low • This technology can utilize thermal storage to better match supply with the demand • It is high on efficiency • Scalable to the 100MW+ level	• It is Intermittent • It has Low energy density • Construction/installation costs can be high • Relatively new technology involved • The technology is slightly more expensive than solar PV • This technology is difficult to compete against the availability of very cheap natural gas • Considerable space is required for setting up the plants • They are also not considered to be aesthetically pleasing by some individuals • Some time pollution is caused by the manufacturing processes. • Such technology is highly location dependent • Will involve significant transmission distances/losses

Solar thermal technology faces some challenges. Some of the most prominent of such challenges are as:

- The most obvious is competition with abundant and inexpensive coal. Unless and until nations begin taxing on carbon emissions, especially the United States and China, the cost of plants which are coal-fired will remain cost effective and economical.

- Growth in the thermal technology will have a natural cap.

- Large scale conversion to solar around the world is not going to happen easily until solar is considered and taken to be the cheaper alternative as compared to other resources. It is hoped by the industry leaders that such a pint would be reached within a decade.

- Utilization of desertification can prove to be advantageous for solar thermal real estate procurement and development.

Despite the sun's enormous size, and because of its distance from the earth, it is not quite a point source. It actually occupies 1/2° in the sky. When making a concentrator, the architecture of the system needs to take into account this subtended angle of the sun. The maximum theoretical concentration of line focus is 212:1. Line focus solar thermal plants are reporting 80-100x concentration, with some claiming 112x – in other words, people are achieving about half of the maximum theoretical concentration.[5]

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5 <http://www.solar-thermal.com/solar-thermal.pdf> **Solar Thermal Energy** an Industry Report (*Accessed on 11th November, 2015*)

2.1.2 *Solar Lantern*

Solar Lantern is a portable light source which gives an omni directional pure white light. Solar lantern, designed in the form of a traditional lantern uses Compact Fluorescent Lamp (CFL) as the light source. The solar photovoltaic module provided with the lantern charges the sealed maintenance - free battery inside the lantern when exposed to sunlight. The battery supply power to the Compact Fluorescent Lamp whenever required.

Solar Photovoltaic module, battery, Compact Fluorescent Lamp, Charge Controller and Inverter are the main parts in a solar lantern. The lantern can be used for 3-4 hours after a sunny day's charging.[6]

Solar Lantern Programme of the government provides for the definition and the specification of a solar lantern. As per the guidelines issued by MNRE, A solar photovoltaic lantern (Solar lantern) is a lighting system consisting of a lamp, battery and electronics, all placed in a suitable housing, made of metal, plastic or fiber glass, and a PV module. The battery is charged by electricity generated through the PV module. The lantern is basically a portable lighting device suitable for either indoor or outdoor lighting, covering a full range of 360 degrees. A lighting device which provides only unidirectional lighting will not be classified as a solar lantern in the present context.

Such solar lantern should provide a minimum of three hours of lighting per day under average daily solar radiation conditions of 5 kWh / sq. m. on a

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6 <http://www.dcmsme.gov.in/reports/electronic/solarlantern.pdf> > PROJECT PROFILE ON SOLAR LANTERN, MSME-Development Institute Govt. of India, Ministry of MSME (*Accessed on 12th November, 2015*)

given horizontal surface, which of course may vary depending upon the location and season.[7]

The details specification have been provided by the MNRE and the details for such can be accessed on the its website http://mnre.gov.in

The Solar lantern programme 2007-08 is implemented only through the state nodal agencies/Departments (SNAs) and the Akshaya Urja shops. Such manufacturers of solar lanterns who are carrying out the manufacture at least one of the major items used in the lanterns i.e. PV modules or electronics or storage battery and are having adequate facilities for testing are covered under the programme.

Solar Lantern usage can help in reduction of the use of kerosene oil which is used in the rural household for the purpose of lighting. The government has extended subsidy on the purchase of Solar Lantern which is being put to use in unelectrified villages and hamlets in far flung areas of states falling in special category and UTs/islands.

2.1.3 SPV Home Lighting System

Solar home lighting system provides solar electricity which is used for the purpose of indoor lighting. It is helpful in operation to lights few rooms of a house along with power to run small DC fan or a 12 V DC television with the system. It majorly and usually consists of a PV module of appropriate capacity, a sealed maintenance free or flooded lead acid battery and CFLs. This system is designed and is considered to provide services for a period of 3-4 hours on a daily basis and can work for three cloudy days. The beneficiaries which are eligible to received subsidy include all individuals

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7 <http://mnre.gov.in/file-manager/UserFiles/cfl_spls_2013_14.pdf> (*Accessed on 20th October, 2015)*

and non-profit institutions or organizations. The subsidy varies according to the location area and the categorization specified by the Government.

2.1.4 *Solar Water Heating*

Usage of solar energy for the purpose of heating water is one of the oldest and the most mature renewable energy technologies. The two predominant technologies that are being used are Flat Plate Collector (FPC) and Evacuated Tube Collectors (ETC). Solar water heater (SWH) installations are witnessing a rapid growth through the world. There has been upsurge in the recent years in the use of solar water heaters. The reasons for this demand upsurge in recent years are:

- There has been growth in new urban housing;
- The disposable income is rising;
- There has been increased propensity for the consumer durables
- Arrival of ETC & improvements in supply chain
- Energy price hike

SWH is also of growing interest to Indian consumers, businesses and industry that are increasingly looking at controlling their water heating costs. Solar water heating industry is beneficial to the nation as it:

- saves the country a substantial amount in foreign exchange,
- contributes to improvements in health, hygiene, living standards and income levels,
- helped to cushion some of the adverse economic effects of the oil crisis,
- expanded the renewable energy share, as well as their acceptance and confidence,
- has provided one of the highest rates of economic return on investments for individuals.

During the continuous use or operative conditions, a SWH does not require a regular attention, beside this it requires less maintenance in comparison of an electrical geyser or boiler. Furthermore, expanding the solar water heater market creates jobs and business opportunities.

The Indian Government has been supported in the increased uptake in the SHW, in particular through:

- SWH subsidy scheme paid directly to approved SWH manufacturers who meet a basic SWH
- prescriptive SWH system quality control and product assurance specification ,
- the provision of testing facilities at Solar Energy Center (SEC)
- a range of SWH manufacturer and dealer support activities, and finally
- a range of policy and administrative measures at both the Union (i.e. India wide) and state and at local levels.

There are some mandates to install SWH in government and other buildings; however, the enforcement of these "administrative orders" is still very uneven and has not been that effective.

World-over, the residential sector has the largest market share in the market of SWH. In 2004, around 40 million households worldwide i.e. 2.5% of the total 1.6 billion households globally, were estimated to be using SWH's. In China, it is estimated that 98% of the annual SWH sales are contributed by the residential sector. Overall 10% Chinese households are estimated to be using SWH's; this percentage is expected to go up to 30% by 2020. In Europe, 90% of the installed SWH capacity is in the residential sector. In Europe, majority of the residential systems are single-family homes, while in China a

large number of residential solar water heaters are installed on multi-storey buildings. In China, almost 90% of the SWH are installed in the urban areas. [8]

2.1.5 *Rooftop SPV Systems*

Rooftop photovoltaic power station, or rooftop PV system, is a photovoltaic system that has its electricity generating solar panel which is mounted on some residential or commercial building or any structure. The components include PV Modules, mounting systems, solar inverters and other electrical accessories.

The Rooftop Photovoltaic systems can be of two types:

(i) Solar Rooftop System with storage facility using battery, and

(ii) Grid Connected Solar Rooftop System.

The rooftop solar systems are usually from 1 kWp up to 500 kWp or in combination can be set up on the roofs. Such systems have few advantages which are:

- Since the electricity generation is at the consumption centre there is a saving in the transmission and distribution losses.
- It is easy to feed solar electricity into the public grid and thus enable the installers to have the premium on the generation of kWh.
- No additional land is required as such systems can be installed on the rooftops or existing structure.

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8 "World Energy Outlook, 2011 Executive Summary", © OECD/IEA, 2011, *International Energy Agency*, 9 rue de la Fédération, 75739 Paris Cedex 15, France.

- It can lead to improvement in tail-end grid voltages and reduction in system congestion thereby enabling a higher self consumption of the solar electricity
- It also enables generation of local employment

The disadvantage is that the break even cost for the PV generation is usually found to be relatively high for contribution levels which are less than 10%.

2.2 FACTORS INFLUENCING SOLAR ENERGY GENERATION

Solar Energy though is a bounty of nature still it gets impacted and affected by several of the factors which affect or infleunce its generation.

(i) *Non availability of Sunshine*

Since the generation of solar energy is totally dependent on sun, there is a diadvantge that sunshine is not available for all the twenty hours of the day. During the period when the sun goes down or is heavily shaded, the solar PV stop producing electricity. So, it is only the period when the sunlight is available which can be put to use for the generation of solar energy.

(ii) *Dependency on the storage medium*

Since the sunshine is not available for all hours of a day, there is greater dependency on the storage medium. The energy generated has to be stored in the batteries. The storing facilities of solar electricity has not reached its potential yet. The batteries though available are not adequate for the use in large solar farms.

(iii) *Space constraints*

Solar panels are bulky in nature especially the traditional silicon crystalline wafer solar modules. The installation of the panels requires time, space and technical know how for installation.

(iv) *Inefficiency*

Sometimes it is argued that the solar panels do not produce the energy efficiently as compared to the vast surface area required for the production of electricity. Since not all of the light from the sun is absorbed by the PV panels therefore most of the solar panels have less of the efficiency though there has been increase owing to development of the new technology.

(v) *High initial cost*

The initial cost of purchasing and then setting up the solar is one the higher side and it is one of the major contraint in the dveleopment of the solar energy sector. The takes a longer period to achieve the break even on the cost invested.

(vi) *Pollution*

The PV panels are considered to be generating electricty in a non polluting way still the photovoltaic panels are made up of silicon and other toxic metals like mercury, lead and cadmium. The PV cells can get degraded owing to the high pollution level in the environment. The initial cost and subsequent deterioration of the PV Cells by pollution can prove to be a costly affair in case the proper maintenace and care is not taken in respect of the PV material.

2.3 BENEFITS AND ADVANTAGES OF USING SOLAR ENERGY

There are several benefits in the usage of the Solar Energy. Some of which can be summarised as under:

(i) Renewable in Nature.

Solar energy is renewable in nature and it is readily available during the day and is a natural source of power so there is immense opportunities for the generation of electricity and use of the solar energy for several other purposes.

(ii) Little Maintenance

Once the PV panels are installed, they require little maintenance and the generation of electricity can be had on routine maintenance of PV panels. Countries where intense sunlight is available, the PV have become a cost effective way of electricity.

(iii) Multiple Use

One of the main charcterstics of the solar energy is its usage in different application and that too without gerenation of pollution. The solar energy as thermal energy can be used for Cooking/Heating, Drying / Timber seasoning, Distillation, Electricity/Power generation, Cooling, Refrigeration, Cold storage. Solar radiation through solar photovoltaic cells (SPV) can be converted into DC electricity directly used as or stored in battery. This stored electricity can be used later in the night. SPV can be put to use in number of applications such *viz.* domestic lighting; village electrification; street lighting; pumping of water; desalination of the salty water; railway signals; powering of telecommunication repater stations.

(iv) Slows/Stops Global Warming

Global warming threatens the very existence and survival of the human race. Research over the years has lead to the effeicent solar panel systems which creates electricity without producing global warming pollution. Solar energy is considered to the most important solution in combating the crisis related to global warming. There is no emission of any smoke, gas or any chemical by product.

(v) Use of Solar energy has economical advantages

Use of solar energy in the form of power is resulting in huge savings to the household who have installed the solar PV on rooftops. Germany is a leading example where the household have benefitted from the use of solar power. In the long run, the installation has proved to be economically advantageous and if done with proper planning and design choices it can really been a boon for the user.

(vi) Reliability

There is greater reliability on the rising and setting of the sun. It can be determined to a great extent of the timing of the sunrise and sunset. Despite there being less predictability owing to clouds sometimes, still projections can be well made out in respect of the sunlight to be received in different locations across the world.

(vii) Energy Security

Solar power provides greater benefits in the form of eneregy security. It leads to less dependency of the traditional conventional fuels and provides for energy independence. Usage of solar power decreases the dependency of the nations on the other resource rich nation of conventional fuel and thereby enables them to save the forign currency which is used in oil and gas imports.

(viii) No requirement of ongoing raw material

Generation of solar energy does not require ongoing supply of raw material and its generation requires significantly less labour cost as compared to the conventional power generation.

(ix) Decentralization of power

The generation and usage of solar energy leads to decentralization of the power sector, it thereby makes the societies more self reliant. The movement of the coventional energy sources like oil and gas add to several other costs like transportation cost, social cost – in the form of pollution involved in transportation; wear and tear of the roads etc. The generation of solar power can reduce and make the local societies more self sufficient by generating the electricity at the local levels.

(x) Useful in isolated and remote places

The solar energy is useful for the individuals residing in remote and far of places. The installation cost of power lines and the cost of power is often on the higher side as the it is difficult to manage the infrastructure in such remote and isolated places. The installation of the solar panels on the rooftops and the generation of the electricity going off grid make the user more self reliant and as such the solar power can prove to be very useful in remote places.

(xi) Solar energy sector add to creation of jobs

The Solar Energy sector helps in creation of the jobs. The sector add to jobs in different form. The jobs are created in the manufacturing area, in installtion and comissioning, monitoring and maintenance services related to solar panels, research and design, development, policy jobs.

(xii) Price volatility and related Politics

The solar energy sector has the ability to avoid the politics and the price volatility that is usually centred around the market of conventional fuels. This sector is less vulnerable to the manipulations in the prices. The price of production of solar energy per watt is decreasing day by day owing to the technological advancement and achievement of the economies of scale which is taking effect.

(xiii) Saving of Ecosystems

Since there is no constant mining involved in the solar energy sector there is no destruction of the forest, ecosystems which usually is the case with the fossil fuels. The solar sector thereby helps in saving the environment from degradation and also from various other repercussions which emanate as a result of environmental degradation.

The optimal use of solar energy generation can also lead to several other advantages as can be seen in the case of Narmada Canal Solar Project. This project involves covering the Narmada branch canal in the state of Gujarat with the solar panels. This would not only save the need to have more of land for setting up the solar panels but save the huge quantities of water loss due to evaporated. This small-scale experiment covers a 750 meter stretch of canal to generate 1MW of electricity from the panels. It has also been indicated that the solar panels are capable of producing power at a 15% premium to the power that might be generated on land thanks to the cooling effect of the water running beneath them.[9]

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[9] <http://renewableenergydev.com/solar-energy-narmada-canal-solar-project/> (*Accessed on 21st of October, 2015*)

3 SOLAR ENERGY SCENARIO AND POTENTIAL IN INDIA

3.1 ENERGY - SCENARIO IN INDIA

Energy is one of the basic requirement for the leading a fulfilling life as it is essential for the existence and development of human life. The demand for energy is rising significantly at an alarming rate. The increase in standards of living, the consumption pattern of energy is progressively rising, which is further resulting in overall pressure on the energy supply situation. Use of conventional sources of energy is leading to a constant depletion of the fossil fuel reserves. This depletion coupled with the accelerated demand has caused increase in the cost of the fossil fuel.

Further, the use of fossil fuels causes air pollution which is resulting in air pollution on hand and on the other there is the problem of global warming. The ozone layer has is getting depleted which is further aggravating this problem. The gases released due to the usage of the conventional means of energy are resulting into the serious problems for the living organisms.

There is serious concern relating to the pollution of water bodies and sources which is destroying the aquatic organisms and affecting the valuable biotic environment apart from causing displacement of local inhabitants. All this has resulted in the need to address the issues and there is a great concern shown and expressed by all the regulators, environmentalist and the public in general to look for other sources of energy which are less polluting, if not completely pollution free. Solar energy is one of the sources of energy which is considered to be a natural and clean source.

The energy consumption in India in comparison to the world share is relatively less however it has a sizeable population of the world living in its territories. It is one of the fast growing economies of the world and a guaranteed availability of energy in a economical manner is pre requisite for meeting the energy needs and for the development of India. A large part of its billion plus is without

modern fuels and energy. It faces formidable challenge as far as energy is concerned. India has very less per capita energy consumption if a comparison is drawn with US or Europe. However, it is the rapid urbanisation, increasing consumerism by the sizable portion of the world population living in its territories that is driving the demand for energy. This demand is all the more likely to increase in view of the further growth and also due to the rise in living standards of the population.

To meet the demand it is necessary that not only should the energy be available but should also such source should be easy to access and should afford ease in economical terms that is to say that the source of energy should also be within the reach of average Indian so that he can utilize it easily. The Government also has to see that the development is also economically and environmentally sustainable in the long run. Bulk imports of fuel or energy are neither affordable nor strategically prudent for a country like India. To meet energy demand solar power can play important role. Solar energy seems to be viable option to meet the growing energy demand as it is easily available and is not exhaustible as like the fossil fuels.

