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Solar Power Potential of Rajasthan: Status and Prospects

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Abstract

Renewable energy has become the need of the hour today, owing to the limited availability of fossil fuels, an ever-increasing demand for energy and various environmental concerns. Rajasthan, the largest state of India, is endowed with substantial renewable energy resources which include wind, sunlight and biomass. The state is blessed with two critical resources that are essential for solar power generation: high level of solar radiation per square inch and large amounts of contiguous, relatively flat, undeveloped land. Various initiatives have been taken by the state government in this direction. Solar energy has so far been most optimally utilized for the development of village communities in Rajasthan, but many more possibilities still exist. By meeting the challenges and exploring the opportunities lying ahead, Rajasthan can utilize its immense solar potential more effectively, for its all round development. This paper attempts to highlight the factors that are favorable for the development of solar power in the state and also analyzes the progress that has been made in the state, to harness its potential in both grid-interactive and off-grid solar power since 2007.

Keywords: Decentralized solar power, grid connected solar power, off-grid solar power, solar photovoltaic (SPV), sustainable development.

The Need for Renewable Energy

The energy sector is a pivotal sector for the development of an economy and the demand for energy also increases as the economy expands. In developed countries like USA and Canada, the annual per capita availability of electricity is more than 10,000 units, in China, it is 3,000 units and in India it is only 742 units (Gangvar N.P., 2012). As India targets a year-on-year GDP growth of 9%, its gross energy requirement is expected to reach 2,359 billion KWH in 2020, which will exert tremendous pressure on its already strained non-renewable resources. The overall demand-supply

gap in the energy sector is continuously increasing in India and it was 10.3 percent in 2012 (Gyan Research and Analytics Pvt. Ltd., 2012).

More than a million families still continue to live in darkness after sunset in India. A much larger section of the population, nearly half the rural India, connected to the grid suffers from erratic supply. They depend on kerosene to address their power needs. But kerosene is heavily subsidized and there are huge leakages in the system. Thus to ensure that the benefits of development reach to the far-off rural areas, energy production has to be increased at a rate of 8-10% annually for the next 10-15 years (Gangvar N.P., 2012).

Another important issue of concern is environment. There is a need for production of energy that does not emit green house gases (GHGs), as in the case of energy harnessed from oil-based sources or fossil fuels. It is believed that with the increase of greenhouse gases (GHGs) in the atmosphere, the world is inching forward on a path of self-destruction. Thus, to reconcile economic growth and sustainable development, there is a growing tendency towards development and implementation of low-carbon electricity generation technologies for 'clean energy', namely, solar, wind, biomass and small hydropower energy. On an average, every 1 GW of additional renewable energy capacity reduces 3.3 million tons of carbon dioxide (CO2) a year, thus reducing the intensity of GHG emission in the country.

An analysis of factors influencing energy generation indicates that energy conserved yields more favorable results than energy generated. Therefore, if enhancing energy generation is an integral part of the solution for meeting the ever-increasing demand for energy, so is energy conservation. The flexibility of the clean energy generation technology application offers considerable advantages which include energy efficiency and conservation. Besides this, de-centralized renewable energy generation would eliminate the need for energy required to process and transport fuel. Furthermore, transmission losses associated with energy distribution would be negated through localized clean energy generation.

Out of the total potential of 138,000 MW of renewable energy in India, the installed capacity was only 19,975 MW (as on 31.3.2011). The country's current power generation mix comprises 65% of thermal energy (most of which is coal-based), 21.0% of energy from large hydro sources 11.1% of renewable energy and 2.6% of nuclear energy (Confederation of Indian Industry- Theme Paper, 2011). This analysis indicates that there is a huge

opportunity for clean energy production, which currently accounts for only a small part of the country's total output.

The Current Energy Scenario in Rajasthan

Rajasthan, the largest state of India constitutes about 10.4% geographical area of India. Notwithstanding the recently discovered large hydrocarbon reserves of more than 3.6 x 109 barrel oil and oil equivalent in Barmer basin (Compton P.M., 2009), there are limited available traditional sources of energy such as coal. There are only two perennial rivers, Chambal and Mahi, whose hydroelectric potential has been almost fully exploited. In view of the above, Rajasthan faces two unique challenges in terms of power generation from the conventional sources. On one hand, Rajasthan does not have many hydropower projects due to non-availability of large rivers. On the other, because coal needs to be transported from far-off areas of the country, the transportation alone contributes to 50% cost of energy production.

