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Eminent Economic Policies & Dominant Barriers of Solar Energy in India

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***Abstract*— The following paper probes into the entire current market status of the Photo Voltaic (PV) Cell in India encompassing the national market in view of the global market scenario. PV technology is ideally suited to the urban environment, providing pollution and noise free electricity without using extra space. Since the PV market is expanding and getting as the integral part of the renewable energy system, it also is concerned with the other renewable energy sources available in parallel. The study shows the credibility of the solar energy market in India with the other aspects that it has to overcome with in order to make a stand-alone system. The different barriers that often perplexes the market are mentioned here with the diverse policies imposed in the system.**

Keywords—PV Cell; Renewable Energy System; Solar Energy Technology; Solar Market

I. INTRODUCTION

Solar energy refers to sources of energy that can be directly attributed to the light of the sun or the heat that sunlight generates. Commonly known as solar cells, individual PV cells are electricity-producing devices made of semiconductor materials. PV technology is also widely used in the developing world. The technology is particularly suited here, where electricity grids are unreliable or non-existent, with remote locations often making PV power supply the most economic option.

Crystalline silicon PV cells are the most common photovoltaic cells in use today. They are also the earliest successful PV devices. Therefore, crystalline silicon solar cells provide a good example of typical PV cell functionality.

PV technology has many applications, both for stand-alone systems and for integration onto buildings. PV may be used in applications such as monitoring stations, radio repeater stations, telephone kiosks and street lighting to name just a few examples. There is also a substantial market for PV technology in the leisure industry, with battery chargers for boats and caravans, as well as for powering garden equipment such as solar fountains.

Most of the power distribution companies in India suffer from heavy losses and have been largely unable to meet their renewable purchase obligations. In such a scenario, it makes sense for these states to transfer these obligations to large power consumers which already pay high power tariffs and are anyway close to grid-parity. Going forward, the demand for solar from these power consumers will become another key driver in the Indian solar market.

The market expansion is a very sensitive to micro-level issue in India which are linked with specific barriers. These barriers need to be identified and addressed adequately in order for markets to grow [1]. As the market in India has grown, so has experience in identifying and addressing these barriers. This removal of barriers continues, and provides strong support for the market to expand. Subsequent sections of this paper describe the generic and specific nature of these barriers.

Many solar energy technologies are not yet cost-competitive with conventional energy commodities at either the wholesale or retail levels. Therefore, any significant deployment of solar energy will not be possible unless major policy incentives are introduced. A large number of governments have realized this and have supported solar energy development through a broad range of fiscal, regulatory, market and other instruments. A number of recent studies, such as present in-depth analysis of various policy instruments designed to promote renewable energy, including solar, at the global level as well as for a particular country, such as India [2]. In fact, the strong growth in solar energy markets, notably those for grid-connected solar PV and solar thermal water heating, has been driven by the sustained implementation of policy instruments in Europe, the United States and some developing countries. This section briefly presents key policy instruments that support solar energy for both electric and direct heating applications.

II. SOLAR ENERGY TECHNOLOGIES AND MARKETS – CURRENT STATUS

A. Technologies and Resources

Broad classification of Solar Energy Technology can defined in the following continuum – Passive and Active. Passive solar energy technology collects the energy without converting the heat or light into other forms, viz., the incremental use of the daylight or heat through building designs [3-5]. On the other hand, the active solar energy technology assigns the curbing of solar energy to either store or convert for diversified applications. This in turn can be classified as two different groups – Photovoltaic (PV) and Solar Thermal. Photovoltaic technology converts the luminous portion of light energy into electrical energy when it is incident upon a semiconductor material. Thus, resulting in electron excitation and actively enhancing conductivity [6]. Commonly available types of PV technology are – (a) crystalline Si-based PV cells, and (b) thin film technology, made from various range of different semiconductor materials, e.g. amorphous Si, Cadmium telluride and copper indium gallium (di)selenide (CIGS). Solar thermal technology takes use of solar heat that can precisely be used for thermal or heating application and or for electricity generation. Therefore, it is subdivided into two categories as – Solar thermal non-electric and, solar thermal electric [7-9]. The applications of solar thermal non-electric technology could be solar water heaters, solar air heaters, solar cooking systems, solar cooling systems, etc. While solar thermal electric technology refers the use of solar heat to produce the steam for electricity generation. This methodology is considered as Concentrated Solar Power (CSP). The CSPs available in the market are – Power Tower, Fresnel Mirror, Solar, Dish Collector and Parabolic Trough.