India is a country that is bestowed with the tremendous solar energy potential. This potential is immense due to its convenient placement and location near the Equator in the world map. It being a tropical country has approximate 300 clear, sunny days in a year and receives adequate solar radiation. India receives nearly 3000 hours of sunshine every year, which is equivalent to 5000 trillion kWh of energy. The availability of solar energy exceeds the other possible energy output of all fossil fuel reserves. The daily average solar power plant generation capacity over India is 0.25 kWh per m^2 of used land area, which is equivalent to about 1,500–2,000 peak (rated) capacity operating hours in a year with the available commercially-proven technologies.[10]

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[10] http://www.briefingwire.com/pr/premia-group-is-into-energy-sector> (*Accessed on 13th November, 2015*)

India, as a nation is facing an ever increasing demand - supply gap in energy owing to the burgeoning population which is outpacing the supply position. The Solar Energy is a natural and sustainable source of energy which is clean and be put to several uses like generating solar electricity, solar cookers, solar cooling appliances, solar lighting appliances and solar heating appliances. Owing to the several benefits which solar energy offers, it is imperative to tap its potential so as to meet the different energy requirements of the ever increasing population. India is facing a continuous energy shortage, which is very significant in particular in the electricity sector where there is a great dependence on coal and other non renewable source of energy.

3. 2 INDIA'S POTENTIAL IN SOLAR ENERGY

Energy is one of the crucial elements in our day to day activities of life. The need for energy is growing at substantial rate with there being more or more advancement in the technology and access to various gadgets and other equipments being made available to all. Owing to the depletion of the conventional energy resources, increase energy demand, the conventional primary resources would not be in a position to meet the ever growing demand of energy in India and if would not be possible to meet the demand only through such resources. In order to meet the requirement the only way forward is to reduce the dependency and demand for the conventional fuels and to add more supply.

The Integrated Energy Policy Report, 2006, estimates that India will need to increase primary energy supply by three to four times and electricity generation by five to six times to meet the lifeline per capita consumption needs of its citizens and to sustain a 8 percent growth rate. The government plans to provide universal access and to increase per capita consumption to 1,000 kWh by 2012. This translates into a required generation capacity of 800GW compared to 160GW today. The need to bring on new generation

capacity—and to improve operational efficiency in transmission and distribution—is clear.[11]

Sun is already being considered as of the major source of energy. The sun could be the world's largest source of electricity by 2050, ahead of fossil fuels, wind, hydro and nuclear, according to the reports issued by the International Energy Agency (IEA). The IEA technology roadmaps show how solar photovoltaic (PV) systems could generate up to 16% of the world's electricity by 2050 while solar thermal electricity (STE) from concentrating solar power (CSP) plants could provide an additional 11%. Combined, these solar technologies could prevent the emission of more than 6 billion tonnes of carbon dioxide per year by 2050 - that is more than all current energy-related CO_2 emissions from the United States or almost all of the direct emissions from the transport sector worldwide today.[12]

India is now considered to be the eleventh largest economy in the world, fourth in terms of purchasing power. It is already making stride and is poised to make grow over the next ten years, with significant development. In recent years, there has been growing interest in India and it has emerged as one of the leading destinations for the investors from developed countries. The expansion of investments has brought benefits of employment, development, and growth in the quality of life, but only to the major cities. Now, it is being planned to take the development to the grass root level.

There is a growing fascination in India being considered as the next clean energy destination. This could be due to several reasons. This attraction is partially due to good quality production, good educated individuals and the avaivalibility of the manpower at lower cost. Perhaps it could be the

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11 Gevorg Sargsyan, Mikul Bhatia, Sudeshna Ghosh Banerjee Krishnan Raghunathan, Ruchi Soni *Unleashing the Potential of Renewable Energy in India(2010)* South Asia Energy Unit, Sustainable Development Department, The World Bank

12 <http://www.iea.org/newsroomandevents/pressreleases/2014/september/how-solar-energy-could-be-the-largest-source-of-electricity-by-mid-century.html> (*Accessed on 24th* October,2015)

announcement of plans to construct India's first multi-megawatt solar PV power plant or due to the big goal set by the Indian government to build solar power capacity of 100 GW, permitting 100% forign investment and offering series of tax breaks.

It is being considered that India is all set to have the greatest increase in energy and greenhouse gas (GHG) emissions globally after China and in order to deal effectively it must take the required steps today when the development is still going on so as to avoid an obsolete high emissions trajectory. In order to sustain the annual economic growth and to support the population, India's primary energy demand would multiply three to four times. It is expected that an increase would move India from being the fourth largest energy consumer in the world today to the third largest by 2030 after China and USA.

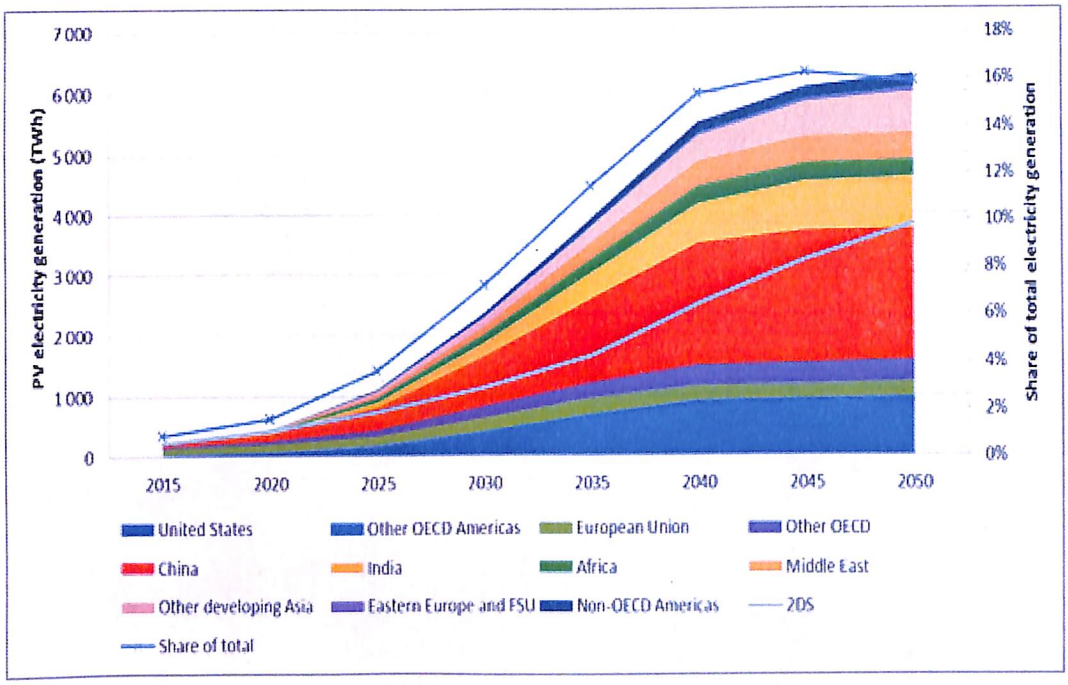
The potential of solar energy market is immense and till date very less of the aggregate potential has been realised. It has one of the biggest solar programmes in the world. The solar programme includes R & D, testing and standradiztion, demonstartion and utilization, industrial and other promotional activities. There are avenues which would come into existence for process raw meterial for solar cells, SPV roof tiles, Inverters, charge controllers. India as do advanced solar water heaters, roof integrated solar air heaters; and solar concentrators for power generation.

There are several hotspots which are can be used for the penetration of the solar energy so there is a need to assess the conditions, identity such land and put the same for the use of solar energy. Solar hotspots are considered to be the regions characterized by an exceptional solar power potential suitable for decentralized commercial exploitation of energy. Identification of solar hotspots in a vast geographical expanse with dense habitations helps to meet escalating power demand in a decentralized, efficient and sustainable manner.

Solar energy usage in the form of PV is showing a growing trend as the world has added mor solar PV capacity in the decades gone by. The Technology Roadmap: Solar Photovoltaic Energy - 2014 edition of the International Energy Agency (IEA) shows the trend of the increase in the electricity generation through PV is bound to rise in the future.

Figure-II

Regional production of PV electricity envisioned in the roadmap



Source: Technology Roadmap: Solar Photovoltaic Energy - 2014[13]

The present power scenario of India has a total installed capacity of 263.66 GW and RE capacity of 34.35 GW (13% of Installed capacity and approximately 7% of electricity produced) [14] India has a great potential to become one of the world's leading solar markets One of the advantages it has is beging in the tropics and close to equator. The low solar park construction costs and with the

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13 <http://www.iea.org/publications/freepublications/publication/technology-roadmap-solarphotovoltaic-energy---2014-edition.html> (*Accessed on 30th October, 2015*)

14 Renewable Energy in India: Growth andTargets, Ministry of New and Renewable Energy (MNRE) GEF National Workshop in India

overall costs of the solar energy taking a plung all augurs well for the India's aim of becoming the major player in solar energy sector in the global scene.

Irradiation scene of India

India is bestowed with the solar irradiation between 4 to 7kwh/sq km/day across the country. India receives the highest global solar radiation on a horizontal surface. It is the western and southern areas which have the higher solar incidence. This can be seen from the image below (Figure-III) relating to the global horizontal irradiation.

Figure-III

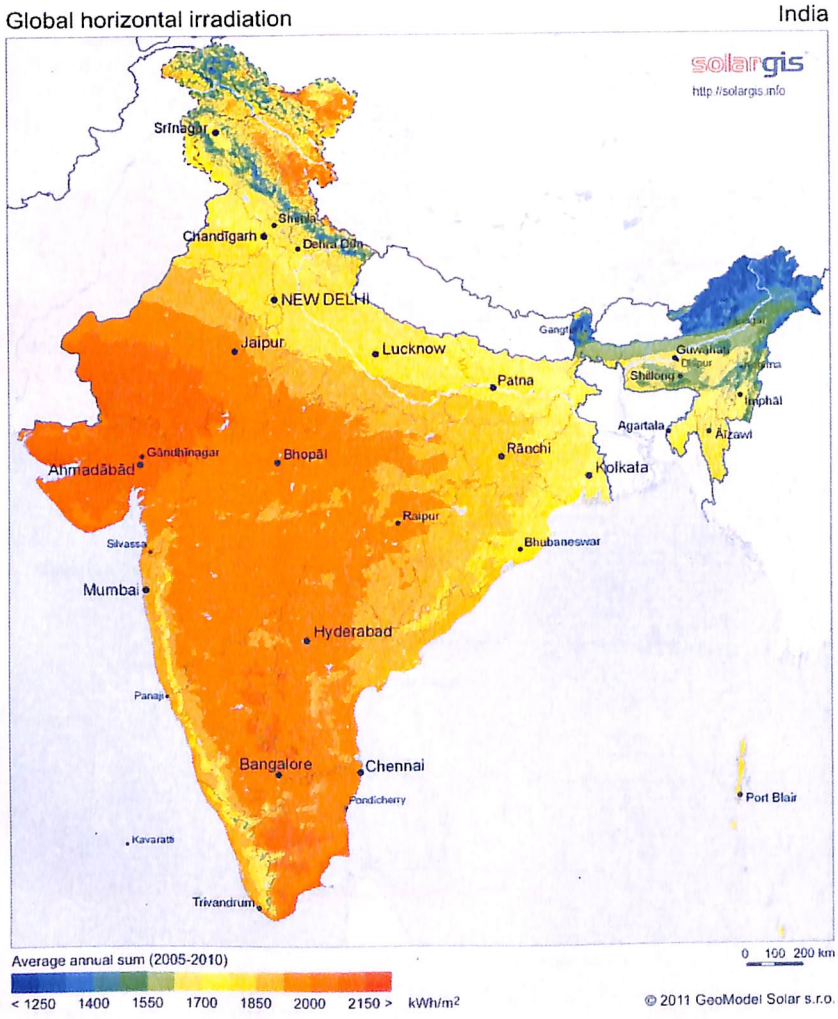


Image Source: http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-India-en.png

The solar energy has been put to use maximum in the western states of India with Gujarat and Rajasthan leading the way followed by Madhya Pradesh, Maharashtra and others. In near future Solar energy will have a huge role to play in meeting India's energy demand. The image below (**Figure -IV**) is showing the pictorial view of Global horizontal solar resource of various parts of India.

Figure -IV

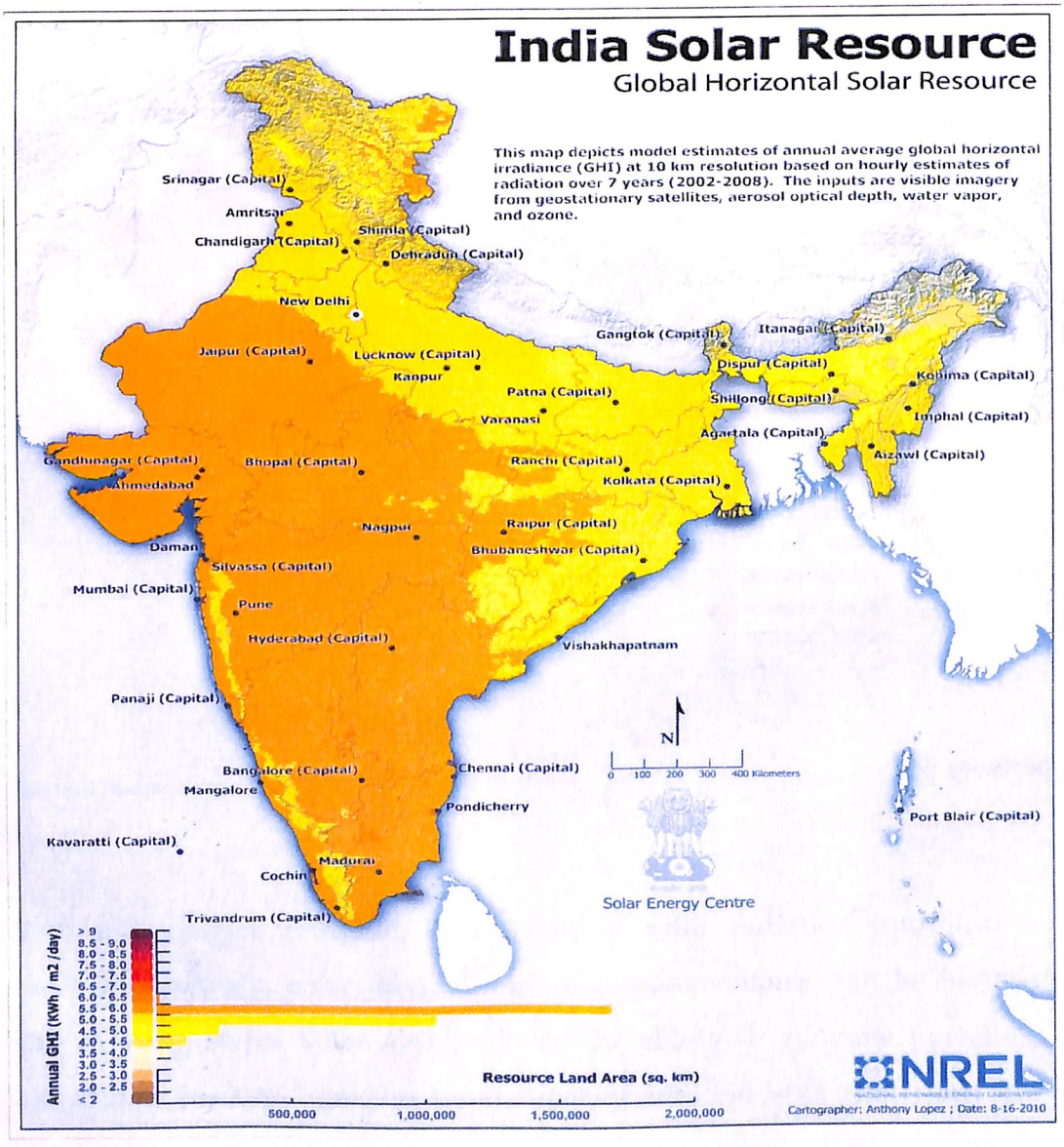
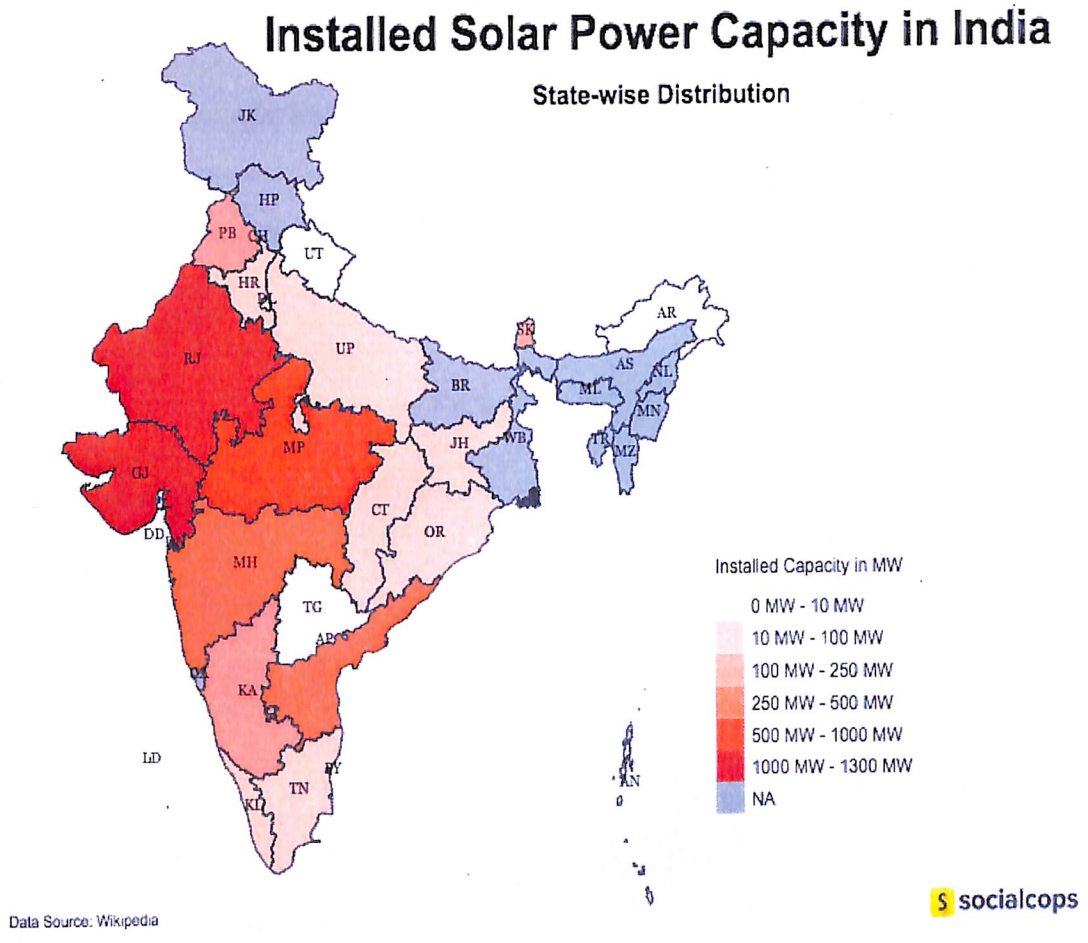


