Inspired, Integrated Initiative

ISA
INDIA SEMICONDUCTOR ASSOCIATION

Solar PV Industry 2010 : Contemporary scenario and emerging trends

Supported by the Office of
the Principal Scientific Adviser to
the Government of India

APIIC
The Future is Here

India Semiconductor Association
UNI Building, 4th Floor
Millers Tank Bund Road
Bangalore 560 052, India
Telephone: +91 80 41473250
Facsimile: + 91 80 41221866
Website: www.isaonline.org
Email: research@isaonline.org

First Print: May 2010

Published by:
India Semiconductor Association, Bangalore

ISA is the premier trade body representing the Indian semiconductor and electronics system industry and has represented it since 2005. It has around 130 members from across the country to establish India as a preferred global destination for semiconductor, systems and solar photovoltaic companies. This includes chip design and embedded software companies, solar fabs and the related ecosystem. ISA has played a prominent role in working with the Government of India in the formation of the Semiconductor Policy 2007. More information about ISA can be found at www.isaonline.org

Disclaimer of Warranties and Limitation of Liability

This study is provided by ISA on an "as is" and "as available" basis. ISA has provided information that is provided by market participants, survey respondents and secondary research of publicly available information. ISA takes no responsibility for any incorrect information supplied to us by market participants (manufacturers or users). Quantitative market information is based primarily on interviews and therefore is subject to fluctuation. No claims are made for the accuracy or applicability of the information to any specific situation.

ISA makes no representations or warranties of any kind, express or implied, as to the information, content, materials, etc., included in this study. The user of the study shall do so at the user's sole risk. In the event the user intends taking any steps that could have an adverse effect on the users business, ISA expressly states that the user should consult its legal, tax or other advisors, in order to protect the interests of the user, which may be specific from case to case. It is emphasized that ISA has participated in preparation of this study in an independent manner and should not be construed as necessarily being reflective of the views or position of any individual member company of the ISA or of the representatives of such member companies that may serve on the ISA's executive council or other member forums.

To the full extent permissible by applicable law, ISA disclaims all warranties, express or implied, including, but not limited to, implied warranties of merchantability and fitness for a particular purpose. ISA will not be liable for any damages of any kind arising from the use of this study, including, but not limited to direct, indirect, incidental, punitive, and consequential damages.

AES Solar ENERGY

We would like to thank AES Solar Energy for sharing
ISA's vision and its support and contribution.

Solar PV Industry 2010 : Contemporary scenario and emerging trends

May | 2010

India Semiconductor Association

The office of
the Principal Scientific Adviser to
the Government of India

MESSAGE

Solar Energy is an important mitigating technology in the context of the climate change threat. The Jawaharlal Nehru National Solar Mission is an important component of our National Action Plan on Climate Change. There is close synergy between the semiconductor technology and solar PV technology - in fact, silicon today is considered more an energy material than an electronic material! Our office had brought out a report on "Catalysing the Growth of Semiconductor Ecosystem in India" under the guidance of Prof. Juzer Vasi in may 2009. The present report on "Solar PV Industry 2010" has been prepared by the India Semiconductor Association and should serve as an important reference source for the various stakeholders in the solar PV industry.

R. Chidambaram

(R Chidambaram)
Principal Scientific Adviser to
the Government of India

PREFACE

Solar Photovoltaic is a key technology option to realize the shift to a decarbonised energy supply and is projected to emerge as an attractive alternate electricity source in the future.

The solar PV manufacturing base in India comprises primarily of cell and module manufacturing; with the bulk of the value addition taking place outside the country. The current scale of manufacturing in India is small in comparison to global standards.

Post the announcement of Government of India's Semiconductor Policy and aggressive initiatives shown by several states, new investors are considering Andhra Pradesh, U.P., West Bengal, Tamil Nadu and other states as their destinations for solar PV production.

The recent investments seen in solar PV manufacturing are essentially from large players looking at both the domestic and export markets. As the cost of power generation from solar PV route reduces further, India itself could emerge as a market for solar energy, given the high solar incidence in India and the initiatives being taken by the Government.

The Jawaharlal Nehru National Solar Mission announced in November 2009 is a major initiative of the Government of India which will give an impetus to the domestic solar PV industry and encourages the strengthening of the capability on various important issues like manufacturing, technology, market and human resources.

This report looks at the contemporary scenario of the solar PV industry, both globally and within India. The analysis is based on a comprehensive review of secondary literature and extensive fieldwork. The report would help the various stakeholders in taking informed decisions and contribute to India's emergence as one of the major solar hubs in the world.

The report has been supported by the Office of the Principal Scientific Advisor to the Government of India, Andhra Pradesh Industrial Infrastructure Corporation Ltd. (APIIC) and AES Solar Energy. We are grateful to these organisations for their support and valuable inputs in bringing out this report.

The concerted efforts of the ISA Solar PV subcommittee on industry research and Feedback Consulting teams are greatly appreciated. We would also like to acknowledge the support of several individuals and organizations from within and outside this industry for this study.

We take this opportunity to especially thank Prof. Juzer Vasi, Deputy Director, IIT Bombay & Head-Core Committee for this study and Dr. RP Gupta, Director, Office of the Principal Scientific Advisor to the Government of India for sharing their invaluable insights and guiding the study towards its successful completion.

Dr. Vidya Mulky from the ISA Secretariat coordinated the process.

Poornima Shenoy
President- ISA

B V Naidu
Chairman

Table of contents

Glossary of terms

Term	Description	Term	Description
1 US $	equivalent to Rs 47	Mn	Million
11th Five Year Plan	2007 to 2012	MNRE	Ministry of New & Renewable Energy
AT&C losses	Aggregated Technical & Commercial losses	MoU	Memorandum of Understanding
CAGR	Compounded Annual Growth Rate	MT	Metric Tonnes
CEA	Central Electricity Agency	MW	Mega Watt
CERC	Central Electricity Regulatory Commission	MWp	Mega Watt peak
Cr	Crores	NPV	Net Present Value
C-Si	Crystalline Silicon	NTPC	National Thermal Power Corporation
DG	Diesel Generator	NVVM	NTPC Vidyut Vyapar Nigam Ltd
DIT	Department of Information Technology	PPA	Power Purchase Agreement
DLS	Domestic Lighting System	PV	Photo Voltaic
FY	Financial Year	R&D	Research & Development
GBI	Generation Based Incentive	REC	Rural Electrification Corporation
GDP	Gross Domestic Product	RGGVY	Rajiv Gandhi Grameen Vidhyut Yojana
GEDA	Gujarat Energy Development Authority	RLP	Rural Lighting Program
GoI	Government of India	RPO	Renewable Purchase Obligation
GW	Giga Watt	RREP	Rajasthan Rural Electrification Program
HAREDA	Haryana Renewable Energy Development Agency	SEZ	Special Economic Zone
HRD	Human Resource Development	SNA	State Nodal Agency
IIT	Indian Institute of Technology	SPV	Solar Photo Voltaic
IPP	Independent Power Projects	Sq mtr	square meter
IREDA	Indian Renewable Energy Development Agency	W	Watt
ITI	Industrial Training Institute	Wp	Watt peak
JNNSM	Jawaharlal Nehru National Solar Mission		
kW	kilo Watt		
kWh	Kilo Watt-hour		

1

Executive summary

Executive summary

Global scenario of solar PV industry

The total global production of solar PV modules during the year 2008 is estimated at 7.3 GW[1], which is 80% higher than production during 2007. China (2.3 GW), Europe (1.9 GW) and Japan (1.2 GW) contributed the most to solar PV production for year 2008, while for installations, Spain (2.7 GW) and Germany (1.9 GW) accounted for 76% during the same period. Other emerging nations for solar PV installation include USA (342 MW) and South Korea (282 MW)[1].