B. *Current Market Status*

The entire world has witnessed solar energy as the largest source of renewable energy supply [10, 11]. The effective diurnal course reaching the earth's surface ranges 0.06kW/m2 at the highest latitudes to 0.25kW/m2 at the lowest latitudes [12].

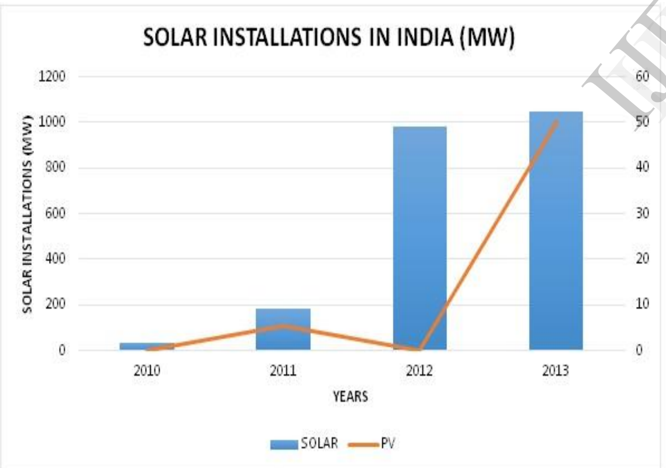

Fig. 1. Upsurge of Solar Installed Capacity in India

In figure 1, the accelerated growth of solar and solar PV can be seen in various years. The installed capacity in India can be understood merely by analysing the solar energy produced in recent past years in various states of the country. The amount of solar energy produced in India in 2007 was less than 1% of the total energy demand [13]. The grid-interactive solar power as of December 2010 was merely 10 MW [14]. Government-funded solar energy in India only accounted for approximately 6.4 MW-yr of power as of 2005 [13]. However, India is ranked number one in terms of solar energy production per watt installed, with an insolation of 1,700 to 1,900 kilowatt hours per kilowatt peak (kWh/KW_P) [15]. 25.1 MW was added in 2010 and 468.3 MW in 2011. By the end of March 2013 the installed grid connected PV had increased to 1686.44 MW, and India expects to install an additional 10,000 MW by 2017, and a total of 20,000 MW by 2022 [16].

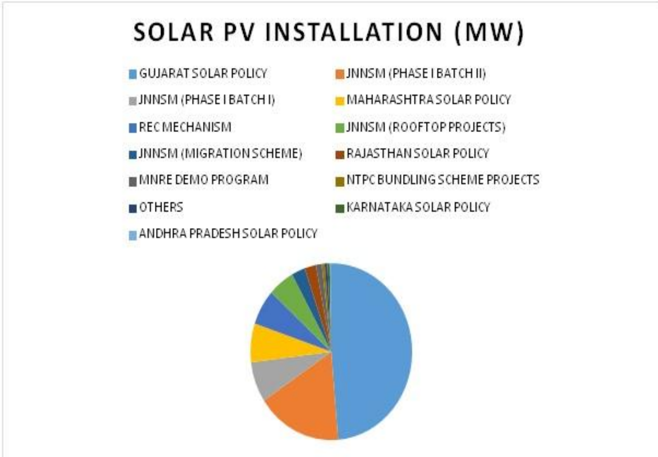

Fig. 2. Encouragement of Various Renewable Energy Policies in India [17]

III. SOLAR ENERGY TECHNOLOGY – BARRIERS AGAINST ADVANCEMENT

Barriers are the impediments that may arise virtually or physically in any course of action. Since, solar energy technology is proliferating gradually overseas, it incurs certain types of barriers too [18]. In such context, this article recognizes disparate barriers that impel the stationing of solar energy technologies for electricity generation and thermal purposes. By and large, barriers can be identified as – Economic, Technical and Institutional barriers. Various barriers are delineated [19] in Table 1.

As seen from the Solar PV column of Table 1, under Technical barrier, the main hindrance comprises - the low conversion efficiencies of the PV modules, performance drawbacks viz. batteries and inverters, and sparse raw material supply like Silicon. Major concern regarding the standalone PV system is storage of electricity produced, as in the short durability of battery as compared to that of the module. Moreover, the safe demolition of batteries becomes difficult in the absence of the proper channel of disposal or recycling processes [20, 21].