Image Source: Jawaharlal Nehru National Solar Mission, Phase – II, Policy Document

This also explains the reasons for the total installed solar power capacity in India is concentrated in the western side. The image below (**Figure –V**) depicts the installed solar power capacity in India.

Figure –V



Both technologies route for conversion of solar radiation into heat and electricity, namely, solar thermal and solar photovoltaics, can be harnessed effectively in India. Solar also provides the ability to generate power on a distributed basis and enables rapid capacity addition with short lead times. Off-grid decentralized and low-temperature applications will be advantageous

from a rural electrification perspective and meeting other energy needs for power and heating and cooling in both rural and urban areas.

From an energy security perspective, solar is the most secure of all sources, since it is abundantly available. Theoretically, a small fraction of the total incident solar energy (if captured effectively) can meet the entire country's power requirements. It is also clear that given the large proportion of poor and energy un-served population in the country, every effort needs to be made to exploit the relatively abundant sources of energy available to the country. [15] It is the realization of the importance of solar energy which had prompted the government to target 100,000 MW solar power by 2022. [16]

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15 <http://mnre.gov.in/mnre-2010/schemes/grid-connected/solar/>(*Accessed on 28th October, 2015*)

16 <http://www.business-standard.com/article/news-ians/government-looking-at-100-000-mw-solar-power- by-2022-114111701373_1.html >(*Accessed 26th October, 2015*)

4 REGULATORY REGIMES IN INDIA FOR SOLAR ENERGY

Regulations supporting the development of renewable energy in India are the Electricity Act of 2003 and the National Electricity Policy of 2005. The Electricity Act of 2003 provides and stipulates for certain percentage of the power procurement by distribution utilities from renewable energy sources. The Electricity Act, 2003 provides for implementation of the renewable portfolio obligation (RPO) is to be guided by the regulatory provisions issued by the respective State Electricity Regulatory Commissions (SERCs). The National Electricity Policy of 2005 also mandates that the share of electricity from non-conventional sources has to be increased progressively.

The regulatory and policy mechanism in respect of the solar sector is influenced or governed by the legislative provisions (e.g. Electricity Act, 2003, Energy Conservation Act, 2001) and several ministries under the Government of India, and the framework of institutional mechanism existing in the form of different agencies, bodies which are either serving as nodal agencies or are facilitating in the growth of solar energy.

There are different and multiple agencies which are involved in the renewable sector. The same holds good for the solar sector also. SERC is mandated by the legislation in the form of Electricity Act, 2003 which mandates it to promote generation of electricity from renewable resources by providing suitable measures for connectivity with the grid and sale of electricity to the persons.The Ministry of New and Renewable Energy is the nodal ministry which is related with all the matters relating to new and renewable energy. This Ministry works in coordination with the various agencies in the different states.

The institutional role for state and governmental agencies in policy development, regulation and promotion of renewable energy in India is mentioned in the following **Table – III** below:

Table-III

LEVEL	CENTRAL GOVERNMENT	(MINISTRY OF POWER / MINISTRY OF FINANCE)	CERC
Central	• Develops national electricity tariff policies, which also cover renewable energy • Provides fiscal incentives for promoting renewable energy	• Develops national renewable energy laws • Sets technical standards for renewable energy • Conducts resource assessments for renewable energy; supports R&D in renewable energy technologies • Promotes effective use of information technology for renewable energy, manages database • Reviews renewable energy programmes to understand their effectiveness and efficiency	• Sets guidelines for feedin-tariff design for different renewable energy technologies • Regulates the regional electricity corporation Mechanism • Regulates interstate open access, and third party sales
STATE	**STATE GOVERNMENT**	**STATE NODAL AGENCY**	**SERCS**
	• Develops state-level renewable energy policy • Provides fiscal incentives for promoting renewable energy sources	• Conducts resource assessments for various renewable energy sources • Allocates renewable energy projects and progress monitors • Provides facilitation services to project developers – Facilitates clearances and land acquisition • Creates awareness and educates the masses about adoption of renewable energy • Maintains database on renewable energy sources	• Develops feed-in tariff methodologies for different renewable energy technologies Determines RPOs and enforcement mechanism • Sets regulations on intrastate wheeling, open access, and third party sale

4.1 INSTITITIONAL FRAMEWORK

4.1.1 *Ministry of New and Renewable Energy (MNRE)*

MNRE is the nodal Ministry of the government of India for all matters relating to new and renewable energy and the administrative ministry for policies and programs in this area. This Ministry itself is organised into several divisions dealing with different technologies and applications. Due to the sudden increase in the price of oil, uncertainties associated with its supply and the adverse impact on the balance of payments position led to the establishment of the Commission for Additional Sources of Energy in the Department of Science & Technology in March 1981.

The Commission was charged with the responsibility of formulating policies and their implementation, programmes for development of new and renewable energy apart from coordinating and intensifying R&D in the sector. In 1982, a new department, i.e., Department of Non-conventional Energy Sources (DNES), that incorporated CASE, was created in the then Ministry of Energy. In 1992, DNES became the Ministry of Non-conventional Energy Sources. In October 2006, the Ministry was re-christened as the Ministry of New and Renewable Energy.[17]

MNRE is a scientific ministry in charge of the production development and application of solar energy including solar photovoltaic devices. It deploys strategy for the development and manufacture of the new and renewable energy product and services. This Ministry is responsible for the research and development of other non conventional/ renewable sources of energy and related programs. It promotes programs and extends assistance to the

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17 <http://mnre.gov.in/mission-and-vision-2/mission-and-vision/> (Accessed on 14th *November, 2015*)

industry in achieving the standards, specification and performance parameters. It brings about standardization in the industry and align them with the international standards and parameters

4.1.2 *Ministry of Power*

The Ministry of Power is mainly responsible for evolving general policy in the field of energy. The ministry is involved in overseeing the Central Government entities in the electricity sector. It formulates general policy in the electric power sector and issues relating to energy policy and coordination thereof. (Details of short, medium and long-term policies in terms of formulation, acceptance, implementation and review of such policies, cutting across sectors, fuels, regions and intra country and inter country flows. Amongst the various work items dealt with by the Ministry, this Ministry also oversees the administration of the Electricity Act, 2003 and the Energy Conservation Act, 2001 and all matters relating to Central Electricity Authority, Central Electricity Board and Central Electricity Regulatory Commission. [18]

4.1.3 *Ministry of Environment and Forests*

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal agency in the administrative structure of the Central Government for the planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programmes.

The primary concerns of the Ministry are implementation of policies and programmes relating to conservation of the country's natural resources including its lakes and rivers, its biodiversity, forests and wildlife, ensuring

[18] <http://powermin.nic.in/responsibilities> (*Accessed on 8th November, 2015*)

the welfare of animals, and the prevention and abatement of pollution. While implementing these policies and programmes, the Ministry is guided by the principle of sustainable development and enhancement of human well-being.[19]

MoEFCC deals with various issues which have a direct bearing on the solar sector. MoEFCC administers through various legislations number of consent, approvals and permission which are accorded by the bodies constituted under the environmental related laws. The Environmental Impact Assessment (EIA) is carried out by the MoEFCC before a project can be allowed.

4.1.4 Ministry of Finance

Ministry of Finance lays down the fiscal and monetary policies. It also provides for the budgetary provisions. This Ministry also deals with all the policy related issues pertaining to energy sector. It examines all the proposals which are received from the Ministry of New and renewable Energy for allocation of funds. It grants and allocate fund for several of the projects and schemes.

Apart from the Ministries which directly or indirectly play an important role in propagation of solar energy, there are other bodies and agencies which have an important role in connection with the solar sector in India

4.1.5 Central Electricity Regulatory Commission

Central Electricity Regulatory Commission ('CERC') is a statutory body functioning under Section - 76 of the Electricity Act 2003 (CERC was initially

[19] <http://www.moef.nic.in/about-ministry/about-ministry> (*Accessed on 10th November, 2015*)

constituted under the Electricity Regulatory Commissions Act, 1998 on 24th July, 1998). The Commission intends to promote competition, efficiency and economy in bulk power markets, improve the quality of supply, promote investments and advise government on the removal of institutional barriers to bridge the demand supply gap and thus foster the interests of consumers.

In pursuit of these objectives the Commission aims to –

- Improve the operations and management of the regional transmission systems through Indian Electricity Grid Code (IEGC), Availability Based Tariff (ABT), etc.
- Formulate an efficient tariff setting mechanism, which ensures speedy and time bound disposal of tariff petitions, promotes competition, economy and efficiency in the pricing of bulk power and transmission services and ensures least cost investments.
- Facilitate open access in inter-state transmission
- Facilitate inter-state trading
- Promote development of power market
- Improve access to information for all stakeholders.
- Facilitate technological and institutional changes required for the development of competitive markets in bulk power and transmission services.
- Advise on the removal of barriers to entry and exit for capital and management, within the limits of environmental, safety and security concerns and the existing legislative requirements, as the first step to the creation of competitive markets[20].

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[20] <http://www.cercind.gov.in/Mission.html> (*Accessed on 7th November, 2015*)

As entrusted by the Electricity Act, 2003 the Commission has the responsibility to discharge the following functions:-

Mandatory Functions:-

- to regulate the tariff of generating companies owned or controlled by the Central Government;.
- to regulate the tariff of generating companies other than those owned or controlled by the Central Government specified in clause (a), if such generating companies enter into or otherwise have a composite scheme for generation and sale of electricity in more than one State;
- to regulate the inter-State transmission of electricity ;
- to determine tariff for inter-State transmission of electricity;
- to issue licences to persons to function as transmission licensee and electricity trader with respect to their inter-State operations;
- Improve access to information for all stakeholders.
- to adjudicate upon disputes involving generating companies or transmission licensee and to refer any dispute for arbitration;
- to levy fees for the purposes of the Act;
- to specify Grid Code having regard to Grid Standards;
- to specify and enforce the standards with respect to quality, continuity and reliability of service by licensees;
- to fix the trading margin in the inter-State trading of electricity, if considered, necessary;
- to discharge such other functions as may be assigned under the Act.

Advisory Functions:-

- formulation of National Electricity Policy and Tariff Policy;
- promotion of competition, efficiency and economy in the activities of the electricity industry;
- promotion of investment in electricity industry;

- any other matter referred to the Central Commission by the Central Government.[21]

There exist several nodal agencies and departments at the state level which operate for the effective implementation of the solar energy. These agencies come under the purview of the state government and are entrusted with the role and function of promoting the solar energy deployment by providing assistance, channeling central-level subsidies and implementing demonstration projects.

The MNRE provides grants to such agencies for their expenditure which is recurring and non-recurring in nature. The Indian Renewable Energy Development Agency (IREDA) – the financial arm of the MNRE provides financial assistance to renewable energy projects. It provides loans and also channels funds and other initiatives to promote renewable energy.

4.1.6 State Electricity Regulatory Commission

The State Electricity Regulatory Commission ('SERC') has been envisaged in the Electricity Regulatory Commissions Act, 1998. As per Section 17(1) of the Act, the State Government may, if it deems fit, establish an Electricity Regulatory Commission for the State. Portion of the relevant said section is below

"Section 17 **ESTABLISHMENT AND INCORPORATION OF STATE COMMISSION.** -

(1) *The State Government may, if it deems fit, by notification in the Official Gazette, establish, for the purposes of this Act, a Commission for the State to be known as the (name of the State) Electricity Regulatory Commission.*

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[21] <http://www.cercind.gov.in/Function.html (*Accessed on 6th November,2015*)

(2) *The State Commission shall be a body corporate by the name aforesaid, having perpetual succession and a common seal, with power to acquire, hold and dispose of property, both movable and immovable, and to contract and shall, by the said name, sue or be sued.*

..."

The main functions of the SERC would be:

(i) to determine the tariff for electricity, wholesale, bulk, grid or retail;
(ii) to determine the tariff payable for use by the transmission facilities,
(iii) to regulate power purchase and procurement process of transmission utilities and distribution utilities, to promote competition, efficiency and economy in the activities of the electricity industries, etc.

Subsequently, as and when each State Government notifies, other regulatory functions could also be assigned to SERCs.[22]

SERCs have responsibilities similar to the CERC. They have the authority to make regulations, act as the regulator and also fulfil quasi-judicial functions concerning intra-state matters. SERCs also are responsible for:

- granting the electricity transmission, distribution and trading licences in respect of their intra-state operations;
- stipulating the general and special conditions of the licence;
- revoking licences or selling licences through bidding;
- regulating the tariff of generating stations owned by a state government entity or by generating companies involved in generating electricity within a state;
- regulating the intra-state transmission and supply of electricity; and

[22] <http://powermin.nic.in/state-electricity-regulatory-commission>(*Accessed on 11th November, 2015)*

- promoting co-generation and generation of electricity from renewable energy sources by providing suitable grid connectivity measures and regulating the sale of such electricity. In this respect, the SERCs are required to specify the renewable energy purchase obligation (RPO) for distribution licensees (both private and state-owned), open access consumers and captive power plants.

4.1.7 *The Indian Renewable Energy Development Agency* (IREDA)

IREDA is a Non-Banking Financial Institution which is under the administrative control of the Ministry of New and Renewable Energy. IREDA provides term loans for renewable energy and projects focused on energy efficiency. IREDA is registered as a non-banking financial company and arranges its resources through market borrowing and lines of credit from bilateral and multilateral lending agencies.

The mission of IREDA is to promote, develop and extend financial assistance for renewable energy and energy efficiency/conservation projects The IREDA financial services include direct project financing, equipment finance, business development finance, loans for manufacturing facilities of energy efficiency equipment, and loans to banks/financing institutions for on-lending. It is funded partly through the Central government and also receives funding from the German development bank (KfW), French development bank (AFD), Nordic Investment Bank (NIB), European Investment Bank (EIB), Japan International Cooperation Agency (JICA), World Bank, Asian Development Bank, and other international financial institutions.

