The Future of Solar Energy in The Indian Economy

Om Prakash Samal[1*], Prayag Prajapati[2]
[1*]Assistant Professor, Department of Mechanical Engineering, Nalanda Institute of Technology, Bhubaneswar, Odisha, India
[2*]Assistant Professor, Department of Mechanical Engineering, Nalanda Institute of Technology, Bhubaneswar, Odisha, India

*Corresponding author e-mail: omprakash@thenalanda.co.

ABSTRACT

Solar energy, a clean, renewable source with no emissions, provides a huge amount of energy potential that can be captured utilising a wide range of tools. Solar energy systems are now freely accessible for both industrial and home use, with the added benefit of requiring no maintenance. Government tax breaks and rebates could make solar energy economically viable. The majority of wealthy nations are converting to solar energy as one of their main sources of renewable energy. When creating building blueprints, the modern architectural designs provide for photovoltaic cells and necessary wiring. The National Solar Mission is a significant project of the Indian government and state governments to encourage environmentally friendly growth while addressing India's problem with energy security. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. The objective of the National Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible. The Mission's immediate goal is to concentrate on creating a conducive environment for the penetration of solar technology in the nation on both a centralised and decentralised level. The National Action Plan on Climate Change also notes that India is a tropical nation with longer and more intense daily sunshine hours. As a result, solar energy has enormous promise as a source of energy in the future. Also, it offers the benefit of enabling decentralised energy distribution, which empowers local residents.

***Keywords**: :* *Photovoltaic Cells, Zero Emission, Geothermal Energy, Biomass Energy, Solar India*

1. INTRODUCTION

India is suffering from a severe energy shortage, which is impeding its ability to build its economy and industry. Importing extremely volatile fossil fuels is a necessity for the construction of new power facilities. Therefore, it is crucial to address the global energy issue through the wise usage of a variety of renewable energy sources, including geothermal, solar, and biomass energy. Renewable resources will aid India in reducing climate change in addition to increasing energy availability. India's energy requirements are largely met by fossil fuels. The majority of power is produced by coal- and mineral-oil-based power plants, which significantly increase greenhouse gas emissions.

Solar energy, a clean, renewable source with no emissions, has a huge amount of energy potential that can be captured utilising a number of tools. Solar energy systems are now freely accessible for both industrial and home use, with the added benefit of requiring no maintenance. Government tax breaks and rebates could make solar energy economically viable. The majority of wealthy nations are converting to solar energy as one of the main sources of renewable energy. When creating building blueprints, the modern architectural designs provide for photovoltaic cells and necessary wiring. India's average yearly temperature ranges from 25°C to 27.5°C due to its location between the Tropic of Cancer and the Equator. India therefore has enormous solar potential. The south/east coast, from Kolkata to Madras, is where there is the most sunshine.

2. HISTORICAL GROWTH OF THE SOLAR MARKET IN INDIA

The Rural Electrification Program of 2006 was the first step by the Indian Government in recognizing the importance of solar power. It gave guidelines for the implementation of off-grid solar applications. However, at this early stage, only 33.8MW (as on 14-2-2012) of capacity was installed through this policy. This primarily included solar lanterns, solar pumps, home lighting systems, street lighting systems and solar home systems. In 2007, as a next step, India introduced the Semiconductor Policy to encourage the electronic and IT industries

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This included the Silicon and PV manufacturing industry as well. New manufacturers like Titan Energy Systems, Indo Solar Limited and KSK Surya Photovoltaic Venture Private Limited took advantage of the Special Incentive Scheme included in this policy and constructed plants for PV modules. This move helped the manufacturing industry to grow, but a majority of the production was still being exported. There were no PV projects being developed in India at that stage. There was also a need for a policy to incorporate solar power intothe grid.

The Generation Based Incentive (GBI) scheme, announced in January 2008 was the first step by the government to promote grid connected solar power plants. The scheme for the first time defined a feed-in tariff (FIT) for solar power (a maximum of Rs. 15/kWh). Since the generation cost of solar power was then still around Rs. 18/kWh, the tariff offered was unviable. Also, under the GBI scheme, a developer could not install more than 5MW of solar power in India, which limited the returns from scale. One of the main drawbacks of the GBI scheme was that it failed to incorporate the state utilities and the government in the project development, leaving problems like land acquisitions and grid availability unaddressed. As a result, despite the GBI scheme, installed capacity in India grew only marginally to 6MW by 2009. In June 2008, the Indian government announced the National Action Plan for Climate Change (NAPCC). A part of that plan was the National Solar Mission (NSM). The NSM guidelines indicated that the government had improved on the shortcomings of the GBI scheme. It aimed to develop a solar industry, which was commercially driven and based on a strong domestic industry. The extra cost of generation of solar power was being borne by the federal government under the GBI scheme.