On the other hand, solar thermal application has two main technical barriers. Firstly, it is defined to the heat carrying capacity of the heat transfer fluids and secondly, the thermal losses from the storage systems [22, 23]. Again from the Table 1, the limitations in context with the system design and assimilation, and with the operating experience for system boost up. As in when there is deficiency of integration with building materials, designs, codes and standards, they result in the inadequacy of the applications of solar space and water heating applications.

Considering the concentrated solar power, the technologies like molten salt-in-tube receiver, along with the volumetric air receiver technology and the energy storage systems should be focused more for large scale applications [24]. The solar energy are supposed to emanate and sustain itself on the terms of energy-infrastructure which is devised around the topologies used by conventional energy technologies. In such a context, the economic barriers pertain to the fundamental cost system.

The contrast between the user and the supplier has differed the established technologies with growing industry experiences and economy scale. This technology thus, experiences a stalling faith in the growing market even if the social, environmental and more often hygiene benefits are not included in costing [25]. Barriers when elaborating will lead to financial issues as well. In such a case Finance is another said major barrier [26]. Referring to the Table 1, the financial institutions assesses such a technology viz. solar energy projects, have lesser longevity, also have lengthy payback periods and small revenue system [27-29].

Another impediment for both PV and solar thermal technology comes as Institutional; a type that rises from the originality of such a technology. This refers to the hindrances like insufficient trained people along with those who are capable of training them, also, leading to the installation and maintenance issues. Making it evident that without the institutional efforts the new technologies are hindered naturally.

Attributing to the low standards, research and development (R&D) need to be incorporated in the system, which enhances the relevance of the existence of the energy sector. Standardization of the system will lead to the justification of the cost as it will prove worthy to the investors e.g., companies to invest in the correct standards which will be proven by the country's R&D.

IV. SOLAR ENERGY SECTOR OF INDIA – CHALLENGES

Finally, India is experiencing the boom in renewable energy market currently. Like every technology, since its inception, encounters various challenges in the milestone, dominantly the high cost of solar power generation. For such cases, the higher efficiency devices may take an important part in escalating to the energy targets in India. According to the numbers, the solar energy prices in Indian market has come down to ₹7/kWh (2013F) from ₹18/kWh (2011) while the thermal power prices is pushing to ₹4/kWh including subsidies [30]. Since, solar projects are the capital centric, so the ineffective financing infrastructure for such projects will be the hindrance for the growth in this sector. The other critical challenge of India currently is the divergence in solar potential across different states. Accounting to the various other factors that restricts the growth are the lack of standards which leads to the dissolution of the market among the supplier and the producer.

V. SOLAR ENERGY TECHNOLOGY – POLICIES IN SUPPORT

There are numerous policies that are either being implemented or introduced nationally in favour of the solar energy market to enhance their uses [31, 32]. Amongst various policies, aforementioned are the ones that has benefited countries globally and thus are entertaining Indian solar energy market.

A. *Subsidies*

A subsidy is a form of financial or in kind support extended to an economic sector (or institution, business, or individual) generally with the aim of promoting beneficial economic and social outcomes. It is very likely desired by any of the industry to seek governmental or any other form of subsidy to encourage the growth of the sector. In India, subsidies have always been the primary policy driver since ages. Presently, the production based subsidy offered by the government has been augmented by the accepted rate structure to offer a mixed feed-in-tariff of approximately ₹ 15/kWh for solar PV and solar thermal projects commissioned beyond 31st of March 2011 stretching for 25 years [33]. Peeping into the yesteryear numbers, say in the year 2011, experienced the Remote Village Electrification Program has received higher number of subsidies. This aimed to electrify the non-electrified Indian village, and by the year 2012, it was seen that the 91% of the system cost was covered by the governmental subsidies. For below poverty line (BPL) society, 100% of the system cost was under the authority of the respective state governments [34].