The main objectives of IREDA are:

1. To give financial support to specific projects and schemes for generating electricity and / or energy through new and renewable sources and conserving energy through energy efficiency.
2. To increase IREDA's share in the renewable energy sector by way of innovative financing.
3. To strive to be competitive institution through customer satisfaction.
4. To maintain its position as a leading organization to provide efficient and effective financing in renewable energy and energy efficiency / conservation projects.
5. Improvement in the efficiency of services provided to customers through continual improvement of systems, processes and resources.[23]

There are several nodal agencies which are in working in various states. Such nodal agencies are engaged in carrying out and implementing various policies related to solar sector in different states. These agencies help the Central Government in achieving and implementing the targets related to penetration of solar energy to the grass root levels. Some of the nodal agencies are Andhra Pradesh State Load Dispatch Centre, Assam Energy Development Agency, Bihar Renewable Energy Development Agency, Chhattisgarh State Renewable Energy Development Agency, Energy Efficiency & Renewable Energy Management Centre, Gujarat Energy Development Agency, Haryana Renewable Energy Development Agency (HAREDA), Directorate of Energy (DOE), Jammu & Kashmir State Power Development Corporation, Jharkhand Renewable Energy Development Agency, SLDC, KPTCL, ANERT, Maharashtra Energy Development Agency (MEDA), Zoram Energy Development Agency, Punjab Energy Development Agency, Uttar Pradesh New and Renewable Development Agency, Tamil Nadu Transmission Corporation Limited (TANTRANSCO), State Load

[23] <http://ireda.gov.in/> *(Accessed on 9th November, 2015)*

Despatch Centre (SLDC), Uttarakhand Renewable Energy Development Agency (UREDA), West Bengal State Load Despatch Centre

4.2. LEGISLATIVE FRAMEWORK AND POLICY FRAMEWORK

4.2.1 Electricity Act, 2003

The Electricity Act of 2003 ('Electricity Act') transformed the power sector in India. It brought about changes by way of deregulating the power generation, providing for and opening access in transmission, and by allowing the state electricity regulatory commissions to fix the level of renewable energy procurement.

Electricity Act consolidates laws of electricity relating to generation, transmission, distribution and trading of electricity. It creates and aims to further achieve an environment which is conducive for development of electricity industry by introduction of competition. It provides for the establishment and constitution of Central and State Regulatory Commissions *(details of which are provided hereinbefore)* to rationalize electricity tariffs. Electricity Act has created provisions for the protection of the interest of the consumers, rationalization of the tariffs, ensuring transparent policies towards subsidies, promotion of efficient and environmentally benign policies.

The salient features of the Electricity Act are preparation of the National Electricity Policy and tariff policy by the Central Government in consultation with the State Governments. It also provides for optimal utilisation of the power generating resources, including the renewable energy resources. This Act gave thrust to towards rural electrification and provided for the management of rural distribution by involving panchayats, cooperative

societies, non-government organizations, franchises, etc. Thus, there is more decentralization approach provided for relating to the issues connecting with electricity. The generation has been relicensed and captive generation has been freely permitted. Private sector participation has been encouraged. Cross subsidy phase out is provided for gradually. Stringent punishments have been provided for theft related to electricity.

The guidelines for competitive procurement have been framed under Section 63 of the Electricity Act, 2003 which states:

"Notwithstanding anything contained in Section 62, the Appropriate Commission shall adopt the tariff if such tariff has been determined through transparent process of bidding in accordance with the guidelines issued by the Central Government"

Section 86 (1) (e) of the Electricity Act, 2003 provides for the promotion 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 consumption of electricity in the area of a distribution licence. The relevant section is provided for in **Annexure A**

4.2.2 *National Electricity Policy 2005*

In compliance with section 3 of the Electricity Act 2003, the Central Government notified the National Electricity Policy. National Electricity Policy aims at laying guidelines for accelerated development of the power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders keeping in view availability of energy resources, technology available to exploit these resources, economics of generation using different resources, and energy security issues. The

National Electricity Policy aims at achieving the objectives: of providing access to Electricity and making availability of Power on demand.

The aim of the National Energy Policy is to overcome energy and peaking shortages overcome and make available adequate spinning reserve. Ensure supply of reliable and quality Power of specified standards efficiently and at reasonable rates and to increase the per capita availability of the electricity. The National Electricity Policy has been evolved in consultation with and taking into account views of the State Governments, Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC) and other stakeholders. The policy aims and provides for conservation of energy. It is considered that solar water heating systems and solar passive architecture can contribute significantly to this effort.

4.2.3 *The National Tariff Policy, 2006*

Section 3 (1) of the Electricity Act 2003 empowers the Central Government to formulate the tariff policy. The tariff policy has been evolved in consultation with the State Governments and the Central Electricity Authority (CEA) and keeping in view the advice of the Central Electricity Regulatory Commission and suggestions of various stakeholders.

The objectives of this tariff policy are to:

(a) Ensure availability of electricity to consumers at reasonable and competitive rates;
(b) Ensure financial viability of the sector and attract investments;
(c) Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimise perceptions of regulatory risks;

(d) Promote competition, efficiency in operations and improvement in quality of supply

Tariff policy lays down following framework for performance based cost of service regulation in respect of aspects common to generation, transmission as well as distribution[24].

4.2.4 *Jawaharlal Nehru National Solar Mission* (JNNSM / SOLAR MISSION)

The Jawaharlal Nehru National Solar Mission was launched on the 11th January, 2010 by the Prime Minister. 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.[25]

Jawaharlal Nehru National Solar Mission (JNNSM) was started to establish India as a global leader in solar energy, by creating the policy conditions for its large scale usage across the country as quickly as possible. The Mission has been planned in 3-phases, beginning in the 11th Plan and first year of the 12th Plan (up to 2012-13) as Phase I, the remaining 4 years of the 12th Plan (2013-17) as Phase II and the 13th Plan (2017-22) as Phase III.

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24 TARIFF POLICY at http://www.mahadiscom.in/consumer/national%20tariff%20policy.pdf > *(Accessed on 10th November, 2015)*

25 < http://www.mnre.gov.in/solar-mission/jnnsm/introduction-2/> *(Accessed on 11th November, 2015)*

The targets set by the JNNSM are as mentioned in **Table -IV**[26]

Table -IV

Sector	Phase I	Phase II	Phase III
Utility Grid Power including rooftop (in MW)	1,100	4000-10000	20,000
Off Grid Solar Installations(in MW)	200	1,000	2,000
Solar Collectors (in million square meters)	7	15	20

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. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. This mission was an initiative under the India's National Action Plan on Climate Change (NAPCC).[27]

In launching the NAPCC, the then prime minister Dr. Manmohan Singh observed:

> *"Our vision is to make India's economic development energy-efficient. Over a period of time, we must pioneer a graduated shift from economic activity based on fossil fuels to one based on non-fossil fuels and from reliance on non-renewable and depleting sources of energy to renewable sources of energy. In this strategy, the sun occupies centre-stage, as it should, being literally the*

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26 <http://mnre.gov.in/file-manager/UserFiles/draft-jnnsmpd-2.pdf> *(Accessed on 25th October, 2015)*

27 < http://www.mnre.gov.in/solar-mission/jnnsm/mission-document-3/> *(Accessed on 25th October, 2015)*

original source of all energy. We will pool our scientific, technical and managerial talents, with sufficient financial resources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people. Our success in this endeavour will change the face of India. It would also enable India to help change the destinies of people around the world."

The National Action Plan on Climate Change also points out: "India is a tropical country, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has great potential as future energy source. It also has the advantage of permitting the decentralized distribution of energy, thereby empowering people at the grassroots level".

Based on this vision a National Solar Mission is being launched under the brand name "Solar India".[28] The main objective of JNNSM is to establish India as a global leader in solar energy, by creating the policy conditions for its large scale diffusion across the country as quickly as possible. The immediate aim of the JNNSM was to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level.

The objective of JNNSM is also to create a policy and regulatory environment which provides a predictable incentive structure that enables rapid and large-scale capital investment in solar energy applications and encourages technical innovation and lowering of costs.

The Electricity Act already provides a role for renewables but given the magnitude and importance of the activities under the Mission, it would be necessary to make specific amendments. The National Tariff Policy 2006

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[28] Jawaharlal Nehru National Solar Mission; Towards Building SOLAR INDIA

mandates the State Electricity Regulatory Commissions (SERC) to fix a minimum percentage of energy purchase from renewable sources of energy taking into account availability of such resources in the region and its impact on retail tariff. National Tariff Policy, 2006 would be modified to mandate that the State electricity regulators fix a percentage for purchase of solar power.[29] Besides regulatory framework there are certain regulations which are framed by the respective governments that also govern the solar sector in India.

However, despite overall constraints especially the initial capital investment required in the adoption of the solar energy it is heartening to see the progress made by the government under the JNNSM.

Table -V

Summary of targets and achievements during Phase-I of JNNSM (2010-13)[30]

APPLICATION SEGMENT	TARGET FOR PHASE I (2010-13)	ACHIEVEMENTS TILL MARCH, 2013
Grid solar power (large plants, roof top & distribution grid plants)	1,100 MW	1686.44 MW
Off-grid solar applications	200 MW	252.5 MW
Solar Thermal Collectors (SWHS, Solar Cooking, solar cooling, Industrial process heat applications, etc.)	7 million sq. meters	7.01 million sq. meters

A huge interest has been generated in the solar sector by the progress made in the Phase – I of the JNNSM (2010-13). Number of Grid connected and off grid projects were commissioned throughout the country. The achievements as can

[29] JAWAHARLAL NEHRU NATIONAL SOLAR MISSION, Ministry of New and Renewable Energy, Annual Report 2014-2015

[30] < http://mnre.gov.in/file-manager/annual-report/2014-2015/EN/Chapter%204/chapter_4.htm> JAWAHARLAL NEHRU NATIONAL SOLAR MISSION, Ministry of New and Renewable Energy, Annual Report 2014-2015 (*Accessed on 10th November, 2015*)

be seen from the **Table – VI** clearly depict that Achievements of Phase-I of JNNSM have exceeded the target set for the period.

The achievements in Phase – I has set the pace and momentum for Phase-II, Accordingly, the targets have been set as can be seen from the Table –VI below

TABLE - VI

Targets of Phase-II

APPLICATION SEGMENT	TARGET FOR PHASE 2 (2013-17)
Grid solar power (large plants, roof top & distribution grid plants)	9,000 MW
Off-grid solar applications	800 MW
Solar Thermal Collectors (SWHS, solar cooking, solar cooling, Industrial process heat applications, etc.)	8 million sq. meters

As per NATIONAL INSTITUTE OF SOLAR ENERGY after taking into account the data from census of 2011, the state wise potential as carried is provided for in Annexure C.

5. INVESTMENTS POTENTIAL AND MARKET FOR SOLAR ENERGY IN INDIA

There is an immense potential that India has in the solar sector and that it can offer to the world at large. It is well known that Europe, Japan and China have been the major contributor to the development of the solar industry in the past. It is the Europe's feed in tariff which actually propelled the growth in the solar industry. It was followed by China which brought in the low cost manufacturing and also billions in capacity expansion at an enormous pace.

The growth now in US and Japan is growing demand based on the market forces. India relatively has been a bit late starter in the solar sector despite the several advantages it has as compared to other countries. Apart from the fact that India receives sunshine of approximate 3000 hours in a year which is more or less equivalent of 5000 kWh of energy and that it can generate over 1,900 billion units of solar power annually, which is enough to service the annual power demand, it has a burgeoning population which is underserved. The population of over 1 billion offers an immense opportunity for growth that could well last and serve for decades.

The Indian power sector has an investment potential of Rs 15 trillion (US$ 237 billion) in the next 4–5 years, thereby providing immense opportunities in power generation, distribution, transmission, and equipment, according to Union Minister Mr. Piyush Goyal. The immediate goal of the government is to generate two trillion units (kilowatt hours) of energy by 2019. This means doubling the current production capacity to provide 24x7 electricity for residential, industrial, commercial and agriculture use.[31]

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31 <http://www.livemint.com/Industry/ZbiJfKOmhGGN5H6XewPhuJ/Power-sector-has-investment-potential-of-250-bn-in-next-56.html> (*Accessed on 28th October, 2015*)

India is still not amongst the top ten countries making the use of the solar energy however; owing to growth in the sector it is not far that India may well become the fourth largest user of solar energy after Germany, Japan and China. India has several advantage one of them is to have solar radiation in abundance. The country receives solar radiation equivalent to more than 5,000 trillion kWh/year, which is far more than its total annual energy requirement.[32] India is located between the Tropic of Cancer and the Equator and has an average annual temperature that ranges from 25°C - 27.5 °C. This situation provides India with a huge solar potential.

The Indian Government has realised the potential and it is for this reason it has revised the National Solar Mission with the electricity production target of 100,000 MW by 2022. The thrust and push given by the government has already generated interest in the investors looking to tap into the emerging market. Japanese telecom multinational SoftBank, India's biggest wireless telecom provider Bharti Enterprises and Taiwan's technology manufacturer Foxconn Technology have together announced a $20 billion joint venture[33]

The Chief Executive of Softbank Mayayoshi Son realises the importance and that led to comment "India can become probably be the largest country for solar energy". It is the low cost at which the construction of solar park which is going in favour of India. Son said "India has two times the sunshine of Japan. The cost of construction of the solar park is half of Japan. Twice the sunshine, half the cost, that means four times the efficiency," Son said.[34]

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32 http://mnre.gov.in/schemes/decentralized-systems/solar-systems/

33 Japan's Softbank to Invest $20 Billion in Solar Energy Projects in India at http://time.com/3931551/softbank-solar-energy-power-india-japan-climate-change/ (*Accessed on 7th November, 2015*)

34 Japan's Softbank to Invest $20 Billion in Solar Energy Projects in India at http://time.com/3931551/softbank-solar-energy-power-india-japan-climate-change/ (*Accessed on 7th November, 2015*)

Even the cost of land is relatively cheaper. India has vast land which can be put to use for the generation of the electricity through the use of solar energy.

SunEdison announced that it would put $2 billion into a joint venture with Adani Group to manufacture photo voltaic modules. China's Trina Solar has plans to invest to invest in a plant to make panels in joint venture with India's Welspun Energy [35]

Central and state governments have embarked on several initiatives to promote solar energy. There have been various scheme which have been introduced which aim at increasing the penetration of the solar energy into everyday life. This change is being given effect in a gradual manner. The scheme relates to solar parks, standalone mini-grids for rural electrification, rooftop solar projects and off-grid applications such as solar cookers, lanterns and others for generating maximum solar power and its usage in India.

The Government of India has identified power sector as a key sector of focus so as to promote sustained industrial growth and the government has been aggressively pursuing the implementation of solar energy. Some initiatives undertaken by the Government of India to boost the Indian power sector:

- A Joint Indo-US PACE Setter Fund has been established, with a contribution of US$ 4 million from each side to enhance clean energy cooperation.
- The Union Cabinet of India approved 15,000 MW of grid-connected solar power projects of National Thermal Power Corporation Ltd (NTPC).

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[35] For Investors, India's Solar Push Could Signal A Gold Rush at <http://www.forbes.com/sites/saritharai/2015/07/07/for-investors-indias-solar-push-could-signal-a-gold-rush/> (Accessed on.13th November, 2015)

- US Federal Agencies committed a total of US$ 4 billion for projects and equipment sourcing, one of the biggest deals for the growing renewable energy sector in India.

- On 20 January 2015, a Memorandum of Collaboration (MoC) was signed in New Delhi between all Indian Institute of Technology (IITs) and Oil & Natural Gas Corporation (ONGC) to work towards a collective research and development (R&D) programme for developing indigenous technologies to enhance exploration and exploitation of hydrocarbons and alternative sources of energy.

- The Reserve Bank of India (RBI) has notified to include renewable energy under priority sector lending (PSL). Therefore, banks can provide loans up to a limit of US$ 2.36 million to borrowers for renewable energy projects.

- The Andhra Pradesh Government plans to establish an 'Energy University', which would focus on research orientation and development of energy efficiency, energy conservation, and renewable sources. [36]

The potential of the Indian solar sector can be ascertained from the facts mentioned below:

- From barely 20 MW in 2011, India's installed solar capacity has increased to 3.74 GW as on 31.03.2015.

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[36] INDIAN POWER SECTOR at http://www.ibef.org/industry/power-sector-india.aspx *(Accessed on 6th November, 2015)*

- India has vast untapped renewable energy resources – wind energy has installed capacity of 23.44 GW and an estimated potential of 102.8 GW.
- Small hydro has installed capacity of 4 GW and an estimated potential of 19.7 GW.
- Bio-power (including biomass and bagasse co-generation) has an installed capacity of 4.4GW as opposed to an estimated potential of 22.5 GW.
- Solar power has installed capacity of 3.74 GW with the potential of 7.48 GW.
- The Solar Policy of Rajasthan notified in 2011 envisages the setting up of solar manufacturing facilities at proposed solar parks.
- The Gujarat Solar Park also makes special provisions for encouraging on-site manufacturing facilities to provide equipment to projects coming up within the park as well as adequate repairs, maintenance and skilled manpower to service projects within the park.[37]

India's solar energy market provides a great opportunity for foreign investors, since the China's market has proved impenetrable. The aggressive capacity addition which has been outlined by the government, India is slated to be the next destination for investment by the global players.