Massive capacity expansion plans are underway and the planned capacity expansions are way above the projected market growth, which means that the capacity utilization rate will reduce, transforming this market from demand driven to oversupplied market. Such a development will increase pressure on the margins of the manufacturers and could accelerate consolidation of the solar PV industry. The PV industry now offers reliable products with sufficient efficiency & energy output for a lifetime of 25 years. On the other hand, increasing power interruptions from grid and increasing cost of power from other sources are driving the growth of the solar PV industry. On the technology front, Crystalline Silicon (C-Si) accounts for more than 85% of current production. The shortage of polysilicon in the year 2008 and the availability of turnkey production lines for Thin Film technology are driving the attractiveness of Thin Film production capacities across the world.

Increasing investments in production capacity of polysilicon, emergence of Thin Film technology and reduction in material consumption per silicon solar cell, are expected to drive the reduction in the cost of solar systems.

The capacity in India is currently estimated in excess of about 400 MW[2] for cells and about 1,000 MW for modules. Based on the interactions with the industry, the capacity of PV cells and modules in India is estimated to cross 750 MW and 1250 MW by the end of year 2010. The production in India for year 2008-09 is estimated at 175[3] MW of cells and 240[3] MW of modules. A large proportion of the production was exported.

Relevance of solar PV in India

India has a cumulative power generation capacity of 152 GW[4] and faces a deficit of 11% in overall demand and 12% in peak demand[5]. With an expanding economy, the demand for power is growing at about 6% every year and the peak load is expected to reach 176 GW by 2012 and cross 778 GW by 2031-32.

The Indian power sector is highly dependent on coal as fuel. 53%[6] of the total installed capacity is based on coal based generation. With the current scenario, coal consumption for power sector is likely to reach the level of 173 million MT by 2012. As per the Ministry of Coal, the existing coal reserves estimates will last for another 40-45 years.

Renewable Energy (RE) initiatives began in India in the year 1981. At present, RE power generation capacity is 13,242 MW, accounting for about 8.7% of India's installed generation capacity of 152 GW. Wind power (10.5 GW[3]) accounts for a major part of the renewable energy capacity in India. Considering the localized potential for wind energy, solar energy is one of the best solutions to meet India's demand for low cost, off-grid solutions in the short to medium term. Considering the life of solar modules of 25 years and the reducing cost of solar panels, solar energy would be competitive for grid connected installations in the long term. As of December 2009, the total grid connected solar PV power generation capacity was about 6 MW.

Status of PV industry in India

According to the Annual Report of MNRE (2008-09), there are about 15 players in cell manufacturing, over 20 players in modules and more than 50 in solar assembly. As in India, global trends, crystalline silicon technology accounts for most of the market and the share of Thin Film technology is estimated at about 10%[2]. Currently, India does not have any infrastructure for raw material production (polysilicon) and is entirely dependent on imports for the same. In the last few years, the industry has faced many issues relating to the availability and fluctuating prices of the raw materials. The scenario is expected to change with polysilicon production projects being granted in-principle approval by Department of Information Technology (DIT), Ministry of Communication & Information Technology (MCIT) under the SIPS scheme.

Due to low demand in the domestic market and declining exports in 2009, (as a result of the economic slowdown), the solar PV industry is likely to grow at about 5%[2] during 2009-10. In the export market, India is facing a major threat from China, which has aggressive plans to increase solar PV capacity, including polysilicon.

Government initiatives to promote solar PV

Currently, over 60 countries have policies in place to promote renewable power generation. Feed-in tariff has been introduced by about 45 countries and has emerged as the most popular tool for countries to offer financial assistance to power producers. Earlier, though the policies were focused more on hydro, wind and biomass based power projects, in the last 2-3 years; solar has gained importance across many nations. In Europe, Bulgaria increased the feed-in period from 12 to 25 years for solar PV. Spain reduced tariffs for solar PV because its 2010 target was already achieved; set 10% annual tariffs reductions; and instituted a 500 MW solar PV capacity cap for both 2009 and 2010. Portugal added a feed-in tariff for micro-generation (maximum capacity 5.75 kW). Germany instituted reduction in annual tariff for solar PV ranging from 15% - 16%[7] for freelancing & roof top applications and 2-6% for new installations exceeding 3,500 MW. France added a new solar PV tariff for commercial buildings[3]. Greece revised solar PV tariffs (stabilized through 2010/2012); eliminated an unofficial capacity cap; and instituted competitive bidding for large scale solar PV plants greater than 10 MW.

New or expanded solar PV promotion programs continued to appear around the world at the national, state/provincial, and local levels. Most significant was the opening of the grid-connected solar PV market in China with a new policy for building-integrated PV, (solar panels used as architectural components), which also applies to off-grid applications. The policy provides initial subsidies in 2009 of $3 per watt for installations

1. *Navigant [Min 2009], JRC- European Commission*
2. *Industry experts*
3. *MNRE Annual Report 2008-09*
4. *CEA, as on 31.08.2009*
5. *CEA Load Generation Balance Report 2009-2010*
6. *Working Group on Power for XIth plan*
7. *Secondary research*

larger than 50 kW. The policy also specifies minimum solar cell efficiencies and gives priority to building-integrated systems and public buildings.

In the United States, Massachusetts and New Jersey adopted capital subsidies ($1.75 per watt for residential up to 10 kW and $1 per watt for non-residential up to 50 kW in New Jersey). A number of U.S. states and cities have been considering residential solar lease/loan programs, following the lead of emerging programs in Connecticut and the city of Berkeley, California.

Japan increased national solar PV subsidies for schools, hospitals, and railway stations from 33% to 50%, in addition to reinstating subsidies for households that had expired in 2005 (although at a lower level of about 10%). Japan also plans to have more than two-thirds of newly built houses equipped with solar PV by 2020.

World Bank also supports several programs to promote application of solar power in rural areas. By 2008, the cumulative installations through Solar Home Lighting Projects in Bangladesh and Sri Lanka reached to about 260,000 households and 125,000 households respectively. In 2008, two new World Bank projects in Bangladesh were approved for 1.3 million solar home systems to be installed by Grameen Shakti and IDCOL (These projects are among the first to incorporate off-grid PV carbon finance). The World Bank's China Renewable Energy Development project was completed in mid-2008 with solar PV systems for more than 400,000 households in northwestern provinces (11 MW total). A German project in Morocco was also completed in 2008, with installations of solar PV in 40,000 households.

Government of India initiatives for solar PV industry

There have been several initiatives from the Government of India to promote solar PV applications. In 2006, the National Rural Electrification Policy was announced, which focused on providing a minimum 'lifeline' level of consumption of 1 unit (KWh) per household per day. The villages, where grid connectivity was not economically feasible, were awarded to MNRE for electrification, using renewable energy sources. MNRE framed various policies for different technologies for this purpose, but solar lighting system emerged as the best possible solution to be adopted by State Nodal Agencies (SNAs). Currently, solar lighting system is finding applications in most of the cases and the program has been renamed Remote Lighting Program (RLP). Under this program, the Government is offering capital subsidy up to 90% on solar PV appliances in rural areas. The project is monitored by the respective states and in a state, is implemented by various financial institutions, including microfinance institutions.

Due to its high cost, solar PV based power plants are not financially viable at the existing per unit cost of conventional power. To promote solar PV plants, countries like Germany and Spain, have policies in place to incentivize the power producers. There were no such policies in India until December 2007, and all the solar projects were either off-grid or with Government agencies. Private participation was non-existent. To promote large capacity grid connected solar PV plants, MNRE initiated the Generation Based Incentive (GBI) scheme in early 2008, implemented through IREDA. The scheme offered GBI up to Rs 12 per KWh for plants with an installed capacity of more than 1 MW, over and above the tariff to be paid by the State Power Utility. The scheme was limited to 10 MW per state and 5 MW per developer.