B. *Feed in Tariff*

Feed-in-tariff (FIT) refers to a tariff or payment made in renewable energy technologies that may are relatively expensive or not be competitive with conventional technologies for electricity generation. The tariff is based on the cost of electricity produced plus a reasonable profit for the producer. The objective of this policy is to create awareness amongst the potential investors to make prolonged investments [35]. FITs cover all types of solar energy technologies (e.g., small residential rooftop PV to large scale CSP plants). The tariffs, however, differ across countries or geographical locations, type and size of technology [36]. FIT policies are devised to periodically adjust and to account the changes in technology costs and market prices over the time [37]. FIT in India, say for 20 years is said to be as ₹ 1,880/kWh. "In September the Central Electricity Regulatory Commission (CERC) indicated that it would pay ₹ 18.80 per kilowatt hour (one unit) of solar electricity in order to kick start the Solar Mission and rapidly boost installed capacity." Overall, the feed in tariff in India, uphold but it is still unclear if this program will be of the national standard, or if there will be different regional tariffs.

C. *Net Metering*

It is an environment friendly and power efficient electricity assessment system. Net metering system is a new opinion in India, but this programme has successfully entertained countries like Australia, Canada, Italy, Spain, Denmark and United States. It is a concept that is based on special metering and billing agreement between utilities and their customers. It facilitates the relation of small, renewable energy-generating systems to the power grid. This system defines that the excess energy generated by the solar photovoltaic plant at a given point of time is exported to the grid rather than being stored using a battery but if there is a deficit in the power generated by the solar panels either during the night or any undesirable day, then energy is drawn from the grid. At the end of the billing period, the distribution licensee pays the consumer at a pre-determined price if more energy is exported to the grid than imported.

TABLE I. DIFFERENT TYPES OF BARRIERS FALLING UNDER SOLAR ENERGY TECHNOLOGIES

Barriers	Solar Thermal	Solar PV
Economical	The creditworthiness risk goes high due to the high upfront cost blending with the lengthy payback periods and small revenue streams.	Riskier when creditworthiness is assessed by the Financial Institutions because of their dearth of experience with projects.
	Additional cost is enforced for Backup Heater which is essential for the reliable heating in Water Heating System.	In the developing countries, the immediate obstacles are the severe initial cost and lack of sustained financial options.
	The limitation of rooftop area deficit of Building Integrated System curbs widespread application.	As compared, the degrading cost of Balance of System is independent to that of the decline in the price module.
	Use of Copper for water heating and distribution purpose adds to the overall cost.	Distributed technologies being the trend is preferred over the conventional energy agencies and efficiency.
	Domestic water heating system has lower financial entity	
Technical	Drawbacks of Concentrated Solar Power systems are the thermal losses and the energy storage system.	Limited conduct of Balance of System components like inverters, batteries and other power conditioning appliances.
	When product diversity is required to match the demands of assorted consumer profiles, the orientation supply in the design of solar water is necessitated.	Current market scenario indulges with the efficiency constraints as 4-12% for thin-film and 22% for crystalline PVs.
	The obstruction lies with the heat carrying capacity of the fluid heat transfer.	The use of Cadmium & Tellurium being by-products of Zinc & Copper needed for certain thin-film cells are exposed to the only availability on the evolution of industries like zinc mining and copper processing industries.
	In conjunction with the typical building materials, designs, infrastructure and existing appliances, and with the standards, the lack of integration has restrained widespread application for solar water heating.	The increased asking demand for PV in 2004-05 surpassed the silicon supply and partially temporised the growth of solar sector.
	Considering the central receiver systems, the favourable technologies viz. the molten salt-in-tube receiver, and the volumetric air receiver both along with the energy storage system requires substantial experience to be outsourced as large scale application.	In order to get the concurred metering and billing the adequate infrastructure is absent.
Institutional		Inadequate understanding amongst elite national and local institutions regarding the fundamental systems and financial factors.
		Insufficient resources to educate numerous technicians so as to work efficiently under new solar energy infrastructure.
		Shortcomings of effective and appropriate laws like Renewable Portfolio Standards (RPS) for expediency, to motivate wider adoptions.
		Strategic issues like the need to protect financing from diverse sources and allowances from different agencies as for example MNRE, IREDA, the Planning Commission, and the Ministry of Agriculture and Rural Development in country like India.