5.1 *Opportunities for Solar Thermal Power Generation in India*

Rajasthan and Gujarat (northern part) receive the highest annual global radiation and are considered to be the places in India where the solar thermal technologies can be really put to use and which can be give the required boost to the add up to the capacity build up in the energy sector.

First Solar Thermal Power Plant of 50kW capacity was installed by MNRE at Gwalpahari, Gurgaon. This commissioning of this Plant was carried out in the

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[37] <http://www.makeinindia.com/sector/renewable-energy> (*Accessed on 13th October, 2015*)

year 1989. Mathania in Rajasthan has a Solar Thermal Power Plant with the capacity of 140MW, which the Rajasthan Government has sanctioned.

Rajasthan has and offers immense opportunities in development and use of Solar Thermal Power Plant as it has huge tract of land which is barren in nature and is sparely populated. This makes such areas suitable as locations for the development of large central power stations that are based on the use of solar energy. The government has laid emphasis on development of such projects. These projects are being developed with the main thrust being laid on:

(i) Development of the solar power technology in order to lead and minimize the production cost;

(ii) Reduction of the greenhouse gases (GHG) with a long term perspective;

(iii) Show casing the operational viability of the generation of power through the use of parabolic trough solar thermal technology;

The demonstration of the operational viability is important as this would demonstrate to others the opportunities India can afford. The operational viability can be demonstrated by way of operation of a solar thermal plant with the delivery arrangement with the grid and commercial power sales. Training and technical assistance would support the Technology development.

Such demonstration projects aim at ensuring capacity build up by way of 'hand on' experience in the operation, design and management of projects under the conditions, which is actual in nature. Such projects augment the capability of the local technical expertise and also to the capacity build up. The local players like Rajasthan State Power Corporation Limited (RSPCL), Rajasthan, private construction and operations contractors, Rajasthan State Electricity Board (RSEB), Rajasthan Energy Development Agency (REDA), Central Electricity Authority (CEA) have a role to play by being involved in such projects and this augurs well for the Indian renewable energy sector especially the Solar

Thermal Power projects since it would enable the development in India of the solar power sector in the longer run.

Demonstration of such solar projects would yield benefits in the form of follow up investments from the private sector in the manufacture of components in the solar field and of the solar station in India. The promotion of megawatt scale projects is carried out MNES and the private sector participation is being encouraged through financial assistance from the Ministry.

Solar thermal power generation plays an important role in meeting the demand supply gap for electricity. The three main types of applications were the solar thermal power generation can possibly play an important role is:

1. Rural electrification using solar dish collector technology.

2. Typically these dishes care of 10 to 25 kW capacity each and use striling engine for power generation. These can be developed for village level distributed generation by hybridizing them with biomass gasifier for hot air generation.

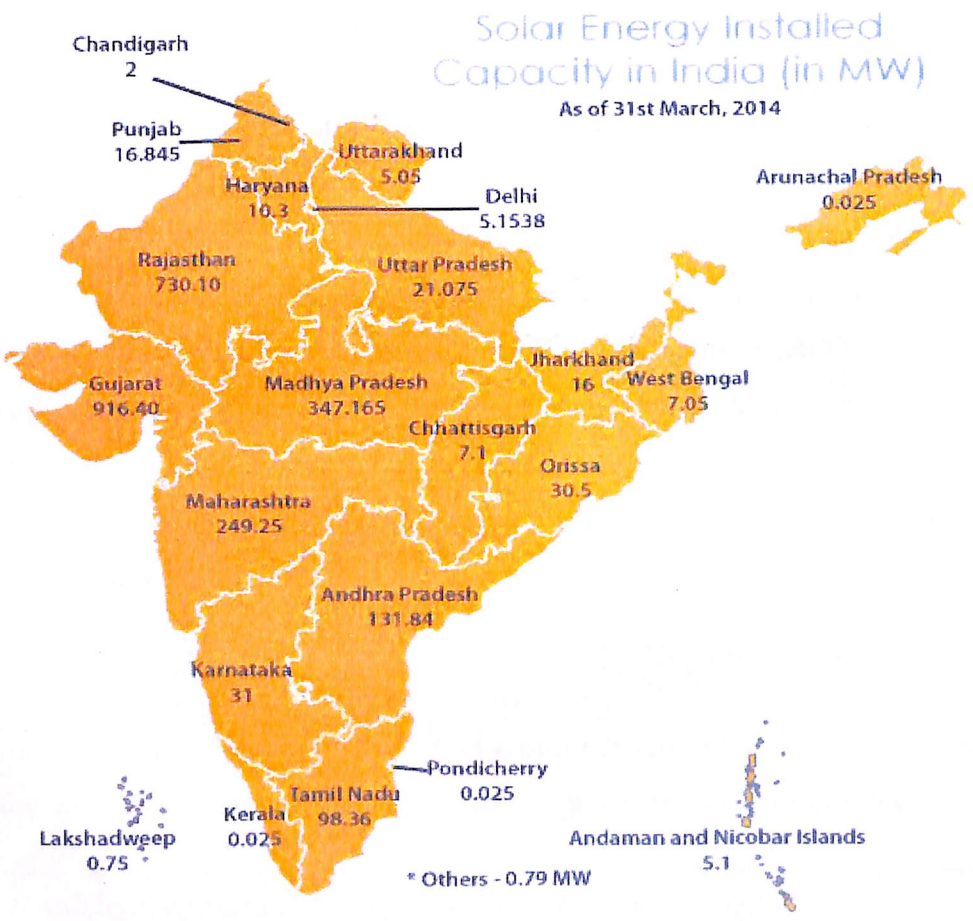
3. Integration of solar thermal power plants with existing industries such as paper, dairy or sugar industry, which has cogeneration units Many industries have steam turbine sets for cogeneration. These can be coupled with solar thermal power plants. Typically these units are of 5 to 250 MW capacities and can be coupled with solar thermal power plants. This approach will reduce the capital investment on steam turbines and associated power-house infrastructure thus reducing the cost of generation of solar electricity.

4. Integration of solar thermal power generation unit with existing coal thermal power plants. The study shows that savings of up to 24% is

possible during periods of high insolation for feed water heating to 241°C.[38]

As of March 2014, India's solar energy installed capacity was majorly spread across 8 states Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu, Karnataka and Uttar Pradesh.

Figure – VI



State-wise Solar Energy Installed Capacity in India (in MW)[39]

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38 **Aniket Dwivedi, Ajay Bari and Gaurav Dwivedi (2013)** *Scope and Application of Solar Thermal Energy in India-A Review,* International Journal of Engineering Research and Technology. p 137 *accessed* at http://www.ripublication.com/irph/ijert_spl/ijertv6n3spl_04.pdf. (*Accessed on* 10.11.2015)

In India, solar energy is slated to play an important role. Solar Energy is expected to account for 18 per cent of total power generation capacity in India by 2030 from one per cent at present, playing a key role in the country's efforts to achieving 40 per cent installed power capacity from renewable energy.

In its recently-submitted Intended Nationally Determined Contributions (INDC) ahead of the crucial climate change conference in Paris from November 30 to December 11, India has committed to achieving 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 203040

As of 31st March 2014, India had 2631.9038 MW of grid connected solar power projects which were commissioned under Jawaharlal Nehru National Solar Mission (JNNSM). This included 687.8 MW projects by Ministry of New & Renewable Energy (MNRE), 1322.59 MW under various state government policies, 90 MW under renewable purchase obligation (RPO), 490.685 under renewable energy certificate (REC) scheme, 15.6288 MW by private initiative (roof-top) and 25.2 MW by central public sector undertakings (CPSUs). This was an increment of 947.4683 MW over last year which ended with 1684.4355 MW as of 31st March 2013.[41]

Export Scenario

India currently has an overall production capacity of 1GW for cells and 2MW for modules. This production capacity exceeds the present PV installation

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39 <www.greensummit.in/.../India-Renewable-Energy-Status-Report-2014>*p.37 (Accessed on 13.11.2015)* MNRE, INDIA RENEWABLE ENERGY STATUS REPORT 2014

40 <http://articles.economictimes.indiatimes.com/2015-11-05/news/68043930_1_power-generation-capacity-energy-needs-cent> By 2030, solar power to make up 18% of Indian energy generation PTI (Nov 5, 2015) (*Accessed on* 9th November, 2015)

41 < www.greensummit.in/.../India-Renewable-Energy-Status-Report-2014> INDIA RENEWABLE ENERGYSTATUS REPORT 2014 (*Accessed on* 9th November, 2015.)

capacity in the country significantly and will remain so in the coming years considering the annual growth rates witnessed in the past. India's export of solar PV cells was at US$ 49.77 million in 2003-04 which rose to US$ 207.21 million in 2013-14 (Apr-Dec). India exported US$ 2351.21 million worth of solar PV cells and the overall exported quantity was 47.33 million units between 2003-04 and 2013-14 (Apr-Dec).

India's exports of solar PV cells and modules have fallen after FY 2010-11 majorly due to fall in prices by about 80% (US$ 3/watt to US$ 0.6/watt) during 2010-13. The major reason behind this was the huge increase in capacity buildup by Chinese manufacturers backed by a US$ 43 billion subsidy and soft loans from Chinese government.[42]

India's import of solar PV cells was at US$ 14.94 million in 2003-04 which rose to US$ 539 million in 2013-14 (Apr-Dec). India imported US$ 3914.31 million worth of solar PV cells and the overall imported quantity was 599.61 million units between 2003-04 and 2013-14 (Apr-Dec). The main drivers and inhibitors which are considered to be drivers of the solar energy market are mentioned in Table VII:

Table -VII

INHIBITORS	DRIVERS
- High Initial Investment - Large Land Requirements - Variable Energy Outputs - Lack of Transmission Infrastructure - Delay in Payments - Lack of Strict Enforcement of RPOs - Poor State of R&D - Cheap Solar Imports from Countries Like China	- Huge Demand-Supply Gap in Power Sector - Government Incentives - Cost Competitiveness of RE - Shift to Clean Energy - Distributed Electricity Demand - Huge Untapped Potential

[42] <www.greensummit.in/.../India-Renewable-Energy-Status-Report-2014> INDIA RENEWABLE ENERGYSTATUS REPORT 2014 p.42 *(Accessed on 11th November, 2015)*

5.2 *Potential and market – Solar Lantern*

The World Resources Institute estimates that in India, the off-grid energy access market includes 114 million households who are at the base of the pyramid (BOP) earning less than $2/day. Specifically, decentralized renewable energy enterprises (DRE) offer an annual market opportunity of $2.04 billion while the solar home lighting (SHS) market is estimated to be $27.4 million a year.[43]

In India approximately 400 million people are without access to electricity and country spend over $60 billion annually on energy (primarily inefficient and antiquated sources such as kerosene). This is indicative of the fact the people are willing to pay for energy services even at the base level of the market. The opportunity can be assessed if one assumes that a peak demand is of 1 kWh per household. So if by 2020, the country will have 100 million households still without access to electricity, then there lies an opportunity to serve this market of a 100 GW with off-grid energy. As per Solar Energy Foundation, Off -Grid Business Indicator report India ranks highest among the top five off-grid markets in the world. Nearly 'fifty percent of India's rural population – 80 million households – has little or no access to grid-based electricity and instead, relies on kerosene as its primary source of lighting.

The use of kerosene has the disadvantages of getting a dim, low quality lighting which impacts vision; negative impacts like environmental pollution from the carbon emission and illness which arises due to high levels of indoor air pollution. Improvement in lighting, leads to better the potential of income generation. So, providing of better quality lighting has a far reaching effect and the off grid energy solutions have social, environmental and economic impacts. Bihar, Uttar Pradesh, Odisha, West Bengal and Madhya Pradesh have more than half of the total underserved rural population.

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[43] <http://www.bridgetoindia.com/blog/off-grid-solar-lighting-market-in-india-set-for-take-off/ >*(Accessed on 8th November, 2015)*

Two-thirds of the underserved rural population live in the states of Uttar Pradesh, Bihar, Odisha, West Bengal and Madhya Pradesh. Government has taken some keys steps for rural electrification some of which are mentioned in Table -VIII:[44]

Table-VIII (key Step for rural Electrification)

Initiative	Implementing Agencies	Implementing Agencies for OGE Businesses
Electricity Act, 2003	Ministry of Power (MoP)	• Removed the need for licenses in order to generate power(in all area) and distribute power (in rural areas only) • Allowed OGE(off grid energy) businesses to more easily provide an alternative source of electricity
Remote Village electrification Program (RVEP) 2005	Ministry of New and Renewable Energy (MNRE)	• Initially supported the distribution of solar lanterns and home systems in remote villages • Currently supports mini grid installations in villages not covered under the Central grid extension scheme and operated by VECs (Village Elected Councils) • Provided subsidies for villages to install DRE utilities upto 90%
Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGY) 2005	Ministry of Power (MoP)	• Decentralized distribution generation scheme outlined the off grid projects in areas where off grid extension was not considered feasible. • Provide subsidies to encourage off grid based franchise based projects in these areas.
Village Energy Security Program (VESP) 2005-2012	Ministry of New and Renewable Energy (MNRE)	• Capital subsides of up to 90% offered to set up bio mass-gasifier based DRE systems in off grid regions. • Focus was on community partnership and ownership of assets. • Demonstrated benefits of Community-based models

[44] <http://www.theclimategroup.org/_assets/files/The-business-case-for-offgrid-energy-in-India.pdf> (*Accessed on 25th October, 2015*)

Initiative	Implementing Agencies	Implementing Agencies for OGE Businesses
Jawaharlal Nehru National Solar Mission (JNNSM) 2010	Ministry of New and Renewable Energy (MNRE)	• In addition to the ambitious 20,000 MW target for grid- connected solar PV Systems, it aims is to install 2000MW of off grid solar PV system especially for providing electricity access, • The program offers capital subsidies for installation of solar projects • Created the Indian Renewable Energy Development Agency (IREDA) responsible for re-financing of solar energy projects • Funding for subsidies (30%-90%)available for installing planned capacity • Re-financing facility (IREDA) available to banks who provide loans to OGE enterprises and allow for low interest rates of less than 5%

The government has already announced its plans under JNNSM to install 68000 solar PV off-grid lighting systems at an estimated cost of INR 3.67 billion during 2013-14. The off-grid solar PV lighting systems are used to store electrical energy during daytime in batteries which are used during night time to produce light using LED lights. During phase II of JNNSM, the government has envisaged and set a target to achieve installation of 1million offgrid solar PV lighting systems.

5.3 *Potential and market – Solar Water heating*

Solar water heaters were introduced in India in 1980's. In terms of product life-cycle, it is at the beginning of the growth phase. Demand for solar water heaters is influenced and depends mainly on the availability of irradiation and the requirement for hot water.

However, in real terms the demands for solar water heaters are dependent on the factors which *inter alia* include:

(i) cost of the system:;

(ii) urbanization, services;

(iii) supply chain improvements;

(iv) demand for energy saving equipment;

(v) increase in energy price;

(vi) Policy compulsion from the state and central government and incentives for solar water heater installation.

Uses of solar water heaters are concentrated in South Indian states like Karnataka and Maharashtra. The two predominant technologies that are used are Flat Plate Collector (FPC) and Evacuated Tube Collectors (ETC).

Solar water heater installations are witnessing a rapid growth through the world. The government has taken policy initiatives. The highlights of the present policy environment are as follows.

- Several of the municipal corporations have issued orders making solar water heaters use compulsory for new multi-story housing and houses constructed on plots having area more than 500 sq. yards.
- A few of the municipal corporations are offering rebate in property tax.
- A few of electricity distribution companies offer rebate in monthly electricity bills.
- Several states offer upfront subsidy for residential systems.
- IREDA through banks is operating an interest subsidy scheme to offer concessional finance for installation of solar water heaters.

Today, India ranks fifth in terms of the number of SWHs installation, accounting for mere 1.6% of the total heating capacity through solar water heaters around the world (REN21:Global Status Report 2014). The total installed collector area has increased from 119,000 sq. m in 1982 to 11 Million sq. m 2013. This sector has been incentivized by capital subsidies and soft loans in the past, with commercial and industrial sectors contributing to 80%

in 2001. But, presently residential sector is the largest sector contributing 80% of installation/sales for SWHs[45].

The cumulative capacity in respect of in respect of SWH installations is as provided for the website: http://www.indiaenergy.gov.in/what_IESS.php which is merely an indicative of the capacity considering different scenarios still it provides a picture of the potential of India.