As per census 2011, only 67% of the households have electricity in Rajasthan (58.25% in rural areas, as compared to 93.88% in urban areas), 30.91% use kerosene, and 1.24% use other sources, while 0.84% of the households do not have access to any source of lighting. Another important feature of Rajasthan's power scenario is that there has been a consistent energy deficit in power generation, as depicted in Table 1.

Table 1
Energy Scenario in Rajasthan

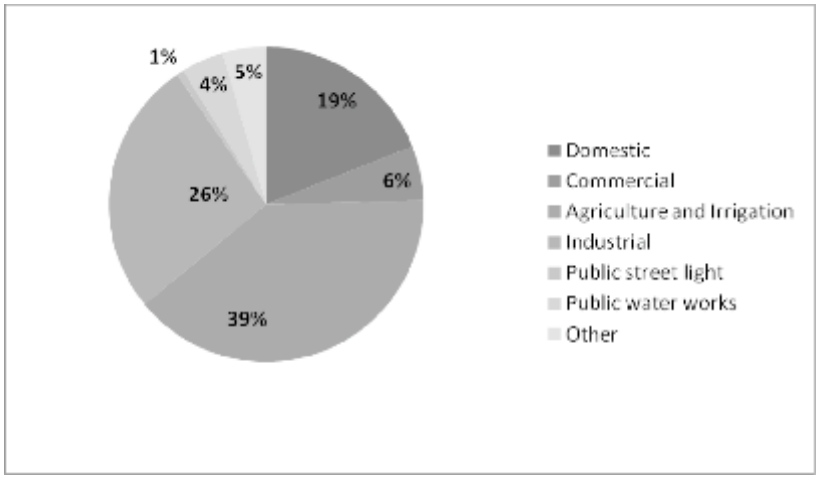
Year	Energy Requirement (MU)	Energy Availability (MU)	Energy Deficit (MU)
2007-08	36738	35597	-1141
2008-09	37797	37388	-409
2009-10	44,109	43,062	-1,047
2010-11	45,261	44,836	-425
2011-12	51,474	49,491	-1,983

Source: Power Scenario at a Glance, Central Electricity Authority, 2012

One of the major reasons for this deficit is that the demand for energy is continuously increasing while the supply is not able to keep pace with it. A sector wise analysis of electricity consumption shows that agricultural

sector is the largest consumer of electricity, followed by the industrial sector.

Figure 1
Sector-wise Consumption of Electricity (2009-10)



Thus, growing energy demand from all sectors, particularly agriculture and industry, recurrent energy deficits, lack of hydropower projects, high costs involved in energy generation from conventional sources, rising environmental concerns on GHGs emissions from energy generation through fossil fuels and climate change etc. are some of the factors which have lead to the need for developing cleaner-renewable energy resources in Rajasthan.

It is a fortunate fact that Rajasthan is endowed with substantial renewable energy resources including wind, solar and biomass and among these, solar power is most abundantly available in the state.

Solar power generation technologies can be broadly classified into two broad categories:

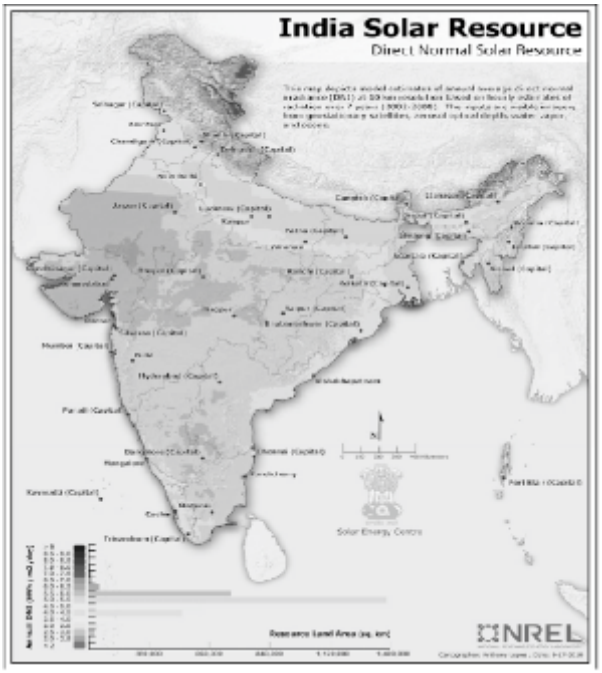
a. Solar Photovoltaic (SPV) technologies: Photovoltaic converters are semiconductor devices that convert part of the incident solar radiation directly into electrical energy.