Eastern Power Distribution Company of AP Limited (APEPDCL) in association with New and Renewable Energy Development Corporation of Andhra Pradesh (NREDCAP) on 29th September 2013 launched net metering, an eco-friendly concept of encouraging power consumers to take solar power production to manage the energy demand and supply. Some banks have even come forward to sanction loans to interested consumers under National Bank for Agriculture and Rural Development (NABARD) supported schemes. The Tamil Nadu Electricity Regulatory Commission (TNERC) has issued a draft order on net-metering facility, which would enable the solar rooftop generators to supply excess power to the grid.

D. Investment Tax Credit

Tax incentive that permits companies or individuals to deduct a specified percentage of certain investment costs from their tax liability in addition to the normal allowances for depreciation. Investment credits are similar to investment allowances, which permit investors or businesses to deduct a specified percentage of certain capital costs from taxable income. Both investment credits and investment allowances differ from accelerated depreciation by offering a percentage deduction at the time an asset is purchased. In effect, the credits are subsidies for investment. Investment credits and investment allowances were adopted by the U.S. in 1962 in order to protect domestic business from foreign competition but have since been applied toward the support of energy conservation, pollution control, or various forms of desirable economic development.

The solar Investment Tax Credit (ITC) is one of the most important policy mechanisms concerning nationwide to support the deployment of solar energy all across the globe. The ITC continues to drive growth in the industry and job creation across the country. Despite their instrumental role in promoting solar energy, investment tax credits schemes are criticized for their impacts on government revenues [38].

E. Carbon Trading

Carbon Trading is definitely the "Greenest" pastures for business trading for the small and large scale private and governmental sectors in India with opportunities for everyone [39]. The defined value of one carbon trading as the equivalent amount of one tonne of CO2 emissions. According to the protocol, the credits can be sold in the international markets at the existing prices with the exchange of certain credits. This methodology was ascertained in the Kyoto Protocol which ensures that the credit helps the developing or the underdeveloped countries as they pertain lower per capita carbon emissions than those of developed countries. Here, these countries can sell their carbon credits to other countries and acquire the profit economically by not polluting the environment and thus, contributing in sustain greener planet.

Solar power generation emits lesser amount of CO2 compared to conventional sources of energy such as coal. This will partially help in offsetting the high cost of solar production. Carbon credits has created a market for reducing GHG emissions by giving a monetary value to the cost of polluting the air. Emissions have become an internal cost of doing business and are visible on the balance sheet alongside raw materials and other liabilities or assets [40].

F. Renewable Portfolio Standards

Renewable Portfolio Obligation (RPO) also known as Renewable Portfolio Standards (RPS) generally places an agreement on electricity supply companies to produce or consume a specified fraction of their electricity consumption from renewable energy sources [41]. In India, the legislative support for Renewable Portfolio Obligation is reflected from the Electricity Act-2003 which specifies in section 86(1) (e) as – to promote co–generation and generation of electricity through renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any persons, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee [42].

National Action Policy on Climate Change in India set a renewable portfolio standard in the year 2008 that was named as Renewable Purchase Obligation (RPO) in order to produce 15% of the country's electricity with renewable energy sources by 2020 [43]. Further, under the Jawaharlal Nehru National Solar Mission, the Indian government aims to develop approximately 20,000 MW of solar energy by 2022. To help reach these ambitious targets in a cost-effective manner, India has launched a market-based mechanism called Renewable Energy Certificates (RECs) in 2010.

G. Regional Energy Certificates (REC)

A market based medium that provides the evidence that a producer has generate a certain amount of electricity from a renewable energy resource. A Renewable Energy Certificate signifies the environmental facet of the renewable energy. This concept seeks to address the mismatch between availability of RE sources and the requirement of the obligated entities to meet their Renewable Purchase Obligation (RPO). This is also entitled to motivate the renewable energy capacity addition in the states having the potential for generation as the REC framework seeks to create a national level market for such generators to recover their cost. RECs are expected to become the currency of renewable energy markets because of their flexibility and the fact that they are not subject to the geographic and physical limitations of commodity electricity. Also, instead of producing renewable energy by their own, states can purchase RECs from each other to increase their energy content in total energy. This mechanism will enable low potential states to purchase RECs from high potential states, enabling them to meet NAPCC's (National Action Plan on Climate Change) increased demands. Moreover, these purchases will stimulate high potential states to produce more than presently required. This will enhance an overall increase in renewable energy production.