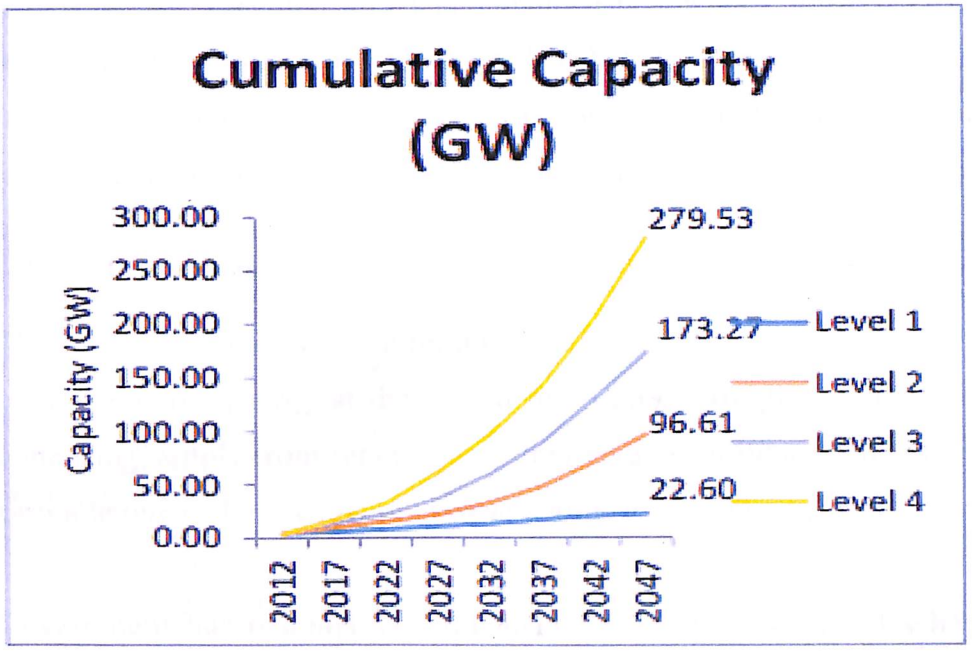

Figure - VII[46]

The size of the market for solar water heaters (SWH) in India, it is estimated to be around 600 Crores (INR). Globally, the industry has been growing at 15% annually. China and European Union are the two largest markets of solar water heaters. India accounts for around 1.5 %. According to Optimistic scenario, the cumulative installations of solar water heaters in residential sector in India are expected to grow from 2.74 million m2 in 2010 to 20.28 million m2 in 2022. The cumulative installation of solar water

[45] http://www.indiaenergy.gov.in/supply_water-heater.php >*Accessed on 12th November, 2015*

[46] < http://www.indiaenergy.gov.in/supply_water-heater.php> *Accessed on 12th November, 2015*

heaters in hotel sector is expected to grow, from 1,98,520 m2/year in 2010 to 12,73,200 m2/year in 2022. The cumulative installation of solar water heaters in hospital sector is expected to grow, from 1,03,643 m2/year in 2010 to 9,58,118 m2/year in 2022.[47]

Government has already announced its plans to install 4,00,000 square meters collector area in next two years at a cost of INR 3.6 billion. This project will be executed under National Clean Energy Fund (NCEF). Solar Water heating systems are being used in hotels, hospitals, residential and industrial establishments. The use is being carried out through the use of insulated tanks and the collector based system.

5.4 *Solar City Scheme*

The solar city scheme aims at minimum 25% reduction in projected demand of conventional energy at the end of five years, through a combination of enhancing supply from renewable energy sources in the city. It is aimed to promote renewable energy as a power source to local governments.

Government has planned to implement this above mentioned scheme in over 100 cities across India under phase II of JNNSM. MNRE has already given sanctions for 48 cities which have received in-principle approvals and they have engaged consultants for preparation of master plan.
These cities are: Agra, Moradabad, Rajkot, Gandhinagar, Nagpur, Kalyan-Dombiwali, Kohima, Dehradun, Chandigarh, Gurgaon, Faridabad, Thane, Panaji City & Environs, Bilaspur, Raipur, Imphal, Itanagar, Jodhpur, Jorhat, Guwahati, Agartala, Ludhiana, Amritsar, Shimla, Hamirpur, Haridwar & Rishikesh, Vijaywada, Aizawl, Mysore, Hubli and Gwalior. **Appendix-B** mentions the cities being considered and the stage of progress of the cities.

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[47] International Journal of Recent Development in Engineering and Technology Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 2, Issue 2, February 2014)

5.5 *Potential in respect of the Grid grid-connected rooftop solar systems.*

The Ministry of New and Renewable Energy has so far sanctioned 361 MWp aggregate capacity of grid connected rooftop solar systems in the country of which 42 MWp have been commissioned[48] According to a study conducted by TERI, a potential of 124 GWp SPV Rooftop plants has been estimated in the country. This can be achieved through active supports from the States.

The programme related to capacity addition in the grid connected rooftop solar systems is implementation through multiple agencies for rapid up-scaling in an inclusive mode. These agencies are:

(i) State Nodal Agencies (SNAs)

(ii) Solar Energy Corporation of India (SECI)

(iii) Channel Partners:

a) Renewable Energy Service Providing Companies (RESCOs)

b) System Integrators

c) Manufactures of any component of the Solar Plants

d) Project developers

e) Vendors/ suppliers of solar equipment

f) Reputed and relevant NGOs of National level

(iv) The Financial Institutions like NABARD, National Housing Banks, Other Banks, IREDA, SECI etc.

(v) Other Govt. Departments/Agencies

The other Govt. Departments/Agencies i.e., Railways, Defense/Para Military Forces, Local Government Bodies including Municipal Corporations/Municipalities, PSUs, Institutions, Development Authorities,

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[48] <http://mnre.gov.in/file-manager/UserFiles/FAQs_Grid-Connected-Solar-Rooftop-Systems.pdf> *(Accessed on 13th November, 2015)*

DMRC, State Departments interested in directly implementing the programme.[49]

The targets as envisaged under the Jawaharlal Nehru National Solar Mission are as mentioned below in **Table - IX:**

Table - IX

APPLICATION SEGMENT	TARGET FOR PHASE I (2010-13)	CUMULATIVE TARGET FOR PHASE 2 (2013-17)	CUMULATIVE TARGET FOR Phase 3 (2017-22)
Grid solar power (large plants, roof top & distribution grid plants)	1,100 MW	10,000 MW	20,000 MW
Off-grid solar applications	200 MW	1,000 MW	2,000 MW
Solar Thermal Collectors (SWHs, solar cooking, solar cooling, Industrial process heat applications, etc.)	7 million sq. meters	15 million sq. meters	20 million sq. meters

[49] <http://mnre.gov.in/file-manager/UserFiles/FAQs_Grid-Connected-Solar-Rooftop-Systems.pdf>(*Acceseed on 10th November, 2015*)

Against such targets the achievements under the JNNSM have been as per **Table – X** below:[50]

TABLE -X

APPLICATION SEGMENT	ACHIEVEMENTS
Grid solar power (large plants, roof top & distribution grid plants)	3382.78 MW commissioned
Off-grid solar applications	357.18 MW sanctioned
Solar Thermal Collectors (SWHs, solar cooking, solar cooling, Industrial process heat applications, etc.)	8.77 million sq. meter

The off-grid rooftop solar systems are used mostly where the grid connectivity is not available. As per 2011 census, India had 330 million houses of which 166 million were having electric connectivity.

According to MNRE estimates, there are 140 million home with proper roofs made of either concrete or asbestos/metal sheets which can accommodate about 1-3 kWp of roof top solar systems. On the other hand large rooftops of industrial sector are capable of accommodating capacities in the range of 100-500 kWp. As per NOVONOUS, the total market potential for rooftop solar for residential sector is worth INR 14000 billion.[51]

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50 <http://mnre.gov.in/file-manager/UserFiles/FAQs_Grid-Connected-Solar-Rooftop-Systems.pdf > accessed at 11th November, 2015

51 <www.greensummit.in/.../India-Renewable-Energy-Status-Report-2014> INDIA RENEWABLE ENERGYSTATUS REPORT 2014 (accessed at 11th November, 2015)

The scheme for development of Solar Parks and Ultra Mega Solar Power Projects was rolled out by Ministry of New & Renewable Energy on 12-12-2014. The said Scheme has been conceived on the lines of the "Charanka Solar Park" in Gujarat which is a first-of-its-kind large scale Solar Park in India with contiguous developed land and transmission connectivity.

This scheme envisages supporting the States for setting up solar parks at various locations in the country with a view to create required infrastructure for setting up of Solar Power Projects. The solar parks will provide suitable developed land with all clearances, transmission system, water access, road connectivity, communication network, etc.

This scheme is intended to facilitate and speed up the installation of grid connected solar power projects for electricity generation on a large scale. All the States and Union Territories are eligible for benefitting under the scheme.

The salient feature of the Scheme is as below:

i. It is proposed to set up at least 25 Solar Parks and Ultra Mega Solar Power Projects targeting over 20,000 MW of solar power installed capacity within a span of 5 years starting from 2014-15.

ii. The capacity of the Solar Parks shall be 500 MW and above. However, smaller parks may be considered in Himalayan Region & other hilly States where contiguous land may be difficult to acquire in view of difficult terrain and in States where there is acute shortage of non-agricultural land.

The State-wise commissioned capacity of Grid Solar Power Projects in India as per the data available from website of the Ministry of New and Renewable Energy is as mentioned in **Table-XI** below:

Table-XI

COMMISSIONING STATUS OF GRID CONNECTED SOLAR POWER PROJECTS UNDER VARIOUS SCHEMES		
Sr. No.	**STATE/UT**	**TOTAL COMMISSIONED CAPACITY TILL 28-02-15 (MW)**
1	Andhra Pradesh	236.86
2	Arunachal Pradesh	0.025
3	Chhattisgarh	7.6
4	Gujarat	949.05
5	Haryana	12.8
6	Jharkhand	16
7	Karnataka	77
8	Kerala	0.025
9	Madhya Pradesh	499.58
10	Maharashtra	334.4
11	Orissa	31.76
12	Punjab	119.77
13	Rajasthan	902.1
14	Tamil Nadu	111.76
15	Telangana	8
16	Uttar Pradesh	49.71
17	Uttarakhand	5
18	West Bengal	7.21
19	Andaman & Nicobar	5.1
20	Delhi	5.465
21	Lakshadweep	0.75
22	Puducherry	0.025
23	Chandigarh	2
24	Others	0.79
	TOTAL	**3382.78**

The possible solar businesses which can be considered for the rooftop installation are:

(a) **Direct Installation by the Customer** – This can be either owned or operated by the customer or the ownership may lie with the customer but the operation can be done by any third party.

(b) **Installation, operation and maintenance of the solar facility by third party** – This can be done by any third party, which can thereafter provide services to other. Such arrangement can be in the form of being the captive generating plant for the roof owners. The implementation is carried out by the third party at the roof or within the premises owned by the customer. The power generated by the third party is then sold off to the customer. The customer may have a stake in the form of equity or may not have the same in the facility. The same is as per the arrangement and as is mutually agreed with the third Party.

There also exist possibilities whereby the third party implementing the solar facility may enter into a lease agreement with the consumer. Such lease can be for a medium or on a long term basis depending upon the agreement between the consumer and the third party. The facility is entirely owner, operated and managed by the third party with the consumer having to make no investment. The power so generated by the facility is used fed into the grid and the owner of the roof top gets the rent. Such an arrangement of business is often referred to Solar Lease Model

(c) **Solar installation can be owner by the Utility** - The DISCOM may own, operate and maintain the solar facility but still it may sub contract the operation and maintenance activity to others. It can recover the cost in the form of suitable tariff. The electricity generated might enable the DISCOM to fulfil the solar renewable purchase obligation. DISCOM

can even provide the funding for setting up the solar facility by providing funds.

5.6 *Solar Water Pumping*

Solar PV systems are used to pump water which is required for the purposes of irrigation or for drinking purposes. Solar pump have been used for the said purpose. The pumps are cost effective and low-maintenance systems as they operate directly on DC without power storage mechanism like batteries. The Government has planned deployment of Solar under the JNNSM

5.7 *Telecom Towers*

In order to provide services the telecommunication companies have to reply to telecom tower which usually are operated with the help of diesel generator sets. As per the study of Telecom Regulatory Authority of India (TRAI) there are more than 3.10 lakh telecom towers the more than 60% of their power requirement is met by the diesel generator sets.

These diesel generator sets on hand use diesel as fuel and at the same time is also adding to the CO_2 emission thereby contributing to the pollution. In case these telecom towers are witched to solar technology, it would not only help in reduction of the pollution levels of the environment which are already alarming but would also save significant amount of fossil fuels. The government has already planned installation of integrated telecom towers using the solar technology for their operation.

The use of solar technology would throw open potential business opportunities for not only the makers of solar panels but also to the other

connected business enterprises which are engaged in the manufacture or trade of batteries, connectors.

5.8 *Solar Water Purification / Desalination*

Solar water purification system is composed of solar PV modules connected to set of batteries which are connected to the inverter system. Such a system can function without the support of any external energy source. During the day when the sun is there, the solar energy is captured by the PV panels which powers the purification installation and charges the batteries. Once the sun disappears, the batteries continue to run the installation during the night. This is also an option which offers the usage of solar technology.

5.9 *Solar Air Conditioning / Refrigeration*

Solar Air Conditioning Systems use solar heat of the sun to directly heat the refrigerant and deliver its directly to the condensor. This is done by bypassing the compressor. This makes possible for the compressor to work less. This curtails and do away with the requirement of CFCs which are impacting by destructing the ozone layer. The Ozone layer acts as a protective shield for the earth and depletion thereof is harmful as the earth is not able to stop the harmful rays emanating from the sun environment.

The Solar Air Conditioning Systems offers immense opportunities in the present prevailing conditions in India where great thrust is being given by the Government on the development. Any development would be possible only by adding the required infrastructure including buildings. The Solar Air Conditioning Systems can be used in the buidling for the purposes of air conditioning.

5.10 Solar Cookers and Steam Generating Systems

Solar cooker system use concentrated solar energy for cooking applications. The parabolic dish is used for thr purpose . The solar cooker is used for cooking food and can be manually tracked or can be used in the form of direct cooking system which can be used in the kitchen itself. These systems are being used in hospitals, hostels, *ashrams,* defense installations etc.

Installation of the solar cooker is being given priority by the governemnt and offer a good market in the rural sector where the traditional method of using *chulha* is still practiced. This solar steam egenrating system are usually used on large scale and can be even used in indutrial use like for cleaning clothes in the textile industry, hotels etc. Government has planned to achieve installation of 50,000 units of solar cookers during phase II of JNNSM.

6 CONCERNS, CHALLENGES AND REFORMS REQUIRED IN THE SOLAR SECTOR

There is a great optimism prevailing in the solar energy sector of India owing to the transforming power of this sector and the increasing interest shown and expressed by the investors in general however, there are still many concerns which need attention.

6.1 CONCERNS AND CHALLANGES

Some of these majors concerns which affect the solar sector in India are as under:

6.1.1 Margins

There is a concern on margins as it is really difficult to earn money on solar projects in India. Pressure on the tariffs which percolates down through the value chain, leaving bare-bone equity returns of around 15% (at a debt cost of 11-13%), if at all. The larger Indian corporate houses would not enter a business that does not offer an equity return of at least 20%.

6.1.2 Availability of Land

It is a well known fact that the installation of solar parks requires large land. The buying or leasing land especially the large one which would be required or necessitated for the development of solar parks is not easy to be obtained. The land in India is often in a dispersed nature. The land more often is distributed amongst several individuals who own the land in their private capacity. This creates lost of legal issues and other constraint in ease of getting the land requires for setting up solar projects.

There are several other issues connected with the land. The land is not properly catalogued showing the ownership. This is due to litigation and prevailing corruption, which is often used to getting around with the things due to lack of transparency. Even the great portion of the land is designated as agricultural land, this add further complication in getting the land. All the more, finding the

land near the good evacuations points further add to the problem. It is even difficult even for the government to find vast land when required. It is not that the land is not available; it is just the issues connecting with the land which creates this position.

6.1.3 Position of Grid Infrastructure

Even if large tracts of land are made available to investors to produce solar power, the lack of grid infrastructure is a hindrance. The electricity grid suffers from high losses (20%+), frequent technical failures, and a lack of monitoring and maintenance. The grid though is managed more actively does not compare well with that of the European or American counterparts. The utilities are in a bad shape. The grid infrastructure has to be bolstered significantly in order to meet the future growth requirements in energy demand in India. The government will have to focus on building up the grid to support the level of solar capacity addition that is being planned.