b. Concentrated Solar Power (CSP) or Solar thermal power plants: Solar thermal power plants produce electricity by converting the solar radiation into high temperature heat using mirrors and reflectors.

Factors that Favour the Development of Solar Power in Rajasthan

Rajasthan is blessed with two critical resources that are essential to solar power production: high level of solar radiation per square inch and large amounts of contiguous, relatively flat, undeveloped land.

Figure 2
Annual Direct Normal Irradiance (DNI) in India



Source: http://www.nrel.gov/international/ra_india.html

It is apparent from the map above that the most intense solar radiation in India is located in Rajasthan.

Rajasthan is uniquely placed to tap solar radiations with 300-330 clear sunny days and average daily solar incidence of 5-7 KWH/m2 (Bureau of Investment Promotion, 2012). Barmer, Bikaner, Jaisalmer and Jodhpur are the key regions with best solar radiation in the State. The total desert area in the State is 208,110sq.km which means that 60% of the area falls under arid and semi arid zone. Moreover, the land is flat, having a slope of less than 1degree. It has been found that 3600 sq.km of land

is required for generation of 100,000 MW of power, which is less than even 2% of the desert land of the state(Somani G., 2010).

Besides the abundance of solar resource, there are certain factors which are favorable for the development of solar energy industry in Rajasthan.

a.) Land and Infrastructure : Rajasthan has a competitive advantage based on the availability of relatively low cost land for industrial use. Adequate availability of electricity here, as compared to other states, enables the development of solar manufacturing industry, which is energy intensive. The peak (3-5%) and average power deficits (1-2%) in State are reported to be lowest in the country. This also gives an edge to Rajasthan over other states.

b.) Human Resources The State has an advantage of labour cost as compared to its peer states (~20-30% lower). In addition, the state has a requisite pool of skilled manpower that could cater to the requirements for solar component manufacturing industry. Besides this, certain skills required in general manufacturing industry (such as glass) are easily transferable to solar manufacturing and related industries (specialized glass for Solar PV and Solar CSP), except high end R&D skills.

c.) Availability of Raw Material : The State has abundance of minerals such as zinc, quartz and salt (necessary for Solar CSP). In fact, the State accounts for about 99% of the country's production of zinc concentrates. The zinc concentrates are used for galvanization of mounting structures for Solar PV and CSP technology. Besides this, Rajasthan has a huge potential to become a solar glass manufacturing hub. Presently, around 500 operating ceramic units, grinding units, etc. are present in the State. Rajasthan is the third largest producer of salt in India. Molten salt is used as a heat transfer fluid in the CSP technology. The State has got high concentration of building material industries such as steel, cement, stone and other chemicals in and around the State.

d.) Logistics : Rajasthan has excellent proximity to end user market as well as supplier base for raw material, providing logistics cost advantage. The State is well connected to major cities and towns of the country through railways. The State is strategically placed on proposed Delhi Mumbai Industrial Corridor (DMIC) and, nearly 60% of the area under the Project Influence Area (PIA) falls in the State.

Development of Solar Power in Rajasthan in Last Five Years

Solar energy development progammes are implemented in two forms i.e. Grid Connected Solar Power and Off Grid or Decentralized Solar Energy Systems or Devices. These are discussed in detail below.

a) Grid Connected Solar Power

Grid-interactive/ grid-connected solar power projects are power generating plants, supplying power to the grid. These projects, mainly private investment driven, with favorable tariff policy regimes established by State Electricity Regulatory Commission (SERC), aimed at generating competitively priced solar thermal and solar photovoltaic power.

