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Solar Power Development In India- A Review

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Abstract: The Indian power sector is witnessing a revolution as excitement grips the nation about harnessing electricity from various renewable sources of energy. India has become the world's next clean energy 'hotspot' as it plans to meet its substantial future energy from renewable sources. These include wind, solar, bio-mass, hydro, wastes etc. Electricity generation from renewable energy sources is increasingly recognized to play an important role for the achievement of a variety of primary and secondary energy policy goals, such as improved diversity and security of energy supply, reduction of local pollutant and global greenhouse gas emissions, regional and rural development, and exploitation of opportunities for fostering social cohesion, value addition and employment generation at the local and regional level. Due to its geographical location; India receives a high intensity of solar radiation. Currently, India is pushing forward a massive plan of generating electricity by using solar radiation. [1][6]. The Jawaharlal Nehru National Solar Mission was launched in 2009 to create policy conditions to make solar power as affordable as conventional power by 2022, and establish India as global leader in solar energy. The Mission creates a secure investment structure designed to encourage large-scale investment, technical innovation and rapid cost reductions in solar energy technologies within India. The Mission also aims to foster inclusive growth by empowering the most disadvantaged and remote communities to service their own energy needs using off-grid applications. Early results show major successes in reducing solar tariffs, but suggest the need for improved initiatives to ensure long-term project sustainability, meet the needs of energy-poor people, attract international financing, and address potential environmental impacts of solar power.[1]

Index Terms: Solar Power1, Indian Solar Potential2, Mission3, and Plan and project4

1. INTRODUCTION

1.1 Renewable Energy In India – An Overview

The electrical and power sector in India has developed significantly over the 65 years of Independence. As the socio-economic pattern of India kept continuously evolving and development reached far off to the remotest village of it, in spite of achieving great strides in electricity sector, access to power and reliability of power remains the major issues. Currently, India is ranked fifth globally in installed power capacity with nearly 147.965 GW. The fossil fuel (mainly coal) based power generation contributes to 76 GW of electricity while renewable comprises of 48.6 GW including hydro- power and 12.6 GW without it. Howsoever, India's fast economic growth comes with a growing demand for energy and it is also predicted that as it propels the path of socio-economic reforms, it will face an acute shortage of power until & unless total generation capacity is increased proportionately. The impact will be most severe on rural masses. There would be a desperate need for some miraculous energy sources for remote village house –holds. The challenges & problems are manifold (energy security being one) before an emerging economy likeIndia which has millions of it populace below poverty line. A country which faces crisis of energy security and at the same time cannot refrain from contributing positively in averring the impact of climate change is left with no other solution than to switch over to renewable energy production. India has been endowed with a vast pool of renewable energy sources such as hydro, solar, wind, bio-mass etc. At presently renewable energy contributes about 9% (12.6 GW) of total installed electricity capacity in India. The result achieved in the renewable energy sector during 10th five year plan (2002-07) was positive and it provided the regulatory authorities with the optimism to initiate major reforms in renewable energy power sector. Even the current five year plan outlines a target of generating additional 14-20 GW of electricity from renewable source of energy. It identifies solar power generation as one of the means to achieve it. If the trend during tenth five year plan (2002-07) was to promote & generate electricity from wind power plants then perhaps current five year (2007-12) plan will be known for generation of electricity from solar power plants. The advantages of renewable energy are expected to contribute significantly in the developmental process. India's recent success in clean energy is just a beginning. [4]

1.2 Solar Energy – The Promising Prospect

The days will not be far off when power plants will shift from large, remote centralized stations to rooftops, basements, backyards with no fuel cost characterized by quality & reliability. As human civilization witnesses a gradual shift towards harnessing cleaner form of energy from various sources; the solar energy is going to play an important role.