3. PRESENT STATUS AND INSTALLED CAPACITY OF SOLAR ENERGY IN INDIA

Solar power has so far played an almost non-existent role in the Indian energy mix. The grid-connected capacity (all PV) in India now stands at 481.48 MW as of 31st January 2012. However, the market is set to grow significantly in the next ten years, driven mainly by rising power demand and prices for fossil fuels, the ambitious National Solar Mission (NSM), various state level initiatives, renewable energy quotas including solar energy quotas for utilities as well as by falling international technology costs.

Encouraging the spread of solar power generation (both CSP and PV) and aiming for grid-parity (currently at around RS.5/kWh) by 2022 and parity with coal power generation (currently at around RS.4/kWh) by 2030, is a key element in India's comprehensive, long term energy supply strategy. Keeping in view the solar annual insolation, solar power could therefore easily address India's long-term power requirements. However, it has to be cost-competitive. As of December 2011, solar power generation in India costs around RS.10/kWh, or over 2.5 times as much as power from coal. Importantly, it is crucial that the industry receives the right policy support to ensure that projects are executed and performed up to the mark.

GROWTH OF SOLAR ENERGY IN INDIA

India's government has begun to acknowledge the importance of solar energy to the country's economic growth. Prime Minister Manmohan Singh, who has said solar energy will transform rural India, launched a National Solar Mission in 2010. Initial growth has been dramatic, albeit from a tiny base. From less than 12 MW in 2009, solar-power generation in the country grew to 190 MW in 2011. By March 2013, it is expected to grow fivefold to 1,000 MW, but the country has a long way to go to reach its goal of increasing solar-power generation to 20 gigawatts by 2020. Across India, there are still thousands of villages with plenty of sun but not enough power.

DECREASING INVESTMENT COST OF SOLAR IN INDIA

With the cost of solar photovoltaic cells falling — prices dropped by 50% last year and are now a quarter of what they were in 2008 — renewable-energy advocates say India is ripe for a solar-power revolution. And it could use it. More than 40% of the countryside is still not connected to the national power grid, and a 2010 report by the National Renewable Energy Laboratory in the U.S. said power demand in India trails supply by 12.7%. Closing this gap "will be critical for India to achieve its growth targets," the report said. Failure to meet that unsatisfied demand could hamper India's growth, the World Economic Forum (WEF) said in a recent report.

4. INDIA'S POTENTIAL OF SOLAR ENERGY

India has a great potential to generate electricity from solar energy and the Country is on course to emerge as a solar energy hub. The techno-commercial potential of photovoltaics in India is enormous. With GDP growing in excess of 8%, the energy 'gap' between supply and demand will only widen. Solar PV is a renewable energy resource capable of bridging this 'gap'. Most parts of India have 300 – 330 sunny days in a year, which is equivalent to over 5000 trillion kWh per year – more than India's total energy consumption per year. Average

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solar incidence stands at a robust 4 – 7 kWh/sq.meter/day. About 66 MW of aggregate capacity is installed for various applications comprising one million industrial PV systems – 80% of which is solar lanterns, home/street lighting systems and solar water pumps, etc. The estimated potential envisaged by the Ministry for the solar PV programme, i.e. solar street/home lighting systems, solar lanterns is 20 MW/sq. kilometer.

The potential of the solar thermal sector in India also remains untapped. The Ministry of Renewable Energy proposes an addition of 500 MW during the phase 1 of JNNSM. Establishing manufacturing units at Export Oriented Units, SEZs or under the SIPS programme presents a good opportunity for firms which can leverage India's cost advantage to export solar modules at competitive prices to markets in Europe and the United States. In terms of all renewable energy, currently India is ranked fifth in the world with 15,691.4 MW grid-connected and 367.9 MW off-grid renewable energy based power capacity. India is among top 5 destinations worldwide for solar energy development as per Ernst & Young's renewable energy attractiveness index.