6.1.4 Weak Position of Discoms

Most of the Discoms are not in a good financial position and this does not augur well for the power sector. The utilities are in bad shape and re struck in the debt trap from which it is not easy to come out. The discoms are mostly managed by states and are inefficient. This financial situation makes utilities reluctant grid investors and non-bankable PPA counterparts. [52]

6.1.5 Torrential Rainfall

For effective utilization of the solar energy, adequate sunshine is very much needed, however, with the fact that India lies in that part of the world where monsoon plays an important role, the period during which there is a rainy season, the clouds mostly act as an obstruction to the use of sunlight for the

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[52] <http://cleantechnica.com/2015/07/27/solar-power-transforming-indias-energy-market-part-ii/> How Solar Power Is Transforming India's Energy Market (Part II) (*Accessed on 9th November, 2015*)

generation of electricity. This affects the efficient use of the PV modules for the purpose of energy generation.

6.1.6 Power Pricing

There are different groups which pay different rates for power. The industrial consumers have to pay more as compared to agricultural customers. The utilities in order to rather supply the power at loss resort to load shedding. Power of the India's energy deficit is by design. The utilities are already struggling with financial constraints they are further limited from buying power from other sectors and this create a roadblock for the power sector. There has to be greater rationalization of the power tariff in order to achieve the reliable power and for the effectively leading the growth in the solar energy sector.

6.1.7 Politics

In India being a democracy there are several push and pulls from the political end. The political parties in order to suit their political agenda and interest would resort to mechanism which is not at all conducive for the business. Power is even provided free of cost as part of electoral strategy. This is especially in the case of the farmers, they are forming major chuck of the electoral population and the politicians in order to garner the votes and appease them often resort to such strategies. There is lack of good governance which leads to further bottleneck in the energy sector.

Despite all the factors influencing the Indian solar energy sector, there is spurt of interest in the solar industry, as more and more interested in generated and there are investors who are ready and willing to come and invest in India. The Gulf players have realised this and are thinking of making investment in India. There is no doubt that these players have realised the importance of the resources of energy then the traditional conventional fuel which on one hand are getting reduced and at the same

time are also the cause of pollution. There is a growing concern of the world over pollution and all efforts are presently focused world over in reduction of the dependency on such fuels.

The players from the Gulf want to invest in India as it provides them the ready market. India has all what an investor would ideally look for. There is abundance of technical expertise as the solar industry in India has developed to a great extent if not considered to have matured enough. There is no shortage of skilled manpower; demand supply gap is enough to prompt entering into the market. China which has seen huge development in the solar sector is not much of inducement owing to the maturity level the solar industry has achieved. The collaboration would enable the players from Gulf to reap benefits from engineering and design capabilities of the Indian which is affordable. Apart from the reason mentioned herein before, a good market size like India where is there is more than adequate demand from the business perspective add to good proposition. India on the other hand would get benefited in the form of introduction of better technology and more of the much needed investment.

6.2 REFORM REQUIRED

In order to boost the growth of the solar sector it is important that the use of Renewable Energy Certificates ('REC') is implemented on a faster pace. These certificates are tradable and are issued for every unit of renewable energy produced. This would facilitate the states to increase their renewable energy content. The states with low potential through this mechanism would be able to purchase these certificates from the high potential states thereby enabling them to meet NAPCC's increased demand. This would also incentivize the state with high potential of renewable energy to produce more thereby leading to overall increase in renewable energy production.

There is a constant need to have effective approaches adopted to enforce renewable purchase obligations (RPOs). This can be ensured by ensuring that states declare their policies relating to enforcement in respect of RPO as a condition before the actual receipt of funds from the central government.

RPO are the mechanism by which SERC are obligated to to purchase a certain percentage of power from renewable energy sources implement. RPO are applicable on the distribution companies, captive power plants and the open access consumers. The RPO were challenged before the Hon'ble Supreme Court of India by some of the business houses having the captive power plants but the Humble Supreme Court of India had ruled the ROP obligations to be justified. The apex court in its order said regulations framed by electricity regulatory commissions cannot in any manner be said to be restrictive or violative of fundamental rights.

The Supreme Court in its order dated 13 May, 2015 in the case between the Hindustan Zinc vs. Rajasthan Electricity Regulatory Commission on the applicability of Renewable Purchase Obligation (RPO) regulations ruled that RPO on captive consumer is justified. It interpreted the same in the context of Article 51A (g) of the Constitution of India which provides for and casts a fundamental duty on the citizen of India to protect and improve the natural environment and also of the mandate of Article 21 that guarantee right to live with healthy life.

In order to push forth with the policies and obligations therein, it is imperative that the Renewable Purchase Obligations should be strictly enforced. In order to reach the targets as envisaged under the phase 2 of the JNNSM, it is important that there is a clear cut policy from MNRE in respect of the solar sector which needs long-term signals in respect of the direction of the market, policy priorities, and of the support measures. This would enable the sector to plan and move as per the requirements. There should

not be focused approach in only one of area of solar energy rather MNRE should continue to foster both Concentrated Solar Power (CSP) and PV technologies. This would enable in providing the market confidence and ensuring diverse energy resources to coexist and thrive.

Information on Solar Resource Incidence and Performance of Technologies is not readily available. In India there is enough information available for the framing of broad policies however, there are certain information which are required for the planning of the projects and is necessary in on monthly and seasonal basis especially during the project implementation. Such data and information should be generated and be provided in the public domain.

Delay in execution of the projects should be monitored and realistic timelines should be developed taking into account the causes for delay. It is more a thing of perception therefore, meeting deadlines should be encouraged and clearly defined timelines for everything would inspire confidence of the investor and change their perception

Financing is one of the important areas which need attention; the government should share information on the sector's track record and remove the doubt amongst the investors. Innovative financial instruments may be suitable alternatives to traditional debt or equity investments. For investments, increasing information flow and capacity building of financial institutions are particularly crucial. Financial Institution can provide long term and short term loans

Incentives must be offers by the government to the project developers to adopt storage technologies and water efficient plants and for the adoption of newer and efficient PV technologies.

One of the examples which can be sited is that of a fund the Indian Government started as initiatives such as the National Clean Energy Fund. In 2011, this Fund was established to fund projects and research in

renewable energy. This initiative taxes coal production so as to create a corpus of funds that would be available to government, public, and private sector players in the form of loans or viability gap funding for up to 40% of the total project cost. In 2014, the tax on coal was doubled to US$1.50 per metric ton of coal produced. This would mean that the fund which is already at US$2 billion would grow at more than US$1 billion per year. Despite this, little funding has made to the projects due to a number of challenges in fund allocation. This fund is managed by the Ministry of Finance, but projects are approved by an inter-ministerial group (IMG). The Ministry of Finance has been slow to move money to the public account accessible to the IMG, to help the government understate overall budget shortfalls.[53]

In order to increase the adoption of the Solar Water Heater (SHW), it is essential that the related market is assessed and taken note of. The adoption of SWH depends primarily on the demand for hot water, regulations, SWH supply chain and paying capacity of the users. It is imperative that MNRE identifies 10-20 districts and focus its attention on implementing SWH programme in such districts.

There is a trend towards high rise building which are used for residential purposes. MNRE may set-up a task force in order to study the issues. Such task force should suggest and developing a comprehensive strategy for multi-storey residential buildings.

The payback period in respect of SWH varies across regions. It is not practical and feasible to stipulate compulsory SWH-installation for old buildings. The incentive package needs to address the regional and vintage differences. MNRE should develop targeted and variable incentive packages

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53 <http://www.theclimategroup.org/_assets/files/The-business-case-for-offgrid-energy-in-India.pdf> (*Accessed on 8th November, 2015*)

which factors in the specific requirements of different regions, sectors and vintage of buildings.

MNRE should work out a blue print for the development of appropriate products, supply chains and a policy package focused on developing rural market for SWH. MNRE needs to work on a package of fiscal/monetary/subsidy policy to promote industry-consolidation, product/technology development appropriate to low/middle-income group market, visible and extensive distribution network, quality-standards and rating.

It will help if the industry, on its part, works out a collective vision and strategy for realizing market-volume projected under the report. MNRE should consider giving this responsibility to an independent organisation to develop and maintain a data-base of SWH manufacturing, sales and installations.[54] There are several barriers for the development of solar sector still there can be no readymade solutions which can be imported and applied to India. In areas related to the strength of the private sector in wind and some of the broad policy and programmatic support for renewable energy, India is actually a leader. It could also become a pioneer in coming up with new solutions.

There are certain steps which can be suggested for bringing about the change in the solar sector.

1. It would be worthwhile to Enact a National Renewable Energy Standard/Policy of 20 percent by 2020 — to create demand, new industries and innovation, and a new wave of green jobs.

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[54] <http://solarthermalworld.org/sites/gstec/files/India%20Greentech.pdf> *(Accessed on 7th November, 2015)*

2. Government should develop favourable policies to ease the project permitting process, and to facilitate by providing start-up capital to promote the exponential growth of renewable energy. It would be appropriate in case there is creation of fund a national smart infrastructure bank for renewable energy.

3. Accelerate local demand for renewable energy by providing preferential Feed-in-Tariffs (FIT) and other incentives such as accelerated depreciation; tax holidays; renewable energy funds; initiatives for international partnerships/collaboration incentives for new technologies; human resources development; zero import duty on capital equipment and raw materials; excise duty exemption; and low interest rate loans.

4. There must be provision for the establishment of R&D facilities within academia, research institutions, industry, Government and civil society to guide technology development. Accelerate the development and implementation of Solar and Wind farms; utility-scale solar and wind generation nationwide.

5. Initiate a move to electrify automotive transportation or develop electric vehicles and/or plug-in hybrids – such as the Nissan Leaf or Chevy Volt, etc. Develop and implement time-of-day pricing to encourage charging of electric vehicles at night. Adopt nationwide charging of electric cars from solar panels on roofs, and solar-powered electric vehicle charging stations around the country.

6. Thousands of these solar-powered recharging stations could spread across India just like the present public call office (PCO), giving birth to the "Green Revolution." These recharging connections could be deployed at highly-concentrated areas including shopping malls,

motels, restaurants, and public places where cars are typically parked for long periods.

6. Aggressively invest in a smart, two-way grid (and micro-grid). Invest in smart meters, as well as reliable networks that can accommodate the two-way flow of electrons. Such networks need to be resilient enough to avoid blackouts and accommodate the advanced power generation technologies of the future.

7. Develop large scale solar manufacturing in India (transforming India into a global solar manufacturing hub).

8. Work towards a Hydrogen Economy development plan. Hydrogen can be fed into fuel cells for generating heat and electricity – as well as for powering fuel cell vehicles. Produce hydrogen using renewable energy with solar and wind power. If done successfully, hydrogen and electricity will eventually become society's primary energy carriers of the twenty-first century.

9. Local design and engineering will play a major role in India's solar market. Inverter and balance-of-system designs that incorporate local requirements and eliminate unnecessary elements that are geared more toward global markets can generate significant benefits. Eventually, global players will see the benefits of manufacturing locally and specifically for the Indian market.

10. Competition from local players could further drive down systems costs. At the same time, local players can bridge capability gaps by striking appropriate alliances, or by recruiting strong teams or individuals. A partnership of foreign technology and local EPC can help both parties climb up the steep learning curve fast, but mechanisms will need to be put in place to ensure that the risks and

upsides are shared equally. Both parties involved will need a long-term view of the market, with lessons learned from initial projects built into subsequent ones.[55]

There should be establishment of coherence in the underlying principles and approach in breaking down the national RPO target into state wide RPOs. (GDP could be a good choice of allocation factor). Such targets should be made mandatory and enforced.

SERCs should be responsible for monitoring annual compliance with RPO targets by state distribution utilities; penalty mechanisms should be introduced as a deterrent for noncompliance. Technology-specific RPOs may not be necessary unless there is a specific objective of the government to promote a particular technology. (The JNNSM's mandating that SERCs fix a percentage for the purchase of solar power is one example of a technology-specific RPO.) [56]

There is considerable risk associated with the solar energy sector. The efforts are required to put a check on such risk and minimise the same in case it is not possible to curtail the same. These risk area are in the area of seeking finance, policy matters, risk related to technical aspects associated with the solar energy sector. In India's solar power sector, the credit risk is considerably high on account of the reason related to high interest rates (upto 13%) and there being low loan periods (around 10 years).

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55 <http://www.renewableenergyworld.com/articles/2013/07/indias-renewable-energy-potential-remains-untapped.html> July 23, 2013 **India's Renewable Energy Potential Remains Untapped**

56 Gevorg Sargsyan, Mikul Bhatia, Sudeshna Ghosh Banerjee, Krishnan Raghunathan, Ruchi Soni Unleashing the Potential of Renewable Energy in India (2010) South Asia Energy Unit Sustainable Development Department The World Bank

There is risk which arises on account of the inability of distribution companies (DISCOMS), who are the buyers of solar power, to pay for the power they purchase. DISCOMS in India in order to meet their renewable purchase obligations (RPOs), are mandated to purchase renewable power, but the high cost of power from solar compared to other renewable sources is making the situation more difficult.

The projects are even having the exposure on the policy front. Any change in the policy related to other energy sources say in respect of fossil fuel may have a bearing on the solar energy sector. Such a change if affect the sector adversely may impact the earning potential of the concerned investor. In the Indian context this assumes importance due to the fact that the renewable revenue project at present depend more on the policy support rather than the prices related to fossil fuels. Not only had the policy related to material, even the policies affecting the land procurement and allocation, government clearances, rates of electricity and even the contribution of solar energy in RPOs for various DISCOMS has a bearing on the solar energy sector in India.

In connection with the solar projects, there are aspects related to technology related risk. Such risks need to be factored in while making the use of the technology. The risk can relate to the operational issues, issues related to weather and related to other infrastructure. For e.g. in case of the use solar thermal technique there is a requirement of vast area of land, direct solar radiation, human resources and large amount of water. There is a constant cleaning required as frequent accumulation of dust lead to reduction of life and may even result in unplanned plant closure. The prevailing weather condition may result in fall in the generation of the volume of electricity produced owing to the lack of solar radiation. Complete dependence on the climatic conditions leads to variability in power generation which may act as

a major obstacle in recovery of costs. Even the variable nature of power output by solar energy systems poses a risk while the integration is to take place with the already existing transmission infrastructure.

The policy as may be framed by the government should duly consider and take into account the challenges that lie in different area of tapping and using the solar energy. The policies should be directed at making arrangements for the land, finance and also provide some form of contingency fund to deal with any adverse impact of the solar industry. The Government of India should lay more emphasis on collecting different data in connection with the various aspects related to the solar energy sector. The information so collated should be provided to investor and other industrial players. Such information enthuse confidence and understanding of the market, energy scenario and would afford them an opportunity to have an evaluation of the market in a better way. Such information might enable the prospective investor to have a better understanding and this might culminate into an investment.

Land reforms are very necessary since availability of the land would be required in order to undertake the installation of the large scale projects for the generation of electricity using solar energy. The government policy should be fair and facilitate the ease of procurement of land to be used for the purpose. The government should have clear and transparent fiscal and monetary policies which augment finance easily and with most suitable financial terms possible. There should be more focus on implementing the policy of ease of doing business as investment would flow only if the regulatory, political and environment in general is conducive for doing business and the economy is performing.

7 CONCLUSION

It is well known that low energy path is the best way forward for the sustainable development. Lot of developing countries and emerging markets, considering the high pollution and scarce non-renewable resources, are entering into renewable energy generation, transmission, distribution and marketing. Hence, there is lot of potential opportunities to tap and develop solar energy, commission solar plants, for generation of electricity.

For a greater penetration of solar energy there has to be greater impetus given by the government which in the Indian context has already been given by setting the enormous target for the generation of the solar energy. However, such a target cannot be achieved in isolation. There has to greater backing on all front.

Emphasis on the renewable sources of energy generation has lead to lot of regulations. Incentives and subsidies have been provided such as feed in tariff system, which are enabling the renewable energy projects to optimize their cost and achieve grid parity. However, owing to political clout and other extraneous political risks, many regulatory changes like reduction in Feed in tariff or elimination of tax subsidy are introduced which directly impacts the feasibility of the present and future projects. Such changes bring about closure of many projects and leads to litigation by investors and renewable energy companies. Therefore, the regulatory risk and political risks associated with renewable energy directly impacts the solar sector.

The policies have to be framed and directed to lend clarity on their applicability, there should be more transparency by the government in their approach as it directly impacts and affects the sentiments of the investors. The policy framework should not be ambiguous or misleading.