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Perhaps, it is the only energy which has absolutely no fuel cost. To tap the infinite energy from the sun and transform as well as to transmit it to each household, the Indian govt. has accelerated promotion of the use of universally available solar energy through its various policies and incentives. India due to its geo-physical location receives solar energy equivalent to nearly 5,000 trillion KWh/ year, which is far more than the total energy consumption of the country today. But it produces a very negligible amount of solar energy i.e. a merely 0.2 percent compared to other energy resources. The Govt. of India, in all its recent policies relating to power sector has given due importance to harness the sun's energy in various ways. Solar energy is harnessed through the available technologies like Solar Photovoltaic (SPV), Solar Thermal (ST), and Concentrating Solar Power (CSP). Some parts of India like western part of Rajasthan (Thar desert) receive the required solar radiation for use of Concentrating Solar Power (CSP) technology. It is estimated that a 60 km x 60 km of area can produce 1, 00,000 MW of power using CSP technology. The advantages which distributed generation of solar energy brings are unique. It provides easy access to power for tail-end users like rural people, it avoids high transmission &distribution (T&D) costs, provides reliable and quality power and is environmentally benign. It also indicates that a decentralized power generation can perfectly complement decentralized development and governance. Even national electricity policy 2005(NEP) envisages that in order to ensure better rural electrification infrastructure and to operate and maintain supply system for securing reliable power; the responsibility of operation & maintenance and cost recovery could be discharged by utilities through appropriate arrangements with panchayats, local authorities, NGOs and other franchisees etc. So, the promotion of generation of solar energy can significantly contribute in attaining the developmental agenda. Such renewable energy power production potential in India can be easily scaled up innovatively in an affordable and sustainable manner. Howsoever, the prerequisite to success of any such massive plan is a comprehensive legal/policy framework for the entire cycle of development for each of these renewable energy resources. Presently, solar energy is facing three fundamental challenges i.e.; cost, its manufacturing procedure (R & D) and the land acquisition for erecting solar power plants. Nevertheless, the Govt. (Central as well as State) through various policy measures has recently attempted to address these challenges. It is also estimated that once the scaling of solar energy is done a greater access to the market will be facilitated and its cost will come at par with conventional source of energy. All the policy measures focus on promotion of R & D in the respective technology to enhance the efficiency and viability of the project. As these technologies will be categorized as environmental sustainable technologies(EST's); under the existing international legal framework, the developed economies have an obligation to transfer technology. The land acquisition policy has been always a controversial issue in India, but, perhaps one of the viable solutions to it is the acquisition through local bodies, panchayats & municipality. All the existing policies provide for the acquisition of land by involving local bodies and panchayats for the
successful implementation of projects.[4][5]

2. IMPORTANCE AND RELEVANCE OF SOLAR ENERGY FOR INDIA

2.1 Cost

Solar energy is currently high on costs compared to other sources of power such as coal. The objective of the Solar Mission is to create conditions, through rapid scale-up of capacity and technological innovation to drive down costs towards grid parity. The Mission anticipates achieving grid parity by 2022 and parity with coal-based thermal power by 2030, but recognizes that this cost trajectory will depend upon the scale of global deployment and technology development and transfer. The cost projections vary – from 22% for every doubling of capacity to a reduction of only 60% with global deployment increasing 16 times the current level..[6]

2.2 Scalability

India is endowed with vast solar energy potential. About 5,000 trillion kWh per year energy is incident over India's land area with most parts receiving 4-7 kWh per sq. m per day. Hence both technology routes for conversion of solar radiation into heat and electricity, namely, solar thermal and solar photovoltaics, can effectively be harnessed providing huge scalability for solar in India. 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. The constraint on scalability will be the availability of space, since in all current applications, solar power is space intensive. In addition, without effective storage, solar power is characterized by a high degree of variability.
In India, this would be particularly true in the monsoon season.

2.3 Environmental Impact

Solar energy is not having any adverse effect on environment. It is ecofrendly.