Solar power is attractive because it is abundant and offers a solution to fossil fuel emissions and global climate change. Earth receives solar energy at the rate of approximately 1,73,000 TW**.** This enormously exceeds both the current annual global energy consumption rate of about 15 TW, and any conceivable requirement in the future. India is both densely populated and has high solar insolation, providing an ideal combination for solar power in India. India is already a leader in wind power generation. In solar energy sector, some large projects have been proposed, and a 35,000 km² area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW.

The India Energy Portal estimates that if 10% of the land were used for harnessing solar energy, the installed solar capacity would be at 8,000GW, or around fifty times the current total installed power capacity in the country. For example, even assuming 10% conversion efficiency for PV modules, it will still be thousand times greater than the likely electricity demand in India by the year 2015. Daytime production peak coincides with peak electricity demand making solar ideal supplement to grid.

With around 300 sunny days a year nationwide, solar energy's potential in India is immense. And with $10.2 billion investments in clean energy, money is starting to follow the opportunity. India received $95 million in venture-capital funding and over $1.1 billion in large-scale funding for solar projects in 2011, according to a report by Mercom Capital, a clean-energy consulting firm. The biggest funding deal was a $694 million loan raised by Maharashtra State Power Generation Co. for its 150-MW Dhule and 125-MW Sakri solar projects.

5. JAWAHARLAL NEHRU NATIONAL SOLAR MISSION

The Jawaharlal Nehru National Solar Mission aims at development and deployment of solar energy technologies in the country to achieve parity with grid power tariff by 2022. 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. The objective of the National Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible. The aim would be to protect Government from subsidy exposure in case expected cost reduction does not materialize or is more rapid than expected. The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level. The main features of the National Solar Mission are:

1. Make India a global leader in solar energy and the mission envisages an installed solar generation capacity of 20,000 MW by 2022, 1,00,000 MW by 2030 and of 2,00,000 MW by 2050.
2. The total expected investment required for the 30-year period will run is from Rs. 85,000 crore to Rs. 105,000 crore.
3. Between 2017 and 2020, the target is to achieve tariff parity with conventional grid power and achieve an installed capacity of 20 gigawatts (Gw) by 2020.
4. 4-5GW of installed solar manufacturing capacity by 2017.
5. To deploy 20 million solar lighting systems for rural areas by 2022

6. SOLAR ENERGY DEVELOPMENT IN DIFFERENT STATES

The Gujarat solar policy initiated a process of the states formulating their own policy frameworks independent of the federal guidelines. The renewable purchase obligations for state distribution companies, a demand-driven scheme, further accelerated the formulation of solar policies at the state level. These policies exist independent

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of each other as well as the NSM. Other states like Karnataka, Andhra Pradesh and Rajasthan have followed suit in developing solar power development programs. Rajasthan has implemented land banks as well to make land acquisition easier. As more states plan to meet their solar power obligations, new policies are expected to be offered, creating as very vibrant set of markets across the subcontinent.

GUJARAT SOLAR POWER POLICY -2009

Gujarat is the first state to launch its own solar policy in 2009. The Gujarat solar policy was in place a year before the NSM was announced. The initial target is to achieve 500 MW of installed capacity by the end of this period. Gujarat Energy Development Agency (GEDA) and Gujarat Power Corporation Limited (GPCL) have been appointed as nodal agencies for the facilitation and implementation of the policy. Gujarat Solar Power Policy is the only policy, which has awarded projects with a fixed FiT, on a first-come-first serve basis. This has resulted in the allocation of a number of projects to in-experienced or unknown developers.

After the NSM policy was formalized in December 2009, developers moved away from Gujarat towards the NSM. In the first phase of the Gujarat policy, only 396.5 MW worth of PPAs were signed out of 716 MW allotments, leading to a conversion rate of 55% (PPAs signed as a percentage of projects allotted). The tremendous interest from developers for NSM led to the competitive bidding for projects and a subsequent fall in tariffs. The fall in the NSM tariff below the levelized tariff in Gujarat suddenly made the Gujarat policy very attractive again to developers. Further, a significantly higher feed-in-tariff in the first 12 years in Gujarat matches investor's timelines, as they would look to cover the cost of debt during this period. To ensure developer commitment, Gujarat's solar policy for the second phase has been amended to include a deposit that would be encashed, if the developers fail to sign the PPAs. Larger available project sizes and the relative ease of land acquisition has led to larger developers getting serious about the Gujarat policy and signing PPAs and starting the implementation of projects. Gujarat has significantly improved the credibility of its solar program from the first to the second phase.