As on 04.02.2013, India had a total installed capacity of 1221.255 MW of solar power. The two major contributors in the installed capacity were Gujarat and Rajasthan, with installed capacity of 824.09 MW and 222.9 MW respectively. Thus Rajasthan's share was 18.25% whereas Gujarat's share was 67.48%. Currently, there are total 49 solar power projects in the state under a wide variety of schemes.

Table 2
Scheme-wise Projects in Rajasthan

Scheme	Installed capacity(MW)	No. of Projects
JNNSM Phase I	152.5	31
State Policy	0	0
RPSSGP/GBI Scheme	12	14
REC Scheme	2.5	1
Other schemes	55.9	3
TOTAL	**222.9**	**49**

Here JNNSM - Jawaharlal Nehru National Solar Mission, RPSSGP - Rooftop PV & Small Solar Power Generation Programme, GBI - Generation Based Incentive and REC is Renewable Energy Certificate.

Table 3 gives a district-wise breakup of installed capacity in Rajasthan.

Table 3
District-wise Installed Capacity and Number of Projects

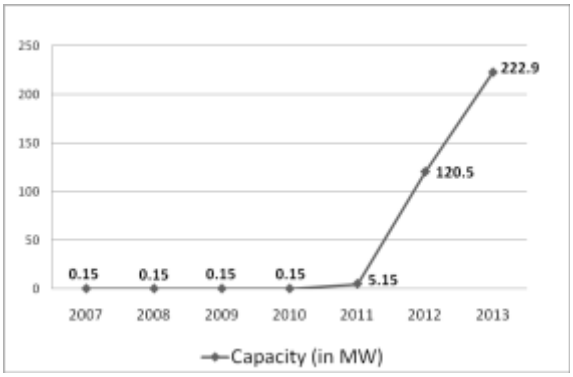
District	Installed capacity (in MW)	No. of Projects
Jaisalmer	89	14
Jodhpur	88.5	20
Bikaner	18.5	5
Nagaur	10	2
Barmer	6	2
Bhilwara	5	1
Churu	1	1
Sirohi	1	1
Jhunjhunu	1	1
Jaipur	1	1
Total	**221**	**48**

Source: MNRE

The table given above clearly shows that Jaisalmer and Jodhpur are the major districts in solar power generation.

While analyzing the growth of grid-connected solar power since 2007, it is seen that a tremendous increase has taken place after 2011. This may be attributed to the launch of JNNSM.

Figure 3:
Cumulative Installed Capacity of Grid-connected Solar Power



Another important development of grid connected solar power can be seen in terms of its contribution in the installed capacity of the state.

As on 31.12.2012 the total installed capacity of Rajasthan was 10615.725 MW. The share of renewable energy (which includes wind, solar and biomass energy) in installed capacity was 24%.

Further analysis of the share of various components of renewable energy in installed capacity shows that wind energy is the most significant contributor, while solar energy contributes 9%.

Figure 4
Percentage Share of Various Renewable Energy Sources

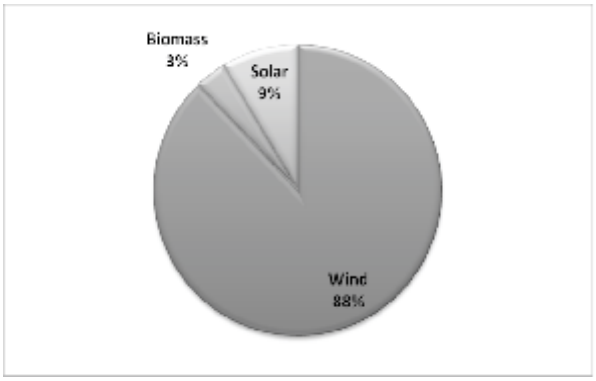
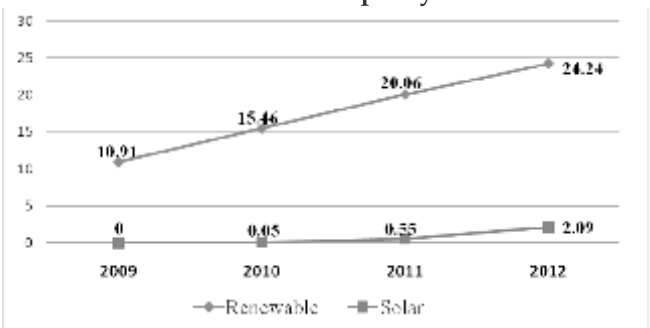


Figure 5 shows that how the contribution of renewable energy, in general and solar energy, in particular, in the installed capacity of the state has increased over the years.