RECs are classified as one, Solar Certificates issued to eligible entities for generation of electricity based on solar as renewable energy source, and second, as Non-solar certificates issued to eligible entities for generation of electricity based on renewable energy sources other than solar. Central Electricity Regulatory Commission (CERC) has notified Regulation on REC in fulfilment of its command to inspire renewable sources of energy and development of market in electricity. The step for REC is expected to give push to renewable energy capacity addition in the country.

H. Governmental Mandatory Regulations & Provisions

Government regulations mandating installation of solar thermal systems is the main policy driver for the development of solar thermal applications in many countries e.g. Scandinavia. These regulations aims to boost the widespread construction of energy efficient green building (solar based) nationwide. This purpose can be achieved by providing promotional incentives for the construction of green buildings for creating awareness by organizing workshops, seminars and trainings for engineers, planners, builders, architects, consultants, housing financing organizations and potential users and besides, for development of technical literature, compilation and publishing of documents related to solar/ green buildings and installation of renewable energy projects/systems in the green buildings. The total budget of ₹ 10 crores has been allocated for implementation of the scheme during the year 2013-14 and rest of the 12th Plan period. This also includes meeting the pending liabilities. The scheme will be implemented through State Nodal Agencies/ Municipal Corporations/ Govt. Bodies/ reputed NGOs, technical institutions, professionals, consultants etc.

I. Policy Mix

Some policy instruments have leading roles in promoting solar energy in some countries, a mix of policies, instead of a single policy, would be more effective. Thus, policy mix is seen to be as an efficient tool in the country's renewable energy production [44]. Since the policies inception, the capital subsidy was the predominant policy instrument in India, but a mix of policy mechanisms, such as, subsidies, fiscal incentives, preferential tariffs, market mechanisms and legislation, were encouraged later for the distribution of solar energy [34].

The growing role of private finance has reduced the role of fiscal policy drivers in the overall financing mix for solar power, and capital subsidies have been slashed down substantially, except in cases such as remote villages and communities. India now efficiently rests on a mix of mechanisms including various tax and generation-based incentives, RPOs, subsidies and accelerated depreciation. Contradictorily, the accumulation of incentive programs and the failure to coordinate them are the obstacles to the development of renewable energy resources in India as it results in unnecessary delays and conflicts.

J. Policy Challenges

Solar PV is recognized as serving a market that is very important in developing countries—electrification of rural and preurban areas that do not yet have access to the electric grid [45]. Solar home systems were encouraged in the rural areas to expand the rural electrification agenda. However, the rural and preurban areas are categorized by low income households that may not be able to afford solar energy technologies unless they are substantially subsidized. But today the aim is to offer subsidies either via government funds or through international donors that may help in growth despite of the fact that these policies are not a long term solution in the country [46].

Solar heating applications enjoy limited policy support as policies like FITs and RPS' are not applicable for heating applications. Moreover, it is more difficult to measure and verify solar water heating performance, and so performance-based incentives are difficult to achieve.

VI. CONCLUSION

After Solar energy possesses tremendous potential in bridging India's energy demand-supply gap in the future. The price of solar power in India as analysed from above that it has come down from a significant amount of ₹ 18/kWh in 2011 to ₹ 7/kWh in 2013 (first quarter), while the price of thermal power is pushing ₹ 4/kWh with subsidies. It is clear that the alternatives of solar energy are going to be immeasurably more expensive.

There are various challenges for this industry, including lowering cost of production, increasing R&D, consumer consciousness, lack of standards and financing infrastructure. It is important to conquer these challenges for rapid growth and mass acceptance of the technology. Some of the immediate actions to enable growth are efficient implementation of renewable energy certificates, usage of carbon trading as a source of revenue, improvement of financing facility, encouragement in private investment, quick implementation of net metering scheme, policy mixing, rapid implementation of grid powered energy in regions of Rajasthan and Gujarat, development of off-grid usage in various applications such as cellular towers and encouraging localized mini grids in areas that lack connectivity today. Research and development capacity will be built in the private sector and in educational institutions. Millions of productive jobs will be created by the need to develop the infrastructure required for the new industries resulting from massive solar projects. Publicizing job creation, in addition to environmental and energy access reimbursement, will strengthen the economic case for clean energy policies and build public support for these initiatives. If these initiatives work as planned, it is only a matter before India becomes one of the world leaders in Solar Energy.

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