2.4 Security of source

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

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country, every effort needs to be made to exploit the relatively abundant sources of energy available to the country. While, today, domestic coal based power generation is the cheapest electricity source, future scenarios suggest that this could well change. Already, faced with crippling electricity shortages, price of electricity traded internally, touched Rs 7 per unit for base loads and around Rs 8.50 per unit during peak periods. The situation will also change, as the country moves towards imported coal to meet its energy demand. The price of power will have to factor in the availability of coal in international markets and the cost of developing import infrastructure. It is also evident that as the cost of environmental degradation is factored into the mining of coal, as it must, the price of this raw material will increase. In the situation of energy shortages, the country is increasing the use of diesel-based electricity, which is both expensive – costs as high as Rs 15 per unit - and polluting. It is in this situation the solar imperative is both urgent and feasible to enable the country to meet long-term energy needs.

3. THE MISSION

India faces a soaring energy demand from its growing population of 1.1 billion and a rapidly expanding economy. Over 400 million people have no access to electricity, including 28 million rural households that continue to burn biomass or diesel to meet their energy needs. India currently depends on coal and fossil fuels at a time when the pricing of international fossil fuels is highly volatile and domestic coal is running out. India's energy goals are further complicated by its voluntary commitment to reduce the emissions intensity of its GDP by 20–25% by 2020.

Launched in November 2009, the Jawaharlal Nehru National Solar Mission (the Mission) addresses India's intertwined challenges of energy security and climate change. It is one of eight national missions under India's National Action Plan on Climate Change.

Dr. Manmohan Singh, Prime Minister of India, during the launch of the India Solar Mission, said: "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 original source of all energy."

The Mission aims to achieve grid parity (electricity delivered at the same cost and quality as that delivered on the grid) by 2020, by fostering the installation of 20 GW of solar installations. Achieving this target would establish India as a global leader in solar power generation, improving its current 10th place ranking with only 0.2 GW installed, behind global leaders including Germany (17 GW), Spain (4 GW) and Japan (2.7 GW).

The Mission also aims to position India as a global solar manufacturing leader by encouraging its nascent industry. Solar installations must use some locally-sourced materials, and the Mission supports domestic firms with loans, lower duties and research and development (R&D) support. These initiatives are intended to grow Indian firms to compete with Chinese firms, who recently claimed a majority of the global market in solar installations.

Solar is an ideal energy source in India due to its tropical climate. It offers abundant, domestically-generated, low-carbon energy. By 2022, wide-scale implementation of solar power in India has the potential to meet nearly 7% of energy needs, mitigate 2.6% of India's carbon emissions and save over 30% of coal imports, equal to US $5.5 billion, of imported coal. The way forward for solar technology depends on reducing its high initial economic costs. The Mission aims to achieve this through economies of scale and technological innovation, enabling India's energy-poor citizens to leapfrog from dirty fossil fuels directly to eco-friendly solar energy.

4. PLAN AND PROCESS

4.1 Mission Structure

The lead agency for the Mission is the Ministry of New and Renewable Energy (MNRE). States are responsible for project implementation, and financial institutions and entrepreneurs for project financing, design and construction. The Mission will require up to 1.5 trillion rupees (US $33.5 billion) from private sector and international climate financing, and subsidies will be financed through government allocations and higher consumer tariffs.

The Mission will be implemented in three phases:

1. In Phase 1 (2012–13) smaller-scale projects have been commissioned that employ only commercially established technologies in order to minimise risks and ensure early successes.
2. In Phase 2 (2013–17) the size and capacity of solar installations will be aggressively expanded to a scale aimed at establishing India as a leader in the solar energy market.
3. Phase 3 (2017–22) will focus on creating favourable conditions for domestic solar manufacturing capability and leadership.

4.2 Grid-Connected Solar Projects

The Mission promotes the move towards solar power by incentivising the installation of 20,000 megawatts (MW) of solar installations by 2022. This is an ambitious target; Germany is currently the largest global solar market, with 17,000 MW of capacity.