The Government also focused on creating opportunities and attracting investment for the production of solar PV cells and modules in India. The Semiconductor Policy announced in 2007 offered capital subsidy to attract investment in solar PV technology. According to the latest update, the Government has received 15 applications, of which 12 have received in-principle approval. Further, 5 proposals have received financial closure exceeding threshold investment of Rs 1,000 Cr. As per the industry estimates, these 5 projects are likely to build 8,000 MT capacity for polysilicon and 5 GW capacity for cells and modules.

In February 2009, MNRE announced a scheme on 'Development of Solar Cities' to promote the usage of Renewable Energy in urban areas by providing support to Municipal Corporations for the preparation and implementation of a road map to develop their cities as Solar Cities. An indicative target of 60 cities/towns, with at least one in each State, has been set for the 11th Plan period (2007-2012). In a major development under this scheme, the Government of Andhra Pradesh has recently (December 2009) announced the development of a solar farm cluster called Solar City on a 10,000 acre land at Kadiri in Anantapur district. Solar City is expected to attract investments worth Rs. 3,000 Cr in the first phase. Four firms - Sunborne, Lanco Solar, AES Solar and Titan Energy - have signed a Memorandum of Understanding with the state to set up establishment in Solar City. These companies will be the anchor units in Solar City and have a proposed combined capacity of 2,000 MW.

A major initiative from the Government to promote solar power in India is the launch of JNNSM. Prior to JNNSM, for solar PV, the focus of the Government was primarily on reaching rural India.

Jawaharlal Nehru National Solar Mission (JNNSM)[2]

Background and objective

The National Solar Mission program was initiated by the Government as one of the 8 programs under the National Action Plan for Climate Change by the Prime Minister of India in 2008. In the month of November 2009, the Mission document was released as the Jawaharlal Nehru National Solar Mission (JNNSM) and the Mission was formally launched by the Prime Minister of India on January 11 2010.

The JNNSM is neutral to the choice of solar technologies and has provision for the development of all viable technologies. Apart from solar PV, the already existing technology in India, JNNSM also has the provision to develop solar thermal technology for large scale grid connected power plants.

Focus on grid- connected systems

The document emphasizes the development of grid-connected applications, by offering feed-in tariffs for the power producers. The feed-in tariff is proposed to be provided for a period of 25 years.

JNNSM proposes to introduce Renewable Purchase Obligation (RPO) to promote the growth of this sector. NTPC Vidyut Vyapar Nigam (NVVN) Ltd. has been designated as the nodal agency for entering into a Power Purchase Agreement (PPA) with solar power developers. The solar power purchase obligation for States would start with 0.25% in Phase I and go up to 3% by 2022. The PPAs shall be signed with the developers who will set up solar projects connected to the grid at 33 KV level and above. The PPAs will be valid for a period of 25 years. For each MW of solar power installed capacity for which PPA is signed by NVVN, MOP shall allocate to NVVN/ the state utility, an equivalent amount of MW capacity from the unallocated quota of NTPC stations.

Focus on off-grid systems

JNNSM also lays emphasis on development of decentralized and off-grid applications as a solution to power-related issues in remote areas where grid penetration is neither

1. *DIT, MCIT / Office of the Principal Scientific Adviser to the Government of India*
2. *JNNSM Policy Document, MNRE*

feasible nor cost effective. The Mission has set a target of 1,000 MW by 2017, reaching million households. To meet this target, the Mission plans to provide solar lighting systems to over 10,000 villages and hamlets and also to set up stand alone rural solar power plants in special category States and areas such as Lakshadweep, Andaman & Nicobar Islands and the Ladakh region of Jammu & Kashmir.

Growth enablers for the domestic solar PV industry include zero import duty for capital equipment, raw material, and excise duty exemption, low interest rates; incentives under SIPS, solar manufacturing tech-parks, etc.

Research & Development (R&D) initiatives

For technology development, the R&D strategy would comprise five categories, viz.

- Basic research having a long term perspective for the development of innovative and new materials, processes and applications
- Applied research aimed at improvement the existing processes, materials and the technology for enhanced performance, durability and cost competitiveness of the systems/ devices
- Technology validation and demonstration projects aimed at field evaluation of different configurations, including hybrids with conventional power systems for obtaining feedback on performance, operability and costs
- Development of R&D infrastructure in PPP mode, and
- Support for incubation and start ups, a 3-tier R&D institutional framework, including high level research council, National Center of Excellence and a network of centers of excellence

Manpower development

Realizing the increasing demand for skilled manpower for solar applications, JNNSM has drawn up a roadmap for manpower development at every level, with specialized courses on solar power – at engineering colleges, ITIs and a short term training module for technicians, in association with the Ministry of Labor

Implementation and monitoring

An autonomous Solar Energy Authority will be established to implement the National Solar Mission. This would include a Mission Steering Group - to approve projects, and a Mission Executive Committee - to monitor implementation of National Solar Mission.

India – a special case for solar PV

Solar PV applications in India have followed a different trend from global practices. While globally, there has been higher focus on grid connected applications, the Indian PV market has predominately focused on off-grid applications. In the Indian context, the power scenario and the nature of energy demand is highly skewed, with huge differences seen between the per capita electricity consumption in the urban and the rural areas. For a high cost resource like PV, the relevance and scope of its applications would, therefore, be vastly different from that of a developed western economy. However, the socio-economic and the geographical features of the country provide ample scope to use new, renewable energy resources like PV. In several cases, PV appears to be not only the most relevant option, but also a viable alternative even at the prevailing price.

Emerging trends

JNNSM is a welcome step from the Government, to accelerate growth of the Indian PV industry. The policy addresses all the major issues currently being faced by the industry and also acknowledges key challenges in achieving the Mission objective. Grid connected solar power generation is a key thrust area of the JNNSM. The appointment of NVVNL to execute PPAs is a major step, which will reduce the project clearance and implementation timelines. The proposal to extend PPA duration to 25 years will improve the financial feasibility for power developers. JNNSM is technology neutral and defines a research & development roadmap to develop indigenous strengths in technology and reducing the dependence on international markets. Capital subsidy offered through SIPS is one of the enablers for the Indian manufacturing companies to operate on a level playing field with international counterparts. Addressing issues related to manpower, JNNSM proposes participation by premier institutes like IIT, Ministry of HRD and Ministry of Labor in the development of skilled manpower across various levels.

Under JNNSM's approach, a roadmap for technologies to achieve a target of 20,000 MW capacity by 2022, would be drafted post 2012. The first phase (up to 2013) will involve experimenting with all technologies and applications before deciding on subsequent steps. The existing Government polices offer incentives for production (SIPS), generation (GBI, PPA & feed-in tariff) and usage (capital subsidy for certain products) of solar PV technology. The private sector has lined up investments to increase module & cell capacity as well as to set-up solar power plants. With 5 projects for polysilicon planned under SIPS, the solar PV value chain in India will expand to raw material as well.

Following the JNNSM launch, a major development has been the release of tariff for renewable energy by the Central Electricity Regulatory Commission (CERC). CERC is responsible for determining the tariff for power from renewable sources on the basis of suo motu petition; at least 6 months in advance, at the beginning of each year under the control period of renewable energy technologies, for which the norms have been specified by MNRE. On December 3 2009, CERC launched the first set of generic tariff for projects to be launched in FY 2009-10. For solar power, the tariff period has been specified for 25 years. The normative capital cost for solar PV projects has been defined as Rs 17 Cr/MW. CERC has determined generic tariff of Rs 18.44 per kWh for solar PV for projects commissioned in FY 2009-10. CERC is in the process of finalizing the tariff for FY 2010-11.

In December 2009, a 1.2 MW grid connected solar power plant was inaugurated in West Bengal. The developer has signed a power purchase agreement @ Rs 5 / kWh from the state utility. In addition, it is also entitled for GBI @ Rs 10 per kWh from MNRE. Another plant, the first 2 MW grid connected solar PV plant, was inaugurated in Punjab on December 15th 2009.

Two projects of 3 MWp each have also been commissioned in the state of Karnataka. The solar plants, located in Kolar and Chikkodi districts, have been implemented under the Arunodaya scheme for ensuring assured power supply to rural areas, especially irrigation pump sets.