INDIA'S FIRST SOLAR PARK

On December 29th 2010, India's first solar park was inaugurated at Charanaka in Patan district of northern Gujarat. So far, land has been allotted in the solar park for projects worth 176MW to 16 companies from the first and second phases. The total capacity of the solar park is 500MW with 30,000 sq. m per MW land allotted to Solar Thermal and 20,000 sq. m per MW of land allotted to PV projects. The solar park has been financed with over Rs. 12 billion by financial institutions like the International Finance Corporation (IFC), the Asian Development Bank (ADB) and the Infrastructure Development Finance Corporation (IDFC). The park tackles land procurement, water availability and grid connectivity issues and offers a "single-window" clearance process. Sixteen companies, including SunEdison Energy India (25MW), Alex Astral Power (25MW), Roha Energy (25MW), GMR Gujarat Solar (25MW), Kiran Energy (20MW), Emami Cement (10MW) and Azure Power (5MW) have been allotted projects worth a total of 176MW in the park. They have all signed PPAs with the state government.

KARNATAKA SOLAR POWER POLICY (2011-16)

Karnataka, a south-western state of India, announced its solar policy on July 1, 2011. Under the solar policy 2011-16, the Karnataka Government proposes to promote solar power as part of renewable energy generation policy in the state.

1. It targets 350 MW worth of projects till 2016.
2. 200 MW is to be developed for direct sale to the distribution companies in the state (40 MW to beadded each year)
3. 100 MW under REC Mechanism
4. 50 MW for bundling of power with thermal power from outside the state at rates to be determined by the State Government subject to approval of KERC.

The minimum capacity of solar PV projects is 3 MW and maximum capacity of 10 MW, while for Solar Thermal the minimum is 5MW with no cap on maximum. The quantum of power to be procured by ESCOMs from solar resources under purchase obligation is 0.25% of the total consumption and the shortfall in

procurement of solar energy by the ESCOMs can be made good by purchase of solar specific RECs. Though the state has come up with its own policy, it will continue to support programs like the NSM. The state has set a combined target of 126 MW of solar power to be developed by 2013-14 through NSM and its own solar policy.

RAJASTHAN SOLAR POWER POLICY - 2011

On April 19th 2011, Government of Rajasthan issued Rajasthan Solar Energy Policy, 2011 to promote solar energy in the state.The policy aims to help Rajasthan, develop as a global hub of solar power for 10000-12000 MW capacity over the next 10 to 12 years to meet energy requirements of Rajasthan and other states of India.

1. It targets a minimum of 550MW of grid connected solar power in Phase 1 (up to 2013).
2. Projects will be awarded through a process of competitive bidding.
3. PV projects will be worth 300MW, out of which 100MW are reserved for project developers and 200MW for panel manufacturers.
4. The minimum and maximum sizes for PV projects are 5MW and 10MW.
5. Module manufacturers that set up their manufacturing plant in Rajasthan can bid for either 10MW or 20MW worth of PV projects based on their manufacturing capacity.
6. A further 50MW will be allocated for rooftop PV (1MW each) and other small solar power plants.
7. The DISCOMS in Rajasthan will provide PPAs for the projects. In addition, projects worth 100MW (50MW PV and 50MW CSP) are targeted for bundled solar power. In such projects, the developer can sell conventional power and solar power in a ratio of 4:1 at the weighted average tariff to the distribution utilities in Rajasthan. Varied project sizes will attract small as well as large developers looking to invest in projects of different scale.

7. SOLAR THERMAL PROCESS

Solar thermal electricity technologies produce electric power by converting the sun's energy into high-temperature heat using various mirror configurations, which is then channeled to an on-site power plant and used to make electricity through traditional heat-conversion technologies. The plant essentially consists of two parts; one that collects Solar energy and converts it to heat, and another that converts the heat energy to electricity.

SOLAR CELL –

A solar cell is a semiconductor device that transforms sunlight into electricity. Semiconductor material is placed between two electrodes. When sunshine reaches the cell, free negatively charged electrons are discharged from the material, enabling conversion to electricity. This is the so-called photovoltaic effect. In theory, a solar cell made from one semiconductor material only can convert about 30 percent of the solar radiation energy it is exposed to into electricity. Commercial cells today, depending on technology, typically have an efficiency of 5 - 12 percent for thin films and 13 – 21 percent for crystalline silicon based cells. Efficiencies up to 25 percent have been reached by the use of laboratory processes. By using multiple solar cells, efficiencies above 35 percent have been achieved.