Figure 5
Growing Contribution of Renewable Energy and Solar Energy in the Installed Capacity



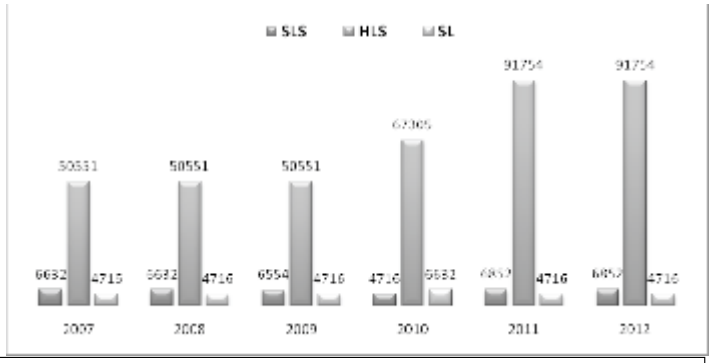
b) Off-Grid or Decentralized Solar Energy Systems

In addition to grid interactive power, decentralized renewable power projects are established to meet the energy requirements of isolated communities and areas which are not likely to be electrified in near future. In Rajasthan, though electricity losses during transmission and distribution (T & D) have come down during recent years, they still remain extremely high, i.e., 30 to 45%. This further increases the need for providing decentralized power systems in the unelectrified areas.

Solar energy technologies are ideally suited to distributed applications, and they have substantial potential to provide a reliable and secure energy supply as an alternative to grid extension or as a supplement to grid-provided power. Some of the renewable energy technologies that are used in villages and rural areas as decentralized systems are solar street lighting systems, home lighting systems, solar lanterns, solar cookers, stand-alone solar based power generators/plants.

Figure 6 shows various off-gird renewable energy devices or systems installed in the state during the last five years.

Figure 6
Off-grid/Decentralized Solar Photovoltaic Systems/ Devices since 2007



SLS=Street Lighting System; HLS=Home Lighting System; SL=Solar Lantern

Thus, it is seen that solar home lighting system are the most widely used and their magnitude has increased after 2010, while there has been no significant increase in solar street lighting system and solar lanterns. The state had the largest number of solar street lighting systems installed as on 31.03.2011, after Uttar Pradesh and West Bengal. However, no systems were installed in the state during 2011-12. According to census 2011, only 0.62 % of the households in the state use solar power as source of lighting.

The major districts using solar power are given in the table below.

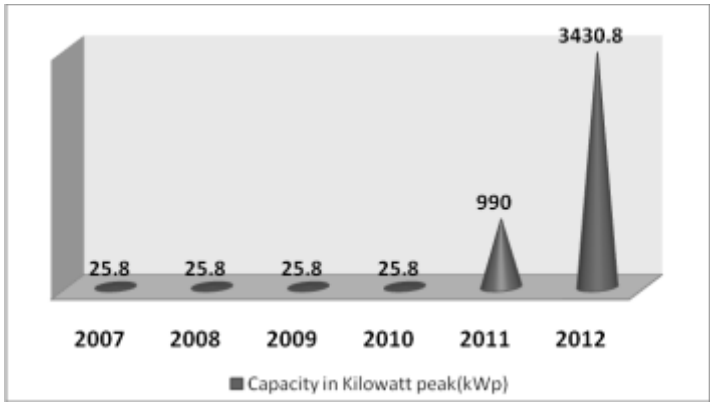
Table 4
Percentage of households using solar power as source of lighting

District	Households using solar HLS (%)
Barmer	4.2
Jaisalmer	3.8
Bikaner	1.8
Karauli	1.7
Jalore	1.3
Udaipur	1.2

Source: Census of Rajasthan, 2011

For the remaining 27 districts, this proportion was between 0.1-0.8 percent. But this indicates increasing awareness and popularity amongst people regarding use of solar power.Another decentralized solar application is a stand-alone power plant. A stand-alone power plant is an isolated power system not connected to the grid, often having storage, catering to specified needs. The capacity of solar photovoltaic power plants has remained constant till 2010 but has increased significantly since 2011; as shown in Figure 7.