Even at the existing price levels, solar PV is a cost economic solution, when compared to Diesel Generator (DG) sets used by the industries for power back-up. The Haryana Renewable Energy Development Agency (HAREDA) recently launched the Solar Rooftop Scheme to motivate commercial and industrial establishments like hotels, hospitals and housing complexes to replace DG sets installed for captive requirement during load shedding. Under this scheme, HAREDA approved 2 standalone solar PV projects of 100 kW each in Gurgaon to demonstrate applications of solar PV for industry power back-up. The State Government has agreed to offer financial assistance of Rs 75 lakh for each project.

2

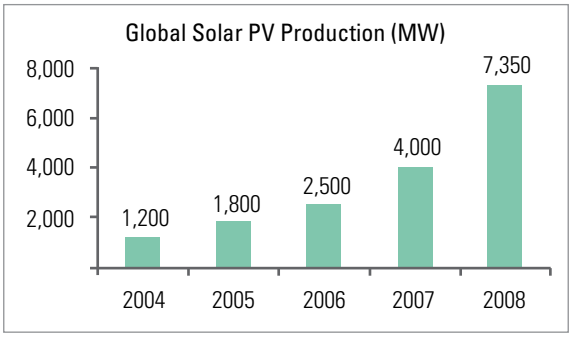
Status of global solar PV industry

Status of global solar PV industry

Global solar PV production capacity and production[1]

The production of solar PV across the world for the year 2008 is estimated at about 7.3 GW of modules. The total production grew by about 84% in 2008 as compared to production in year 2007.

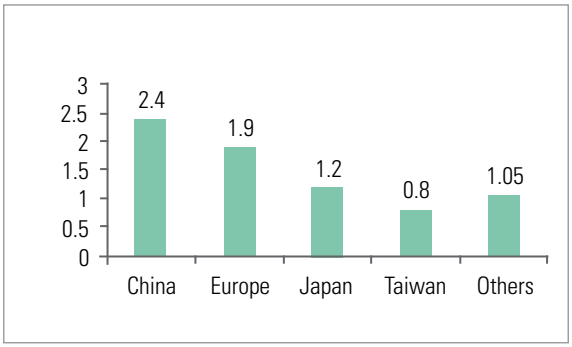
Graph 1: Trends in global PV production



Source: Navigant

During the year, Chinese and Taiwanese production increased over-proportionally, with China at the top, with about 2.4 GW, followed by Europe with 1.9 GW, Japan with 1.2 GW and Taiwan with 0.8 GW

Graph 2: Solar PV production (GW) by region, 2008

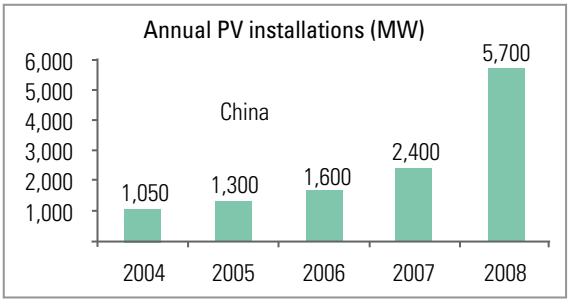


Source: Navigant

Installations of Solar PV across the world

The market for installed systems in 2008 more than doubled as compared to 2007. For 2008, the total global solar PV installations are estimated at about 5.7 to 6 GW.

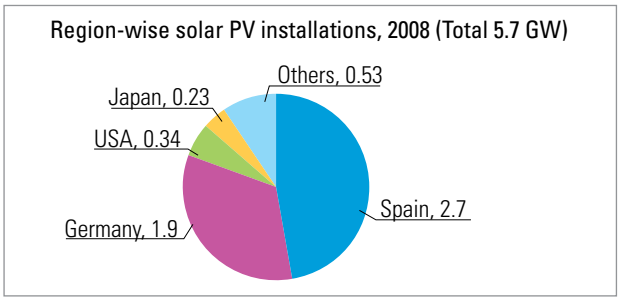
Graph 3: Trend in global PV installations



Source: Navigant

The impressive growth in 2008 is mainly due to an exceptional development in the Spanish market, which rose nearly five-fold from 560 MW in 2007 to 2.7 GW in 2008 [Epi 2009, Sys 2009). The second largest and most stable market was Germany with 1.9 GW, followed by the US (342 MW), South Korea (282 MW), Italy (258 MW) and Japan (230 MW).

Graph 4: Region-wise solar PV installations, 2008



Source: Navigant

Europe

Despite the fact that the European PV production grew again by over 80% and reached 1.9 GW, the exceptional growth did not change the role of Europe as a net importer of solar cells and/or modules. Apart from Spain and Germany, the rapidly developing markets in Europe include the Czech Republic (51 MW), France (46 MW) and Portugal (50 MW). The ongoing capacity expansions and the cap in the Spanish market might change this in future.

USA

The third largest market in 2008 was USA, with 342 MW of PV installations, including 292 MW grid-connected PV. California, New Jersey and Colorado accounted for more than 75% of the US grid-connected PV market. The US Senate voted to extend the tax credits for solar and other renewable energies on September 23 2008. On October 3 2008, the Congress approved and the President signed the "Energy Improvement and Extension Act of 2008", as part of H.R. 1424, the "Emergency Economic Stabilization Act of 2008."

In May 2009, President Obama announced plans to spend over $467 million from the American Reinvestment and Recovery Act to expand and accelerate the development, deployment, and use of geothermal and solar energy throughout the United States. The Department of Energy (DoE) will provide $ 117.6 million in Recovery Act funding to accelerate the widespread commercialization of solar energy technologies across America. $51.5 million will go directly for Photovoltaic Technology Development and $40.5 million on Solar Energy Deployment, where projects will focus on non-technical barriers to solar energy deployment.

South Korea

South Korea became the fourth largest PV market in 2008. At the end of 2006, the cumulative installed capacity of PV electricity system was only in the range of 25 MW. In 2007, about 45 MW were installed and in 2008, the market surpassed the estimated 75 to 80 MW by far, with 282 MW of new installations planned. The driver for this development was the Government's goal to increase the share of New and Renewable Energy Sources (NRES) to 5% by 2011. For PV, the goal was a cumulative installed PV electricity generation capacity of 1.3 GW by 2012 and 4 GW by 2020.

In January 2009, the Korean Government announced the third National Renewable Energy Plan, under which, renewable energy sources will steadily increase their share of the energy mix between now and 2030. The plan covers areas such as investment, infrastructure, and technology development and programs to promote renewable energy. The new plan calls for a renewable energy share of 4.3% in 2015, 6.1% in 2020 and 11% in 2030.

1. *Navigant*

To reach this target, South Korea introduced an attractive feed-in tariff for 15 years, along with investment grants up to 60%. From 2012, it is planned to substitute the tariffs by a Renewable Portfolio Standard. Under the new tariff scheme, it is possible to choose between a 15-year guarantee and a higher kWh price and a 20-year guarantee and a somewhat lower kWh price. The previous 100 MW cap was increased to 500 MW and if not achieved in 2009, the fixed prices applicable for new systems in 2010, will be announced later. However, the cumulative installed capacity at the end of 2007 was 78 MW. The Korean Government aims to equip 1,00,000 houses and 70,000 public/commercial buildings with PV systems by 2012. An interesting aspect is that some of the larger projects will qualify for Clean Development Mechanism (CDM) credits, allowing for trading of Certified Emission Reductions (CER) under the Kyoto Protocol.

Japan

After two years of decline, the Japanese market recovered slightly and reached 230 MW of new installations, 9% higher than in 2007. To change this situation, the Japanese Ministry for Economy, Trade and Industry (METI) proposed a new investment incentive scheme starting from January 2009. The scheme offers capital subsidy to household and small scale users and feed-in tariff for commercial investors. The allocated budget during the last months of FY 2008 (January – March) and FY 2009 would facilitate installation of more than 100,000 systems or 400 MW.