SOLAR PHOTOVOLTAICS –

Photovoltaic has been derived from the combination of two words, Photo means Light and Voltaic means electricity. It is a technology that converts light directly into electricity. Photovoltaic material, most commonly utilizing highly-purified silicon, converts sunlight directly into electricity.

8. RURAL ELECTRIFICATION

Lack of electricity infrastructure is one of the main hurdles in the development of rural India. India's grid system is considerably under-developed, with major sections of its populace still surviving off-grid. As of 2004 there are about 80,000 unelectrified villages in the country. Of these villages, 18,000 could not be electrified through extension of the conventional grid. A target for electrifying 5,000 such villages was fixed for the Tenth National Five Year Plan (2002–2007). As on 2004, more than 2,700 villages and hamlets had been electrified mainly using SPV systems.

Developments on cheap solar technology are considered as a potential alternative that allows an electricity infrastructure comprising of a network of local-grid clusters with distributed electricity generation. That could allow bypassing, or at least relieving the need of installing expensive, and lossy, long-distance centralised power delivery systems and yet bring cheap electricity to the masses.3000 villages of Odissa will be lighted with Solar power by 2014.

The off-grid and rooftop segments will grow exponentially as price parity with consumer tariffs makes solar power an economically viable alternative, particularly for urban and semi-urban consumers. Distributed generation in rural areas and support for latent urban demand has the potential to reach 4 GW by 2020 and increase rapidly to more than 10 GW over the next three to four years.

9. FUTURE GROWTH OF SOLAR IN INDIA

The solar industry's structure will rapidly evolve as solar reaches grid parity with conventional power between 2016 and 2018. Solar will be seen more as a viable energy source, not just as an alternative to other renewable sources but also to a significant proportion of conventional grid power. The testing and refinement of off-grid and rooftop solar models in the seed phase will help lead to the explosive growth of this segment in the growth phase.

Global prices for photovoltaic (PV) modules are dropping, reducing the overall cost of generating solar power. In India, this led to a steep decline in the winning bids for JNNSM projects. With average prices of 15 to 17 cents per kilowatt hour (kWh), solar costs in India are already among the world's lowest. Given overcapacity in the module industry, prices will likely continue falling over the next four years before leveling off. By 2016, the cost of solar power could be as much as 15 percent lower than that of the most expensive grid-connected conventional energy suppliers. The capacity of those suppliers alone, nearly 8 GW in conventional terms, corresponds to solar equivalent generation capacity potential of 25 to 30 GW. Due to implementation challenges, however, it's unlikely that all of this potential will be realized by 2016. Grid parity will be an inflection point, leading to two major shifts in the solar market. First, thanks to favorable project economics, grid-connected capacity will rise at a much faster rate than before, and second, regulations and policy measures will be refined to promote off-grid generation.

According to one estimates, the combination of electricity demand growth, fossil fuel cost and availability challenges, and supportive environmental regulations could increase solar power capacity to more than 50 GW by 2022. The market will see a significant change after 2016. Lower solar costs combined with rising prices of grid power will convince offtakers (including distribution companies, private firms using open access, and firms putting up their own captive capacity) that solar power is economically viable. This shift will signal the start of the growth phase, during which grid-connected solar capacity will rise rapidly to about 35 GW by 2020 as developers build capacity to meet both RPO requirements and demand from offtakers seeking cost-efficient alternatives to conventional power.

10. CHALLENGES AND CONSTRAINTS

LAND SCARCITY

Per capita land availability is a scarce resource in India. Dedication of land area for exclusive installation of solar cells might have to compete with other necessities that require land. The amount of land required for utility-scale solar power plants — currently approximately 1 km² for every 20–60 megawatts (MW) generated could pose a strain on India's available land resource.

The architecture more suitable for most of India would be a highly distributed, individual rooftop power generation systems, all connected via a local grid. However, erecting such an infrastructure which doesn't enjoy the economies of scale possible in mass utility-scale solar panel deployment — needs the market price of solar technology deployment to substantially decline so that it attracts the individual and average family size household consumer. That might be possible in the future, since PV is projected to continue its current cost reductions for the next decades and be able to compete with fossil fuel.

SLOW PROGRESS

While the world has progressed substantially in production of basic silicon mono-crystalline photovoltaic cells, India has fallen short to achieve the worldwide momentum. India is now in 7th place worldwide in Solar Photovoltaic (PV) Cell production and 9th place in Solar Thermal Systems with nations like Japan, China, and the US currently ranked far ahead. Globally, solar is the fastest growing source of energy (though from a very small base) with an annual average growth of 35%, as seen during the past few years.