In order to afford protection to the domestic manufacturers, the Indian government through the Ministry of Commerce had earlier proposed to increase restrictions relating to the use of imported equipment in the II phase of the JNNSM by way of providing for anti dumping duties. Such an imposition of the anti dumping duties can prove to be counterproductive in the era of liberalization and WTO. Solar power generation cost has fallen in India for the last four to five years. Low cost funding from foreign banks has been a major reason for this since it often connected with the obligation to usage of imported modules. This proposal did not find the support from other Ministries like the transportation, coal, power, renewable energy as it was considered that such a move would lead to increase in the production cost of the solar energy. The decision had to be later withdrawn. India also lost the case at WTO. Indian government therefore has to chart a middle path in order to assist the manufacturing industry on the domestic front as well as ensure low-cost funding sources to the developers.

Ramping up the domestic manufacturing is one of the aims of the government under the JNNSM and in order to achieve this government introduced the exclusive projects for the domestic manufacturers. One of the important multi sector programs that have been launched by the government is in the name of "Make in India". This program aims at creation of investment climate which is favourable to the promotion of investment in various sectors and includes the renewable energy. The way of promoting the manufacturing at the domestic level, the government has taken a step to promote local manufacturing. The Make in India program has to be further strengthened by introduction of sector specific scheme to encourage participation. Transparency in respect of policy framework and the regulations would enable building up of apt environment. The RPO should be implemented so as to give the necessary thrust required in the solar sector.

The Procurement effectiveness would become an essential requirement. The Government should focus and encourage more localization. The longer-term value will come from efficiently executed projects, low-cost (and often innovative) financing, and localization. The stage is all sets and it would be the local players, who would be in a better position to exploit downstream side which includes project development, installation, and distribution.

This study leads to conclude that though there are several challenges however, the Indian solar industry is poised for growth. The support environment is improving and this would usher in development of the industry further. The next decade would make Indian solar market worth billions of dollars. In order to take a lead, it is of utmost importance that proper and easy financing is ensured as it is the cost factor which would play an important role in the penetration of the solar technology. The unique position of the India on the world map would afford it far greater reach. It would be a major conduit of business between the Middle East and the south east nations. Hitherto, China had shown good growth but in the years to come it shall be India which shall be becoming one of the major destinations to look forward for the growth in the solar sector. India has good potential of doing so with its educated young population. There are various Research and Development centres in India and more and more companies are setting up their R & D divisions in India. The Indian Government is also laying emphasis on the use of solar. All this augurs well for solar energy penetration. It is just that the support structure for meeting the initial capital requirements should be met in order to sustain the interest in the market, till the time the rates of solar energy generation get reduced and come more or less on par with generation of energy from other fuels.

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BIBLIOGRAPHY

1 <http://mnre.gov.in/schemes/decentralized-systems/solar-systems/>

2 <http://www.sciencedirect.com/science/article/pii/S0038092X03002962>
Dey, C.J. (2004). "Heat transfer aspect of an elevated linear absorber". Solar Energy. 76 (2004): 243–249

3 http://www.redrok.com/LfrIjeit.pdf

4. <http://www.ripublication.com/irph/ijert_spl/ijertv6n3spl_04.pdf.>
Aniket Dwivedi, Ajay Bari and Gaurav Dwivedi (2013) *Scope and Application of Solar Thermal Energy in India-A Review,* International Journal of Engineering Research and Technology. pp 318-319

5 <http://www.ripublication.com/irph/ijert_spl/ijertv6n3spl_04.pdf.>
Aniket Dwivedi, Ajay Bari and Gaurav Dwivedi (2013) *Scope and Application of Solar Thermal Energy in India-A Review,* International Journal of Engineering Research and Technology. pp 318-319

6 <http://www.dcmsme.gov.in/reports/electronic/solarlantern.pdf>
PROJECT PROFILE ON SOLAR LANTERN, MSME-Development Institute Govt. of India, Ministry of MSME

7 <http://mnre.gov.in/file-manager/UserFiles/cfl_spls_2013_14.pdf>

8 "World Energy Outlook, 2011 Executive Summary", © OECD/IEA, 2011, *International Energy Agency,* 9 rue de la Fédération, 75739 Paris Cedex 15, France.

9 <http://renewableenergydev.com/solar-energy-narmada-canal-solar-project/>

10 <http://www.briefingwire.com/pr/premia-group-is-into-energy-sector>

11 Gevorg Sargsyan, Mikul Bhatia, Sudeshna Ghosh Banerjee Krishnan Raghunathan, Ruchi Soni *Unleashing the Potential of Renewable Energy in India(2010)* South Asia Energy Unit, Sustainable Development Department, The World Bank

12 <http://www.iea.org/newsroomandevents/pressreleases/2014/september/how-solar-energy-could-be-the-largest-source-of-electricity-by-mid-century.html>

13 <http://www.iea.org/publications/freepublications/publication/technology-roadmap-solar photovoltaic-energy---2014-edition.html>

14 Renewable Energy in India: Growth andTargets, Ministry of New and Renewable Energy (MNRE) GEF National Workshop in India

15 <http://mnre.gov.in/mnre-2010/schemes/grid-connected/solar/>

16 <http://www.business-standard.com/article/news-ians/government-looking-at-100-000-mw-solar-power- by-2022-114111701373_1.html>

17 <http://mnre.gov.in/mission-and-vision-2/mission-and-vision/>

18 <http://powermin.nic.in/responsibilities>

19 <http://www.moef.nic.in/about-ministry/about-ministry>

20 <http://www.cercind.gov.in/Mission.html>

21 <http://www.cercind.gov.in/Function.html>

22 <http://powermin.nic.in/state-electricity-regulatory-commission>

23 <http://powermin.nic.in/state-electricity-regulatory-commission>

24 <http://www.mahadiscom.in/consumer/national%20tariff%20policy.pdf >

25 < http://www.mnre.gov.in/solar-mission/jnnsm/introduction-2/>

26 <http://mnre.gov.in/file-manager/UserFiles/draft-jnnsmpd-2.pdf>

27 < http://www.mnre.gov.in/solar-mission/jnnsm/mission-document-3/

28 Jawaharlal Nehru National Solar Mission; Towards Building SOLAR INDIA

29 Jawaharlal Nehru National Solar Mission; Towards Building SOLAR INDIA

30 <http://mnre.gov.in/file-manager/annual-report/2014-2015/EN /Chapter%204/chapter_4.htm> JAWAHARLAL NEHRU NATIONAL SOLAR MISSION, Ministry of New and Renewable Energy, Annual Report 2014-2015

31 <http://www.livemint.com/Industry/ZbiJfKOmhGGN5H6XewPhuJ/Power-sector-has-investment-potential-of-250-bn-in-next-56.html>

32 <http://mnre.gov.in/schemes/decentralized-systems/solar-systems/>

33 Japan's Softbank to Invest $20 Billion in Solar Energy Projects in India at <http://time.com/3931551/softbank-solar-energy-power-india-japan-climate-change/>

34 Japan's Softbank to Invest $20 Billion in Solar Energy Projects in India at http://time.com/3931551/softbank-solar-energy-power-india-japan-climate-change/

35 For Investors, India's Solar Push Could Signal A Gold Rush at <http://www.forbes.com/sites/saritharai/2015/07/07/for-investors-indias-solar-push-could-signal-a-gold-rush/>

36 INDIAN POWER SECTOR at <http://www.ibef.org/industry/power-sector-india.aspx>

37 <http://www.makeinindia.com/sector/renewable-energy>

38 <http://www.ripublication.com/irph/ijert_spl/ijertv6n3spl_04.pdf.>**Aniket Dwivedi, Ajay Bari and Gaurav Dwivedi (2013)** *Scope and Application of Solar Thermal Energy in India-A Review,* International Journal of Engineering Research and Technology. p 137

39 <www.greensummit.in/.../**India**-Renewable-Energy-**Status-Report**-2014>*p.37* MNRE, INDIA RENEWABLE ENERGY STATUS REPORT 2014

40 <http://articles.economictimes.indiatimes.com/2015-11-05/news/68043930_1_power-generation-capacity-energy-needs-cent> By 2030, solar power to make up 18% of Indian energy generation PTI (Nov 5, 2015)

41 <www.greensummit.in/.../**India**-Renewable-Energy-**Status-Report**-2014>INDIA RENEWABLE ENERGYSTATUS REPORT 2014

42 <www.greensummit.in/.../**India**-Renewable-Energy-**Status-Report**-2014,>INDIA RENEWABLE ENERGYSTATUS REPORT

43 <http://www.bridgetoindia.com/blog/off-grid-solar-lighting-market-in-india-set-for-take-off/>

44 <http://www.theclimategroup.org/_assets/files/The-business-case-for-offgrid-energy-in-India.pdf >

45 <http://www.indiaenergy.gov.in/supply_water-heater.php>

46 <http://www.indiaenergy.gov.in/supply_water-heater.php>

47 International Journal of Recent Development in Engineering and Technology Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 2, Issue 2, February 2014)

48 International Journal of Recent Development in Engineering and Technology Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 2, Issue 2, February 2014)

49 <http://mnre.gov.in/file-manager/UserFiles/FAQs_Grid-Connected-Solar-Rooftop-Systems.pdf

50 <http://mnre.gov.in/file-manager/UserFiles/FAQs_Grid-Connected-Solar-Rooftop-Systems.pdf>

51 <www.greensummit.in/.../**India**-Renewable-Energy-**Status-Report**-2014> INDIA RENEWABLE ENERGYSTATUS REPORT 2014

52 <http://cleantechnica.com/2015/07/27/solar-power-transforming-indias-energy-market-part-ii/> How Solar Power Is Transforming India's Energy Market (Part II)

53 <http://www.theclimategroup.org/_assets/files/The-business-case-for-offgrid-energy-in-India.pdf>

54 <http://solarthermalworld.org/sites/gstec/files/India%20Greentech.pdf>

55 <http://www.renewableenergyworld.com/articles/2013/07/indias-renewable-energy-potential-remains-untapped.html> July 23, 2013 **India's Renewable Energy Potential Remains Untapped**

56 Gevorg Sargsyan, Mikul Bhatia, Sudeshna Ghosh Banerjee, Krishnan Raghunathan, Ruchi Soni Unleashing the Potential of Renewable Energy in India (2010) South Asia Energy Unit Sustainable Development Department The World Bank

APPENDIX A

SECTION 86 OF THE ELECTRICITY ACT, 2003

APPENDIX B

Ministry of New and Renewable Energy, Annual report 2014-2015
http://mnre.gov.in/file-manager/annual-report/2014-2015/EN/Chapter%206/chapter_6.htm

APPENDIX C

http://mnre.gov.in/file-manager/UserFiles/Statewise-Solar-Potential-NISE.pdf

APPENDIX-A

SECTION 86 OF THE ELECTRICITY ACT, 2003

Section 86. (1) The State Commission shall discharge the following functions, namely: -

(a) determine the tariff for generation, supply, transmission and wheeling of electricity, wholesale, bulk or retail, as the case may be, within the State:

Providing that where open access has been permitted to a category of consumers under section 42, the State Commission shall determine only the wheeling charges and surcharge thereon, if any, for the said category of consumers;

(b) regulate electricity purchase and procurement process of distribution licensees including the price at which electricity shall be procured from the generating companies or licensees or from other sources through agreements for purchase of power for distribution and supply within the State;

(c) facilitate intra-state transmission and wheeling of electricity;

(d) issue licences to persons seeking to act as transmission licensees, distribution licensees and electricity traders with respect to their operations within the State;

(e) promote congenration 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 consumption of electricity in the area of a distribution licence;

(f) adjudicate upon the disputes between the licensees, and generating companies and to refer any dispute for arbitration;

(g) levy *fee for the purposes of this Act;*

(h) specify State Grid Code consistent with the Grid Code specified under clause (h) of sub-section (1) of section 79;

(i) specify or enforce standards with respect to quality, continuity and reliability of service by licensees;

(j) fix the trading margin in the intra-State trading of electricity, if considered, necessary; and

(k) discharge such other functions as may be assigned to it under this Act.

(2) The State Commission shall advise the State Government on all or any of the following matters, namely:-

(i) promotion of competition, efficiency and economy in activities of the electricity industry;

(ii) promotion of investment in electricity industry;

(iii) *reorganization and restructuring of electricity industry in the State;*

(iv) *matters concerning generation, transmission , distribution and trading of electricity or any other matter referred to the State Commission by that Government.*

(3) *The State Commission shall ensure transparency while exercising its powers and discharging its functions.*

(4) *In discharge of its functions the State Commission shall be guided by the National Electricity Policy, National Electricity Plan and tariff policy published under section 3.*

APPENDIX B

State wise achievements and progress of the solar city programme is given in Table-I below.

Table -I

MINISTRY OF NEW AND RENEWABLE ENERY ANNUAL REPORT 2014 - 15

State	Cities Sanctioned	Master Plan	Solar City cell/Stakeholder committee Created
Andhra Pradesh	1.Vijayawada**	Prepared	yes
Assam	2. Guwahati	Prepared	yes
	3. Jorhat	Prepared	yes
Arunachal Pradesh	4. Itanagar	Prepared	Yes
Chandigarh	5. Chandigarh*	Prepared	Yes
Chhattisgarh	6. Bilaspur	Prepared	Yes
	7. Raipur**	Prepared	Yes
Gujarat	8. Rajkot**	Prepared	Yes
	9. Gandhinagar*	Prepared	Yes
	10. Surat	Prepared	Yes
Goa	11. Panaji City	Prepared	Yes
Haryana	12. Gurgaon	Prepared	Yes
	13. Faridabad**	Prepared	Yes
Himachal Pradesh	14. Shimla **	Prepared	Yes
	15. Hamirpur	Prepared	Yes
Karnataka	16. Mysore*	Prepared	Yes
	17. Hubli-Dharwad	Prepared	Yes
Maharashtra	18. Nagpur*	Prepared	Yes
	19. Thane**	Prepared	Yes
	20. Kalyan-Dombiwali	Prepared	Yes
	21. Aurangabad	Prepared	Yes
	22. Nanded	Prepared	Yes
	23. Shirdi**	Prepared	Yes
Madhya Pradesh	24. Gwalior	Prepared	Yes
	25. Rewa	Prepared	Yes
Manipur	26. Imphal	Prepared	Yes
Mizoram	27. Aizawl**	Prepared	Yes
Nagaland	28. Kohima	Prepared	Yes
	29. Dimapur	Prepared	Yes
Delhi	30. New Delhi (NDMC area)	Prepared	Yes
Odisha	31. Bhubaneswar	Prepared	Yes
Punjab	32. Amritsar**	Prepared	Yes
	33. Ludhiana	Prepared	Yes
	34. SAS Nagar (Mohali)	Under preparation	Yes

State	Cities Sanctioned	Master Plan	Solar City cell/Stakeholder committee Created
Rajasthan	35. Ajmer	Under preparation	Yes
	36. Jodhpur	Prepared	Yes
Tamilnadu	37. Coimbatore **	Prepared	Yes
Tripura	38. Agartala**	Prepared	Yes
Uttarakhand	39. Dehradun	Prepared	Yes
	40. Haridwar & Rishikesh	Prepared	Yes
	41. Chamoli-Gopeshwar	Prepared	Yes
Uttar Pradesh	42. Agra	Prepared	Yes
	43. Moradabad	Prepared	Yes
	44. Allahabad	Under preparation	Yes
West Bangal	45. Howrah	Under preparation	Yes
	46. New Town Kolkata	Prepared	Yes
	47. Madhyamgram	Under preparation	Yes
Puducherry	48. Puducherry**	Under preparation	Yes

(* Model Solar Cities, ** Pilot Solar Cities)

Source: Ministry of New and Renewable Energy, Annual report 2014-2015
http://mnre.gov.in/file-manager/annual-report/2014-2015/EN/Chapter%206/chapter_6.htm

ANNEXURE -C

The state wise potential of the estimated solar power potential as per NATIONAL INSTITUTE OF SOLAR ENERGY (NISE) is mentioned below:

STATE WISE ESTIMATED SOLAR POWER POTENTIAL	
Total Solar Power in GWp:	748.98 GWp
State	Solar Potential (GWp)
Andhra Pradesh	38.44
Arunachal Pradesh	8.65
Assam	13.76
Bihar	11.20
Chhattisgarh	18.27
Delhi	2.05
Goa	0.88
Gujarat	35.77
Haryana	4.56
Himachal Pradesh	33.84
Jammu & Kashmir	111.05
Jharkhand	18.18
Karnataka	24.70
Kerala	6.11
Madhya Pradesh	61.66
Maharashtra	64.32
Manipur	10.63
Meghalaya	5.86
Mizoram	9.09
Nagaland	7.29
Orissa	25.78
Punjab	2.81
Rajasthan	142.31
Sikkim	4.94
Tamil Nadu	17.67
Telangana	20.41
Tripura	2.08
Uttar Pradesh	22.83
Uttarakhand	16.80
West Bengal	6.26
UT	0.79
Total	**748.98**

Source: mnre.gov.in/file-manager/UserFiles/Statewise-Solar-Potential-NISE.pdf