China

Though the Chinese PV market more than doubled in 2008 to 45 MW, the domestic market is still less than 2% of total PV production. This situation might change because China's RMB 4 trillion stimulus package, announced in early March 2009, includes RMB 210 billion (22 billion) for green energy programs. During March 2009, the Chinese Ministry of Finance and Ministry of Housing and Urban-Rural Development announced a solar subsidy programme, to promote application of building-integrated solar PV systems. For 2009, the subsidy will be 20 RMB/p (2.10 / Wp) installed.

Till the end of 2008, China had an accumulative installed capacity of 150 MW for PV solar power, of which 55% belonged to stand-alone PV power generation units. The heat collecting area of solar water heaters had reached 125 million m2, accounting for over 60% of the world total; and keeping China the world leader in this field for many years.

Analysts believe that these measures will accelerate the Chinese domestic market. For 2009, a doubling or even trebling of the market seems possible as a starting point for the development of a 1 GW size market from 2012 onwards. China is now aiming for a 12 GW solar capacity in 2011, and in July 2009. Under the new energy stimulus plan, China revised its 2020 targets for installed solar capacity to 20 GW.

Comparison of solar PV industry in India and China indicates that while China's installed base is much higher (about 150 MW, compared to about 2 MW in India), China also has larger installed capacity (2.4 GW) for solar PV. While in the last 8 years, India has exported about 66% of its total solar PV production, for China this proportion is as high as 90%.

China and India face the same problem of non-electrified remote areas. India chose to connect the non-electrified villages through a national program - RGGVY (Rajiv Gandhi Grameen Vidhyut Yojana) and allocated some of the villages to MNRE under its Rural Lighting Program (RLP) scheme. Earlier in 2009, China announced the Golden Sun program1, which focuses on a short term objective of adding 642 MW of solar power generation capacity by 2012. Instead of offering feed-in tariffs, the Chinese Government will share the investments, not only for generation, but also for transmission and distribution infrastructure. The Ministry of Finance of China will share 50% of capital cost for utility-scale projects and those going up at industrial sites. It will pay 70% of the cost of building off-grid projects in remote regions. About 294 projects totaling 642 MW have been approved, and are expected to be operational within three years. Grid companies / utilities are required to buy all surplus electricity output from solar power projects that generate primarily for the developers' own needs, at similar rates to benchmark on-grid tariffs set for coal-fired power generators. There is a cap of 20MW of generating capacity in each province which is considered as a major drawback for developers to benefit from economies of scale. Additional details on selected projects are given below:

- 232 projects -- totaling 290 MW -- to be built at major industrial sites where carbon-heavy manufacturers will consume all of the electricity generated.
- 35 projects -- totaling 306 MW -- to be built as utility-scale solar parks, whose output will flow into China's transmission grid.
- 27 projects -- totaling 46 MW -- to be built by independent producers in remote, powerless regions.

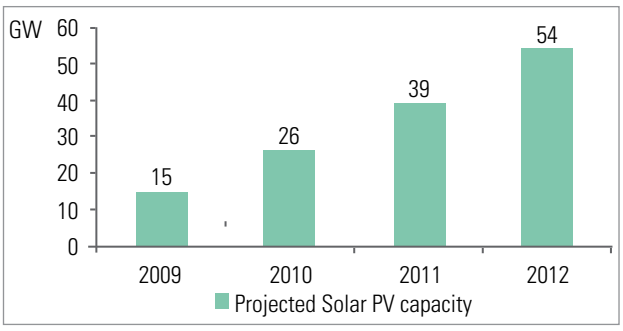
Taiwan

To promote the solar energy industry, the Taiwanese Government has decided to grant subsidies to manufacturers engaged in R&D and offer incentives to consumers who use solar energy. About a dozen manufacturers have expressed their intention to invest in fabricating Thin Films for solar cells, with eight of them setting up their own plants to process the products. Moreover, the Industrial Technology Research Institute (ITRI), a government-backed research organization, will import advanced foreign technology to help local manufacturers.

Future trends expected in global solar PV industry[1]

The global capacity of solar PV modules is expected to reach 54 GW by end of year 2012 as indicated in the graph below:

Graph 5: Cumulative capacity additions planned in solar PV until 2012

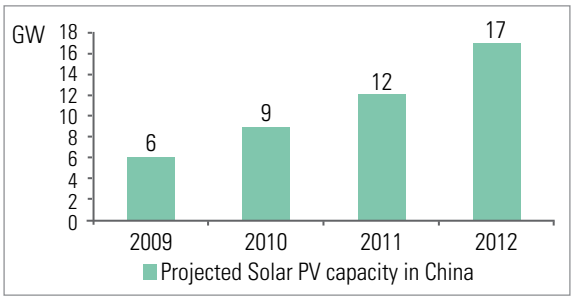


Source: Navigant

1. Navigant

The capacity addition relies mainly on the implementation of projects in China, which has ambitious plans to add capacity. The graph below indicates China's growth plans in the next 4 years. If China achieves its planned target, it will account for 32% of the total worldwide production capacity by 2012.

Graph 6: Solar PV production capacity addition plans of China



Source: Navigant

Solar PV technologies[1]

Crystalline silicon

Despite capacity limitations for feed stock material manufacture, world PV production is growing at a fast rate and c-Si technology continues to maintain its dominant position. Planned expansion programs by almost all existing manufacturers and new capacities being created by fresh entrants are likely to result in a significant increase in world manufacturing capacity for feed stock material (polysilicon). Conservative estimates indicate the world capacity for polysilicon to grow from the existing level of 40,000 TPA to over 120, 000 TPA by 2012.

Typical plant capacities for wafer, cell and module manufacture are growing to several hundreds of Megawatts level and major process equipment manufacturers are coming up with large capacity, fully automated lines. Technology development efforts are focused on reduction in wafer thickness, cell efficiency enhancement and development of less energy intensive manufacturing processes for the feed-stock material (polysilicon).

Such major capacity expansion programs both at the material and product levels coupled with productivity improvements and technology developments are likely to sustain the leading position of C-Si technology for a considerably longer time.

Issues of concern in C-Si mainly pertain to high production costs of polysilicon and high material content of silicon wafers. With physical limitations in reducing these parameters below certain levels, the ultimate cost per peak Watt is more likely to saturate around $1/Wp while it could be less for other technologies (mainly Thin-Film).

Thin Film Technology

In Thin Film solar cell / module technology, very thin layers of a chosen semiconductor material (ranging from nanometer to several micrometers in thickness) are deposited on to either coated glass or stainless steel or a polymer.

Amorphous silicon Thin Film solar cell is the earliest device developed in this area. Other types of Thin Film cells that followed are Cadmium Telluride (CdTe) and Copper Indium Gallium Diselenide (CIGS) solar cells. New developments in this field include 'Micromorph' Cells (a combination of amorphous and microcrystalline silicon materials) that have yielded higher efficiencies and have better stability features.

Advantages of Thin Film technology:

- Significant lower material cost per Wp
- Faster manufacturing processes with less number of steps.
- Comparatively lower energy consumption processes
- Higher energy performance (Thin Film modules generate power even under diffused light and hence can generate more electricity per unit of installed power than crystalline silicon modules of similar power rating)
- Lightweight and flexible substrate.

Disadvantages:

- Lower conversion efficiency
- Poor long term stability
- High capital costs
- Scalability and control of film uniformity over large area designs
- Lower environmental compatibility in respect of CdTe and CIGS technologies

After nearly two decades of technology development efforts, the share of the Thin Film solar cell technology is still low. With the obvious advantages of low material cost per Watt, technology development efforts are focused on improvements in efficiency, deposition rates, yield levels and scalability of the processes involved. CdTe, CIGS and Micromorph (A-Si + μC-Si) technologies are the main contenders in this area. While efficiency levels have been improved over small area depositions, best results in commercial scale operations are at 10% or less.