Figure 7
Cumulative installed capacity of Stand-alone Solar Power Plants



c) Role of State Government (Pandey S. et al, 2011)

Out of a total 1100 MW new project allocations, Rajasthan received the maximum share of 873 MW (i.e., 79.36% of all India allocations) through competitive bidding in the first phase of Jawaharlal Nehru National Solar Mission (JNNSM). Furthermore, 722 reputed companies have already registered their interest for setting up of solar power plants amounting to a total capacity of 16900 MW in Rajasthan (Pandey S. et al, 2011).

This preference is often attributed to geographical and climatic advantage of Rajasthan. Besides this, the following initiatives taken by the government have been attributed for promotion of solar energy in Rajasthan:

c) Renewable and Solar Policy

To promote the renewable energy sector in general and solar energy in particular, Government of Rajasthan enacted the "Policy for Promoting Generation of Power through Non-Conventional Energy Sources" on 11th March 1999, which was updated in year 2000, 2003 and 2004. On April 19, 2011, it issued Rajasthan Solar Energy Policy, 2011 to promote Solar Energy. The main objectives of this policy include: leverage maximum benefit from National Solar Mission, promote off-grid applications of solar energy and the development of solar parks. Other important policy initiatives of Government of Rajasthan embodied in the climate change agenda of Rajasthan, Rajasthan environment mission, Rajasthan Environment Policy 2010, and State Action Plan on Climate Change is to recognize the role of solar energy for sustainable development and energy security.

d) State Nodal Agency and Single Window Clearance

Government of Rajasthan established the Rajasthan Renewable Energy Corporation Limited (RRECL) in year 2003 by merging erstwhile Rajasthan Energy Development Agency (REDA) and the Rajasthan State Power Corporation Limited (RSPCL) to act as state nodal agency for single window clearance of the renewable energy projects. This was also to facilitate the allotment of revenue land, power evacuation approval and coordination with MNRE and State Agencies including State Transmission Utility (STU) and Discoms. It is also engaged in creating awareness among people towards conservation of energy through demonstration projects.

e) Robust Power Evacuation System in Thar Desert

Energy production systems are mostly located in desert districts such as Jaisalmer, Bikaner, Jodhpur, Barmer, but load centers are situated away from these districts. Therefore, it was felt that evacuation and transmission of power was required to be strengthened. Accordingly, a dedicated 400 KV network with associated 220 and 132 KV strong transmission network in these districts was created. Rajasthan is the only State in India which has established a strong power evacuation network in a desert region.

f) Providing Incentives to People

In order to encourage people to use solar energy based appliances, the state government along with MNRE provides certain incentives to people such as a subsidy of 30% of the cost for domestic solar photovoltaic light and solar water heater and a rebate of 25p/unit in electricity bill on using solar water heating system in domestic category.

Rural Empowerment in Rajasthan through Solar Energy

Solar energy can be used to provide sustainable energy solutions to millions of rural households for meeting their energy requirements for domestic and productive uses. Keeping in view the energy needs of the rural areas, renewable off-grid electrification helps to mitigate climate change effects, electrify rural areas and drive local job markets. Some of the villages in Rajasthan have demonstrated how solar energy can be used innovatively for rural empowerment.

The Barefoot College, located in Tilonia Gram Panchayat of Kishangarh Block in Ajmer district, is the first fully solar electrified campus located in rural India. The campus meets its energy needs through 50 kilowatt solar modules. In September 2006, college also established India's first ever solar powered reverse osmosis plant for water desalination at a small voluntary organization called 'Manthan' in Kotri village near Sambhar Salt lake. The approach of the College focuses on using local skills to achieve people-centric and sustainable development and this has been replicated across 751 villages in 16 states of India and 20 other underdeveloped countries.