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The Mission, in Phase 1, is fine-tuning an investment structure that balances the risks and benefits of rapid solar expansion between the government, and project developers. The focal agency is a central state-owned power trading company, NTPC Vidyut Vyapar Nigam Ltd. (NVVN), which enters into 25-year Power Purchase Agreements that guarantee payment for the power generated by project developers. The NVVN mitigates the high cost of solar by bundling it with cheaper coal-based energy and selling the bundled energy to state utilities at a rate set by the central electricity commission. To ensure demand, state electricity commissions require each state utility to purchase a minimum percentage of solar-based power within its energy portfolio. In response to calls for added security the MRNE, in June 2011, set up a **3.3** .86 billion rupee (US $108 million) scheme to secure payment to Phase 1 developers in case cash-strapped state utilities default on payments.The Government offers this financial security to encourage project developers to take financial and technological risks. The first round of bidding saw projects awarded to the lowest cost bids. To discourage unrealistically low bids, developers had to furnish bonds in proportion to the amount of the tariff discount offered and were fined daily if project completion was delayed. [6][8]

4.3 Off-Grid And Decentralised Applications

The Mission aims to reach the energy poor population in rural and remote villages by subsidising 2000 MW of off-grid solar applications and distributing 200 million home solar lighting systems. Target projects range from household-level use (for example of solar lanterns and water pumps) to stand-alone plants for public institutions, banks and rural communities.

The Mission aims to empower the poor by making the high initial costs of small-scale solar installations affordable. The process is decentralised and market-based; individuals and communities apply to approved financial institutions for capital subsidies of 30–90% and/ or 5% interest-bearing loans. India expects to grant subsidies of 2 billion rupees (US $44 million) for off-grid projects annually. To ensure quality installations, program participants must be accredited, use pre-approved components, and provide warranties on parts and installations. Rural attitudes consider solar energy to be second-class power, inferior to grid connectivity. To counter this, financial incentives are offered to banks to fund awareness-raising activities and cash awards are given to villages that achieve 75% solar electrification.

4.4 Domestic Manufacturing

The Mission targets 4–5,000 MW of domestic manufacturing capacity by 2020. Solar developers are required to use some locally-sourced components. Domestic manufacturers are offered zero import duties on capital equipment, and low interest loans. The Mission plans to establish 2–3 large manufacturing parks for solar thermal technology development. [9][8]

4.5 Research And Development

The Mission will launch a major R&D programme focused on developing solar technologies and building up a solar energy workforce; it plans to establish research centres, international fellowship programmes, specialised domestic training courses, and funding for start-ups and pilot projects. India calls for international collaboration on solar power research, aligned with developed nations' responsibilities of technology transfer and assistance financing under the international climate change regime. In May 2011, the United States and India created the Joint Clean Energy Research and Development Center to collaborate on research into energy efficiency, biofuels and solar energy.

5. KEY LESSONS

5.1 Provide A Secure Investment Structure

A key factor in the rapid diffusion of solar energy in India will be the clear, long-term commitment of the central government to guarantee a secure investment structure for solar energy development. Both rounds of bidding to date attracted a huge response and achieved significant tariff discounts. Banks, however, recently expressed hesitation about granting further loans to these projects due to the high discounts and minimal expertise of some developers. Despite these doubts, initial results are promising with 35 of 37 projects having secured financing by the July 2011 deadline, amounting to nearly US $975 million in loans from Indian and international banks.

5.2 Combine Competitive Bidding With Higher Minimum Standards

Competitive bidding successfully drove down solar tariffs but may have attracted unrealistic bids from inexperienced developers. This raises risks of low-quality installations and project defaults. The MNRE Secretary admitted to being "really shaken" at the significant tariff discounts offered by the first round of projects. Project winners included many first-time entrants, including a woollen yarn maker, an animation company and an industrial pipes supplier with no experience constructing power plants.

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Competitive bidding is more effective when combined with expertise and social benefits requirements, or in later programme stages after successful innovations have been developed. To attract the larger, established companies considered best placed to drive solar innovation in the second round of bidding, installations sizes were increased to allow for better economies of scale. Tighter ownership requirements were also included to discourage speculators, requiring at least 50% ownership in projects for a year after power generation begins.