CIGS technology is reported to hold promise for relatively higher efficiency over larger areas. However, certain critical technical issues still need to be addressed for better solutions regarding commercial viability of Thin-Film PV technologies. These include-

- Standardization of equipment for deposition of the absorber layer
- Back-contact stability
- Reduced absorber layer thickness (≤1μm)
- Control of uniformity over large area.
- Prevention of moisture ingress (for flexible CIGS modules)
- Columnar CIGS structures deposited by alternative process for high efficiency cells and modules

In 2005, for the first time, production of Thin-Film solar modules exceeded 100 MW per annum. Since then, the Compounded Annual Growth Rate (CAGR) of Thin-Film solar module production was even beyond that of the overall industry, increasing the market share of Thin-Film products from 6% in 2005 to 10% in 2007 and 12% in 2008. In 2008, shipments of Thin Film increased by 129% over 2007. The average capacity utilization rate of Thin Film technology is 60%, somewhat higher than the overall utilization rate of the PV industry (average – 54%).

Globally, more than 150 companies are involved in the Thin-Film solar cell production process, ranging from R&D activities to major manufacturing plants. The first 100 MW Thin-Film manufacturing plants became operational in 2007 and the announcements of new production capacities accelerated again in 2008. If all expansion plans are realized in time, Thin-Film production capacity could be 11.9 GW (vs. 4.5 GW reported 2007 at the 22nd EUPVSEC in Milan) or 30% of the total 39 GW in 2010 and 20.4 GW in

1. *Industry experts, secondary research*

2012 of a total of 54.3 GW. The first Thin-Film factories with 1 GW production capacity are already under construction for various Thin-Film technologies.

Other emerging technologies

Micromorph technology (ASi+µCSi) is a relatively new development over multi-junction (double and triple junction) Amorphous Silicon technology. It is projected to evolve as a potential competitor to CdTe in the Thin-Film family.

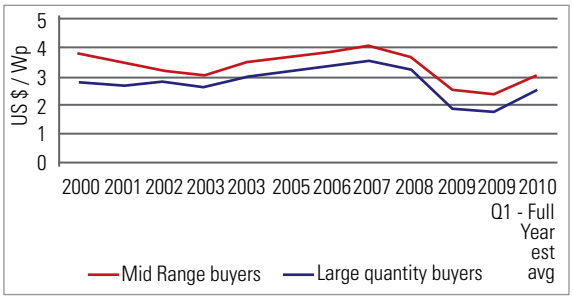
Several new technologies are being pursued mainly from the point of view of achieving high conversion efficiency and cost reduction possibilities through cheaper and abundantly available materials. Carbon nanotubes, quantum dot cells, dye sensitized cells and organic semiconductor based cells are typical examples in this direction.

Trends in global solar PV prices

The global prices of solar PV modules were witnessing downward trend till 2005 when the prices started to increase (from 2005-2008) due to increased cost (because of low availability) of polysilicon till 2008. During 2008, the prices were as high as US $ 3.5 per Wp. Due to the economic slowdown in 2008, year 2009 started with high inventory (estimated at about 2 GW) and high prices. While the manufacturers were holding on to the stock during the first quarter of 2009, the later part of the year witnessed prices dropping to historically low price of about US $ 1.9 per Wp for large quantity buyers ($ 2.5 per Wp for medium quantity buyers). Most of the manufacturers worldwide controlled production and the margins depleted[1].

The inventory levels at beginning of year 2010 are estimated at about 500 MW. Though Germany will remain the key market for solar PV installations, a lot of secondary markets are also likely to emerge in year 2010. It is highly unlikely for industry to sustain the price levels of 2009. As demand recovers and strengthens in current year, the pricing will certainly recover, even from the manufacturers in region where low manufacturing costs and manufacturing subsidies allow for stronger competitive pricing.

Graph 7: Estimated prices to the first point of sales, 2000-2010



Source: Navigant

1. *Navigant*

3

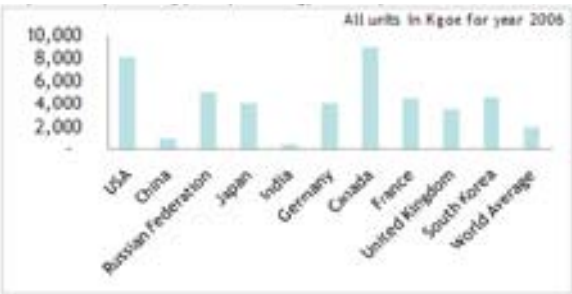
Relevance of solar PV in India

Relevance of solar PV in India

Energy and power scenario in India

The per capita energy consumption level in various countries is shown in the figure below. India's per capita consumption of energy is far lower than that of the world average. Even with such a low per capita consumption, during the year 2008-09, the power deficit is about 11% in total demand and a deficit of more than 12% in peak load demand. This clearly signifies that the available fuel is not sufficient to meet the rising demand for energy of India.

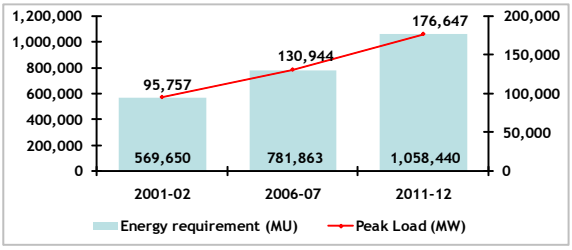
Graph 8: Comparison of per capita energy consumption across nations, 2006



Source: Secondary sources

By end of year 2008, India had power generation capacity of about 152 GW. Even with such an installed base, about 17% of the villages in India are non-electrified, which would translate to about 450 million. With a growing economy, the demand for power is growing at about 6% every year and the peak load demand is expected to reach 176 GW by 2012.

Graph 9: Trends in energy requirement and peak load of India over last 10 years[1]



Source: Ministry of Power, Government of India

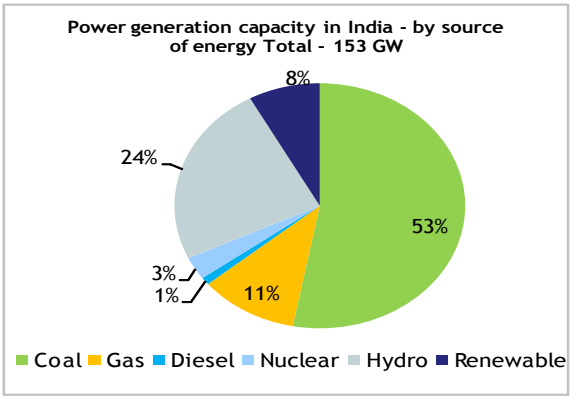
Table 1: Region-wise power demand-supply scenario in India

State / Region	Energy				Peak			
	Requirement	Availability	Surplus (+) / Deficit (-)		Demand	Met	Surplus (+) / Deficit (-)	
	(MU)	(MU)	(MU)	%	(MW)	(MW)	(MW)	%
Northern	241,461	222,875	-18,586	-7.7	35,460	29,970	-5,490	-15.5
Western	276,827	234,819	-42,008	-15.2	37,330	34,276	-3,054	-8.2
Southern	220,126	201,222	-18,904	-8.6	31,384	27,216	-4,168	-13.3
Eastern	91,386	93,613	2,227	2.4	15,110	14,165	-945	-6.3
North – Eastern	10,744	9586	-1158	-10.8	1804	1537	-267	-14.8
All India	**840,544**	**76,2115**	**-78,429**	**-9.3**	**118,794**	**103,816**	**-14,978**	**-12.6**

Source: CEA, Load Generation Balance report 2009 -2010

About 11% of the total power is sourced from oil & gas. Apart from automobiles and industry, the power sector is the largest importer of oil & gas in India. For 2008, the total oil imports accounted for 7% of the GDP.