As a result of these efforts, various socio-economic changes have taken place. The College has imparted training to the community members (essentially with poor economic status) on leadership qualities and

willingness to work for the village as 'Barefoot Solar Engineers' (BSEs). As on May 2010, 480 people have been trained as Barefoot Solar Engineers (BSEs), who have fabricated, installed, repaired and maintained nearly 16,000 fixed solar units and 9,762 solar lanterns across 16 states of India and 20 of the least developed countries like Afghanistan, Bhutan, Cameroon and Kenya etc. Introduction of solar lighting units has helped more than 50,000 children in India to attend Barefoot Night Schools after sunset (as they work during the day). The illiterate people irrespective of their age are being trained to work as school teachers, doctors, solar engineers, water drillers, architects, artisans, phone operators, blacksmiths, carpenters, computer instructors and accountants, etc.

Women empowerment has also taken place. Most of the village women, who earlier used to spend hours in fetching water and collecting fuel wood, can now spend quality time in studying and doing productive work. This has made women financially independent by providing them with employment after training and also addressed the problem of gender discrimination. Nearly 50% of the BSEs are women. Even environmental changes occurred because solar energy is being used as an alternative source of lighting (solar home lighting units), heating (solar water heaters), cooking (parabolic solar cookers) and drinking water (solar powered desalination plant) since its inception. These collective efforts have resulted in saving more than 30,000 litres of kerosene per month. The total carbon emissions reduction from 1986 to 2008 is estimated to be nearly 1.86 million tonnes annually.

Another change has taken place in Indira Nagar village of Soda Panchayat in Tonk district.

Indira Nagar is a small hamlet consisting of the families that have small landholdings cultivated for a single rainfed crop of pulses and groundnut every year; others work as labourers in nearby towns. An initiative by Minda NexGenTech Ltd and the local Sarpanch Ms Chhavi Rajawat which started with the setting up of a solar power-based micro grid, has led to a transformation in the village. The initial investment was done by Minda NexGenTech Ltd with the intention of providing electricity to the village and also empowering them through income generation opportunities such as grinding of lentils (pulses), stitching, and educating the womenfolk. Prior to installation of the solar plant, light meant inhalation of fumes from kerosene lamps and many activities were not possible after sunset. However, the 240W solar power plant provides basic lighting to all houses in Indira Nagar. With the arrival of power, women have also been able to

engage themselves in entrepreneurial activities, as evening hours are now spent under energy-efficient LED bulbs grinding pulses and stitching to supplement family incomes. Access to energy has enhanced studying hours for children, facilitated women's education initiatives, and, in general, brought about a social revolution in the village.

Challenges and Opportunities Ahead

Despite the recent development of solar power as revealed by various success stories, there are certain areas of concern which need attention.

- As Thar Desert experiences frequent dust and sand storms, deposition of airborne dust on outdoor PV modules may decrease the transmittance of solar cell glazing and cause a significant degradation of solar conversion efficiency of PV modules (A dust layer decreases solar power conversion 40% by 4 g m2) (Sharma NK, Tiwari PK, Sood YR, 2012). Therefore, investors would need to find a cost-effective solution to a common problem of dust deposition to maintain the efficiency of energy production systems.
- Most of the solar cells used are imported, as foreign manufacturers dump their products at dirt cheap prices in the country and domestic manufacturers find it hard to compete. In 2011, four projects of a total of 60 MW capacity were financed by the Exim bank of US on the condition that all equipment are purchased from American manufacturers (Yadav, P.S. & Hamberg, J., 2012). Thus there is a need to develop indigenous solar industry and at the same time, mandate developers to buy domestic equipment.
- Another area of concern is unawareness about the long term benefits of solar power among the people. Therefore, Rajasthan would need to invest in educating the consumers about this. Without a clear understanding, the society always gives preference to energy sources with low initial financial costs even though these sources have large costs related to climate change adaptation and mitigation in the longer-term.
- By overcoming these impediments and taking various initiatives and innovations in exploiting solar power, numerous opportunities can be availed, thus providing not only light, but sustainable, all round development.