5.3 Keep The Needs Of The Rural Poor In Mind

Off-grid home lighting systems and solar lanterns have been approved under the Mission in rural and remote villages in Sikkim, Jammu & Kashmir, Himachal Pradesh and Uttarakhand. However, the Mission's full potential to light up the households and farms of the most energy-poor has not been realized to date. Most of the 2010–11 approved projects are small-scale solar plants for schools, government buildings, banks, hospitals, telecom towers and street lights, rather than systems for individual households. [4][3]

The Mission's market-based approach has been criticised as being overly structured. The Mission requires the use of pre-approved components only, limiting the ability of households to design solar applications tailored to their specific conditions. The accreditation process discourages small local entrepreneurs from participating. The Mission offers higher subsidies for remote locations, but despite this, initial costs remain out of reach of the most energy-poor. This is because down payments are required and the subsidies are scaled to a benchmark cost appropriate for general solar plants but not for the more expensive individual and remote systems. Further, only 7% of the subsidies committed under the overall Mission are allocated for the off-grid programme, which indicates a weak state commitment to pro-poor goals. Pro-poor organisations have called for greater focus on interest subsidies, two-tier benchmarks that recognise the higher costs of individual applications, and better servicing arrangements but the Mission has not yet adopted these recommendations.

5.4 Provide Participatory Models

While the Mission offers opportunities for off-grid project delivery by non-governmental organisations (NGOs) and community groups, it actively promotes traditional financing delivery through banks. Banks tend to disfavour granting the riskier loans for smaller, individual applications. Direct government engagement with NGOs and community groups would allow social and environmental benefits to be more relevant in loan decisions. Calls have been made to reform the Mission to include a participatory model that engages community members to develop and maintain the village solar installations. Currently, there are no maintenance requirements, threatening project sustainability in rural areas where local service infrastructure is weak or non-existent. Community engagement is critical for village energy security, project monitoring and creation of rural livelihoods – and would make projects more sustainable.

5.5 Tailor Requirements With Domestic Capacity In Mind

The Mission fosters domestic manufacturing gradually by requiring the use of locally-sourced components for each round of projects. Each requirement so far has reflected existing local capabilities, avoiding the temptation to push local manufacturing expertise beyond what exists or can realistically be achieved. Early results appear promising; Indian solar companies are expanding from basic assembly of panels and modules to the production of more integrated systems. However, the legality of domestic content requirements is currently under dispute and alleged to be a violation of World Trade Organization obligations.

5.6 Seek International Cooperation

India has emphasised that the Mission's success depends on international financing and technology. The Mission has been criticised for failing to provide clear estimates on the Mission's expected costs as well as its avoided carbon emissions: data necessary to attract international climate financing. However, India is actively strengthening its bilateral relationships for climate-related support with the U.S., China and the European Union. In October 2011, India published a report seeking US $750 million from the multilateral Climate Technology Fund, in part for Phase 1 Mission projects.

5.7 Streamlining Environmental Concerns

In June 2011, the Government of India confirmed that environmental impact assessments are not required for solar projects. While this streamlines projects, it ignores known environmental risks in the manufacturing and operation of solar power plants including intensive land and water use and the use of hazardous raw materials. Currently, state pollution control boards may use their discretion to establish environmental protection conditions. The Central Pollution Control Board has undertaken to study the actual environmental impacts of solar plants, which could lead to future changes.[6][7]

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6. IMPLICATIONS

1. A strong national solar energy policy framework designed to create a secure investment environment can enable project developers to take risks to rapidly push down costs and drive innovation.
2. A competitive bidding process without adequate expertise requirements can rapidly reduce solar tariffs, but also attract inexperienced developers. India's experience has demonstrated that such a process risks low quality installations, project defaults and denial of bank financing.
3. Capital and interest subsidies can empower rural villages and households to take ownership over their own energy needs. However, subsidy schemes must be flexible and avoid disincentives such as down payments. Subsidies must be high enough to compensate for the high unit costs of small-scale installations.
4. Rural electrification schemes must include flexible project specifications, guarantee local servicing support, and generate opportunities for participation from the poor to ensure their long-term sustainability.
5. Financing delivery through NGOs or community-level groups, rather than banks, would improve funding access to the most energy-poor.

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