Graph 10: Power generation capacity in India by source, 2009



Source: Ministry of Power, GoI

1. *Ministry of Power, GoI*

The Indian power sector is highly dependent on coal as a fuel, with 53% of the total installed capacity being coal based generation. Given the current scenario, coal consumption by the power sector is likely to reach levels of 173 mn MT by 2012. According to the Ministry of Coal, the existing coal reserves are estimated to last for another 40-45 years.

To meet the 778 GW demand for power by 2031-32, the Government of India is planning heavy investments in coal based power generation, where cost of production is lower than with any other source. Coal based power is grid connected, which leads to another major power related issue in India – AT&C (Aggregated Technical & Commercial) losses. Some key statistics pertaining to AT&C losses in India for 2008-09 are given below:

- Figures vary from 18- 62% across states; a country average of 36%
- Major losses due to theft and pilferage (about Rs 20,000 Cr annually)
- Poor billing and collection efficiency (55% and 41% respectively)

India is positioned on the threshold of a new era of possibilities and opportunities. The exponentially growing demand for resources in both rural and urban India is creating new possibilities every day. It is a well known fact that the rapidly growing population and businesses are placing considerable pressure on India's power resources.

Graph 11: Future projections for installed capacity and electricity demand in India

Source: Energy Policy Report, Planning Commission, India for 8% GDP growth

Renewable sources

In the present scenario, renewable resources emerge as the best alternative. At present, renewable energy accounts for about 11% of India's installed generation capacity of 152 GW.

Much of this capacity is wind-based (about 11 GW), with the share of solar power being only about 6 MW. India is blessed with an abundance of non-depleting and environmentally friendly renewable resources, such as solar, wind, biomass, hydro and cogeneration and geothermal. Wind energy sector, which has shown tremendous growth in the recent year, dominates the renewable energy sector in India.

Table 2: Status of renewable energy in India

No.	Sources / Systems	Achievements during 2009-10 (up to 31.12.2009)	Cumulative achievements (up to 31.12.2009)
I. Power From renewable			
A. Grid-interactive renewable power			
1.	Biomass power (Agro residues)	131.50 MW	834.50 MW
2.	Wind power	683.00 MW	10925.00 MW
3.	Small hydro power (up to 25 MW)	129.15 MW	2558.92 MW
4.	Cogeneration-bagasse	253.00 MW	1302.00 MW
5.	Waste to energy	4.72 MW	65.01 MW
6.	Solar power	3.10 MW	6.00 MW
	Subtotal (in MW) (A)	**1204.47 MW**	**15691.43 MW**
B. Off-Grid/distributed renewable power (including Captive/CHP Plants)			
7	Biomass power / cogen.(non-bagasse)	39.80 MW	210.57 MW
8.	Biomass gasifier	4.10 MWeq.	109.62 MWeq
9.	Waste-to- Energy	3.91 MWeq.	37.97 MWeq
10.	Solar PV power plants and street lights	0.086 MWp	2.39 MWp
11.	Aero-generators/hybrid systems	MW	0.89 MW
	Subtotal (B)	**47.876 MWeq**	**361.44 MWeq**
	Total (A + B)	**1252.346 MW**	**16052.87 MW**
II.	**Remote village electrification**	700 Villages & Hamlets	4997 villages / 1257 hamlets

Source: MNRE

India has an abundance of solar radiation, with the peninsula receiving more than 300 sunny days in a year. PV is progressively becoming more attractive, vis-a-vis other renewable sources of power, as its cost declines. The various factors leading to decline in cost includes setting up of large scale plants, integration across the value chain, declining cost of raw material, reducing material consumption and higher efficiency of modules.

Solar power as a solution to the Indian power scenario

Due to its proximity to the equator, India receives abundant sunlight throughout the year.

Solar PV solution has the potential to transform the lives of 450 million people, who rely on highly subsidized kerosene oil and other fuels, primarily to light up their homes. Renewable energy source is a practical solution to address the persistent demand-supply gap in the power industry.

The following features of solar power make it the most viable renewable source of energy for India:

- Solar energy is available in abundance
- Available across the country – unlike other renewable sources, which have geographical limitations
- Available throughout the year
- Decentralized / off-grid applications – addressing rural electrification issues
- Modularity and scalability

With the launching of JNNSM, the relevance and advantages will be brought in to a sharper focus to meet the energy demand in an elegant and clean way. The PV approach is particularly suited for the geographical and socio-economic features of this country having highly skewed energy distribution between urban and rural areas.

Special provisions under JNNSM are expected to accelerate the growth of PV industry and make India emerge brightly in the global PV scenario.

4

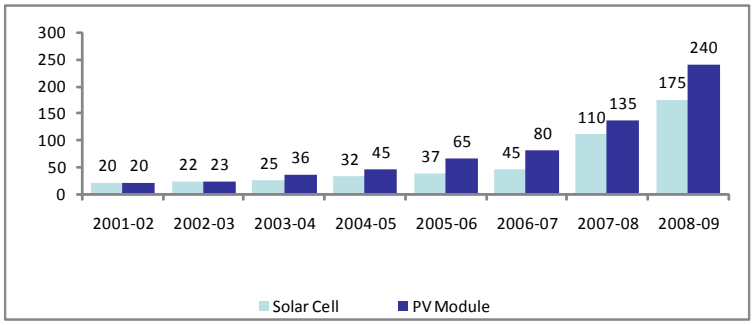
Overview of solar PV industry in India

Overview of solar PV industry in India

Solar cells and solar PV production

According to data obtained from MNRE, during 2008-09, 15 companies were actively engaged in the manufacture of solar cells and 20 companies in the manufacture of PV modules. In addition, about 50 companies were actively engaged in manufacturing a variety of PV systems. The overall production in the country during 2008-09 is estimated to be over 175 MWp of solar cells and 240 MWp of PV modules.

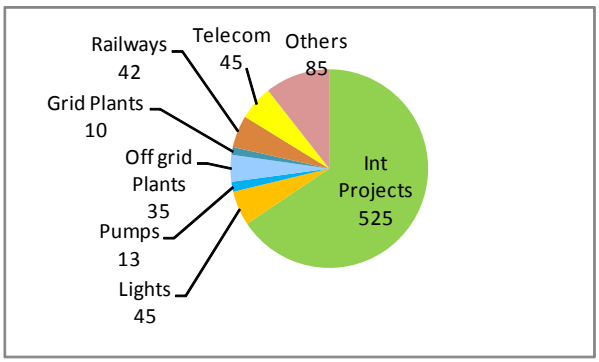
Graph 12: Trends in production of solar PV cells and modules in India



Source: MNRE presentation, Solar Energy Conclave, January 2010

Over the years, the cumulative production of solar PV in India has been about 800 MW. The split of the total production by application areas in represented in the graph below :

Graph 13: Cumulative production of solar PV in India, total 800 MW

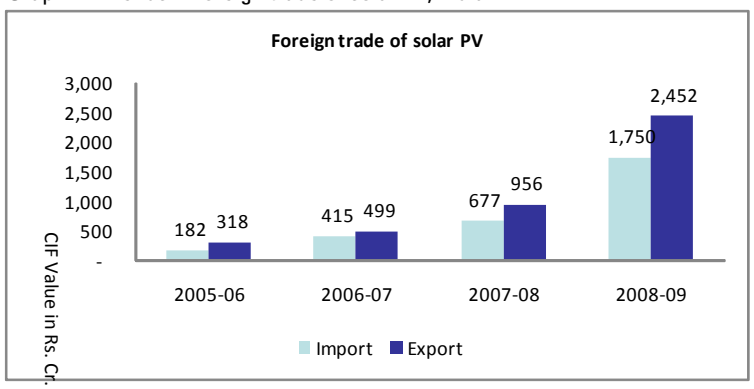


Source: MNRE presentation, Solar Energy Conclave, January 2010

Foreign trade of solar PV

India has always been a net exporter of solar PV technology, with about 66% of cumulative domestic PV production till 2009 catering to overseas markets. The graph below represents the year-wise export-import details of solar PV:

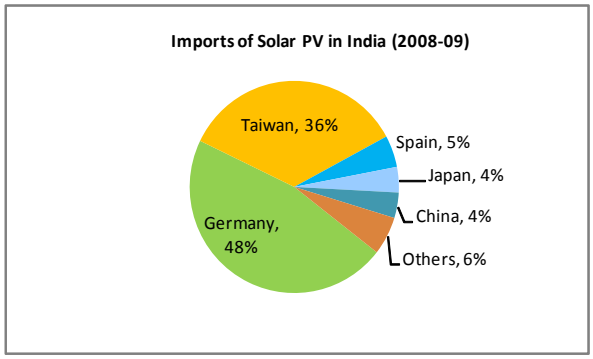
Graph 14: Trends in foreign trade of solar PV, India



Source: Ministry of Commerce, Trade under HS Code: 85414011

Germany is the most preferred source for solar PV imports, followed by Taiwan. During 2008-09, about 80% of the total solar PV imports were from Germany and Taiwan. The other countries for solar PV imports are Spain, China & Japan.