LATENT POTENTIAL

Some noted think-tanks recommend that India should adopt a policy of developing solar power as a dominant component of the renewable energy mix, since being a densely populated region in the sunny tropical belt, the subcontinent has the ideal combination of both high solar insolation and a big potential consumer base density. In one of the analyzed scenarios , while reining on its long-term carbon emissions without compromising its economic growth potential, India can make renewable resources like solar the backbone of its economy by 2050.

GOVERNMENT SUPPORT

The government of India is promoting the use of solar energy through various strategies. In the budget proposal for 2010-11, the government has announced an allocation of Rs.10 billion towards the Jawaharlal Nehru National Solar Mission and the establishment of a Clean Energy Fund. It's an increase of Rs. 3.8 billion

from the previous budget. Also budget has also encouraged private solar companies by reducing customs duty on solar panels by 5 percent and exempting excise duty on solar photovoltaic panels. This is expected to reduce the roof-top solar panel installation by 15- 20 percent.

11. PROBLEMS AND SUGGESTIONS

PROBLEMS

Standalone EPC players will cater to ISPPs and corporations:-

The above scenario will increase demand for engineering, procurement, and construction (EPC) players, as developers opt to outsource turnkey projects due to a lack of internal expertise. EPC players can look forward to $3 billion in annual sector revenues by 2017, thanks to a wide client base of utilities, small independents, and niche players.

11.1.2 The EPC market will remain fragmented:-

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With project sizes typically ranging from 10 to 25 MW, small and medium-sized players will have few constraints competing against larger national and international ones. Scale-driven procurement efficiencies will diminish as rapidly declining costs and improving technology options inhibit the long-term framework agreements that characterize conventional-energy procurement structures.

11.1.3. Manufacturing space will still be dominated by imports:-

One area of the solar market won't be dominated by small local companies: manufacturing of modules. Given global overcapacity in this segment, module-manufacturing facilities likely will not be built in India unless mandated by local regulations. If that happens, the lower-cost economics of Indian manufacturers could delay grid parity by two to three years. Nonetheless, global players have already started setting up bases for balance of systems (BoS) in India, a trend that is likely to continue.

SUGGESTIONS

Global procurement is unlikely to remain a differentiator as more players achieve scale and become adept at it. Creating value in the Indian market, therefore, requires efficient execution, financing, and localization.

11.2.1 EXECUTION

Given the substantial front-end costs of solar projects, delays can wreak havoc on profitability. Even under the most suitable conditions, managing power projects in India is tough—projects are often slowed by infrastructure issues and unreliable local vendors. In addition, stakeholder management at the national, state, and local levels often stands in the way of ensuring efficient project execution and sustained operation. Therefore, building a team of talented project managers and experienced troubleshooters will be crucial.

FINANCING

Innovative means of financing will create win-win situations for all stakeholders and drive significant upfront value for project developers. Differentiated models could include teaming with technology providers from low-cost financing countries—Japan, for example—or with consumers seeking sustainability benefits or tax credits. A pool of low-cost project equity developed from retail or other cost sources can add up to a distinct advantage.

LOCALIZATION

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. Competition from local players could further drive down systems costs.

AN OPEN MARKET

Although India's solar market appears well suited for local players, it's currently open to global players as well. Indeed, global firms that tailor their broad expertise to serve unique local needs in a frugal way could actually extract significant value. 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.

12. CONCLUSIONS

Present Study led us to three major conclusions:

- *Within the next ten years, the solar sector in India may be worth billions of dollars. - During the next decade, grid-connected solar producers are expected to generate up to $4 billion in annual revenues in India thanks to the country's significant solar potential and rapidly increasing support environmente.*
- *Localization, project execution, and funding are essential. Successful Indian solar ventures will be built on a low cost platform. Procurement effectiveness will be necessary as the number of projects and participants grows. Effective project execution, low-cost (and frequently inventive) funding, and localization will produce more long-term value.*
- *The downstream solar sector will be dominated by domestic players. We anticipate local, or at least well-localized, firms to predominate on the downstream side in the early years, including project development, installation, and distribution, in contrast to the upstream industry's (solar*

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modules') global nature. Global players entering India for the first time will be successful if given enough time to perfect their business models. For both local and international players, it will be crucial to get started quickly and learn the ropes.

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