- Solar energy can be used to desalinate sea water for the Thar Desert. Thus, drinking water and other needs of the communities living in remote areas can be met with the help of solar distillation and desalination because it is economical, easy to construct and maintain (Khanna RK, Rathore RS, Sharma C., 2008).
- Since agricultural sector is the largest consumer of electricity in the state. It amounts for approximately 38% of the total consumption of electricity. Electricity is mainly used for irrigation purposes. About 70% area is irrigated by wells & tube wells (ground water) and 27 % by canals. Rainfall is erratic and unevenly distributed and low (an average of 575 mm).
- In view of the above factors, deployment of large number of solar photovoltaic pump operated drip irrigation system could optimize both energy use and water use efficiency.
- Owing to the large solar insolation level, another thrust area is solar water heaters (SWHs). SWHs find a wide use in the following sectors: Residential, Hotels, Hospitals and Industries, with the residential sector being the largest shareholder. Factors like growth in new housing, rising income and increased propensity for consumer durables, demand for hot water have lead to growth of SWH in the residential sector. A study conducted by Greentech Knowledge Solutions (P) Ltd in selected 29 districts showed that Jaipur, with a large population of hotels and hospitals, has a large SWH potential. Almost 35% installation is in residential sector. The city shares around 40-50% of SWH market of the state. The market is expected to grow by 40% per annum for next few years. As regard the state, owing to the large number of hotels and being a major tourist attraction of the country, there is a tremendous need for hot water in this sector. Other important areas include hostels, industries like dairy, food processing, dying and printing, pulp and paper industry.
- Studies note that to meet 50% of the total energy demands, the proposed area for collection of solar and wind energy by means of ultra large scale farms will occupy a mere fraction of the available land and near-offshore area, e.g. a solar PV electricity farm of 26 km2 area required for India represents 0.01% land area of Rajasthan (Asif M, Muneer T., 2007). So, exploring the potential of ultra-large scale solar farms may be another area of interest.

- Solar mini-grid can show the light for a number of problems associated with solar Home Lighting System (HLS), such as poor after sale services and lack of knowledge on operation and maintenance, as it has been demonstrated by the state of Chhattisgarh (Kumar J. & Paliwal A., 2012). Chhattisgarh is the only state that is focusing on providing community-based solar power plants under Remote Village Electrificaton Program (RVEP) instead of individual HLS. Majority of the villages have been electrified through micro-grids and the rest of the villages and hamlets, where houses are scattered, have been given HLSs. After a year-long research conducted by the Centre for Science and Environment (CSE) in various states of India, it has recommended that the government needs to incentivize mini-grids with the same financial model as that of grid-connected solar plants, also allowing entrepreneurs to set up mini-grids. These mini-grids will meet the local needs and when the grid reaches the villages, they could be made grid-interactive (i.e., they can export power to it and import from it). This will create jobs and help build the local economy, as it has been in the case of Indira Nagar village in Tonk district. Thus this is another important area for development.
- Currently, solar energy systems in India are almost entirely based on PV technology. Since solar thermal technology has also been successfully implemented in developed countries, with high solar potential, the development of this technology is imperative in Rajasthan.
- Solar energy generation systems also create regular jobs locally, extending the benefits beyond the income earned from those jobs. Benefits occur when workers spend part of their income in the local economy, generating spin-off benefits known as the 'multiplier effect'.

Conclusion

Keeping in view the rising energy demand, the limited availability of energy and the environmental impact of the conventional sources of energy, renewable sources of energy definitely show the way towards a brighter future. Solar energy has huge untapped potential in Rajasthan on account of the state's high solar insolation level, the best in the country. The progress in the field of solar energy has gained momentum after 2010, with

the state emerging as the second largest contributor in the installed capacity of solar power in India. At the same time, there has been significant growth in installation of decentralized solar devices. If properly harnessed, Rajasthan can become the leading state in solar power generation in India.

Solar thermal power generation, village electrification, developing the solar industry indigenously and using solar power innovatively for various purposes like irrigation and water heating are some of the key areas where solar industry can prove to be an economic engine in the state. The state government has also started taking initiatives for the development of solar power.

Moreover, as 105,385 households continue to live in darkness in Rajasthan, solar energy can be used to provide them with light, and at the same time, empower them to develop skills and improve the condition of women, thus leading to sustainable development of village communities, as it can be seen from the achievements of Barefoot College and Indira Nagar village.136

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