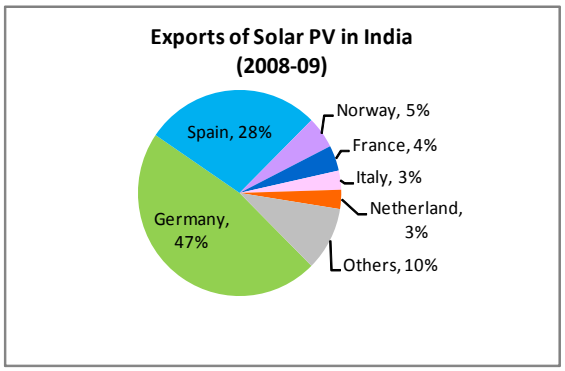
Graph 15: Imports of solar PV in India (2008-09)



Source: Ministry of Commerce, Trade under HS Code: 85414011

Germany and Spain are also the major export markets for Indian solar PV producers. During 2008-09, Germany and Spain accounted for about 82% of the total exports from India. Other export markets include Netherlands, Italy, Belgium and Afghanistan.

Graph 16: Exports of solar PV in India (2008-09)



Source: Ministry of Commerce, Trade under HS Code: 85414011

Solar PV applications in India

The range of applications for solar PV in India is very different from the global mix. Globally, grid connectivity accounts for nearly 75% of the installed capacity and off-grid lighting and consumer applications for the balance 25%.

Currently, PV installations in India, almost entirely consist of off-grid connectivity and small capacity applications, used mostly for public lighting, such as street lighting, traffic lighting, and domestic power back up in urban areas and small electrification systems and solar lanterns in the rural areas. In recent years, it is also being used for powering water pumps for farming and small industrial areas. Government organizations like railways, telecom and other agencies are the major consumers of PV solar systems in India.

The typical applications of solar PV systems are:

Product	Rating
Solar lanterns	2.5 – 5 Wp
Solar PV for individuals households	2 - 15 Wp
SPV blinkers	20 Wp
Solar home lighting system	18/37/74 Wp
Solar street lighting systems	74 Wp
Traffic signals	Up to 100 Wp
Solar power plants for villages	1-5 KWp

Source: MNRE

The installed base of solar PV systems in India as of December 2009 is given below:

Product	Installed base
Solar lanterns	7.67 lakh units
Home lighting systems	5.1 lakh units
SPV pumps	7,247 units
Solar water heating	3.25 mn sq mtr (collection area)
Solar cookers	6.72 lakh units
SPV Street Lighting	82,384 nos.

Source: MNRE

Solar PV technology

Nearly 90% of the solar modules manufactured in India, use crystalline silicon C-Si technology, while only 10% of the solar modules are manufactured using Thin Film or amorphous silicon technology. C-Si modules are more stable and produce higher power per unit area than Thin Film modules. Other technologies are not yet being commercially used in India. Organic technologies are still in the R&D stage.

The Governments of US and India signed a MoU in March 2009 to execute a 50-50 cost-shared 21-kW Thin-Film PV technology validation project to evaluate the performance of Thin-Film photovoltaic (PV) modules under Indian climatic conditions.

Technologies	Extent of commercialization	Market share	Stabilized efficiency	Raw material requirement	Long term stability (modules' warranty)	Remarks
C-Si (mono & multi)	Fully commercialized	Approx. 90% for the last few years	13-18% at commercial scale	10-12 gms silicon / Wp for thickness of 250 microns	20-25 years	Better power per unit area
Thin Film (a - Si)	Not as commercialized as C-Si	Approx. 10% for the last few years	6-9%	0.7-0.9 gms silicon / Wp	20-25 years	Relatively less power per unit area
New Emerging (Organic)	At R&D or pilot study stage		4-6%	Regular commercial production not stabilized	Yet to be established	Uses relatively cost effective material

Source: Industry sources

Given the size and the potential in India, the solar PV industry needs to work in co-ordination with research centers and universities to frame research plans. Efforts are being made to support R&D in new and renewable energy sectors.

Concentrated efforts on R&D towards efficiency enhancement and other production oriented developments to reduce the cost per watt of power generated by PV is a priority under the JNNSM.

Cost of power from solar PV in India

CERC recently estimated cost of power generation for solar PV plants to determine the tariff. For tariff determination, the capital cost of the plant is assumed at about Rs 17 Cr per MW (including cost of BoP, etc). The useful life of the plant is considered to be 25 years with capacity utilization factor of 19%. It is estimated that per MW about 1.66 million units of electricity will be produced in a year.

Based on CERC workings on determining tariff for solar plants for year 2009-10, the cost of power generation from a solar PV plant is about Rs 23.78 per kWh for first year of operation which is likely to reduce to Rs 14.74 per kWh by end of 10th operating year and to Rs 11 per kWh by 25th year of operation. The cost estimation is based on debt equity ratio of 70:30 for the project and with IRR of 19% for first 10 years. CERC tariff for year 2010-11 is under finalization. Currently, there are about 4 solar PV plants where CERC tariffs have been implemented. This includes the new plants inaugurated in states of Punjab, Karnataka and West Bengal.

Challenges facing the solar PV industry in India

The lack of domestic base for raw material, technology, skill set and poor demand are the key challenges for the growth and development of the solar PV industry.

There is no manufacturing base in India for the basic raw material - silicon wafers. The industry hence relies on international markets to source the raw material. The silicon market has been highly fluctuating in the past, leading to imbalance in demand-supply equation, fluctuating prices and availability of raw material. Currently, the silicon production capacity is much higher than the demand and prices are at significantly low levels compared to the scenario a year back. In the past, some of the solar PV firms have entered into rate contracts with silicon wafer suppliers to ensure availability. With a sudden reduction in prices, the contracts now prove to be a loss making proposition for these firms.

Low demand in international market due to the economic slowdown

On a cumulative basis till March 2009, India has exported about 65% of the production of solar cells in a year. Due to the economic slowdown, the off-takes from international clients have reduced, resulting in low capacity utilization by the Indian manufacturers. During the past few years, the demand from domestic market has been very low due to focus on smaller, low capacity application requirements.

Increasing competition from China and Taiwan

Over the last 5 years, China has emerged as the largest producer of solar cells in the world. The country currently has about 2,500 MW of production capacity for solar PV as compared to India's 400 MW. Apart from that, Taiwan, with annual capacity of 800 MW, is also emerging as a major threat to the Indian industry.

Low demand in the Indian industry

On a cumulative basis, domestic market sales account for less than 35% of overall sales of the manufacturers in India. The solar PV market is highly under developed with applications limited mainly to railways, telecom industry and defense. Some of the key reasons for the slow development of the domestic market are low commercialization levels of PV based generation, low awareness across end users and limited Government

initiatives before the year 2007-08 promoting solar PV applications.

Tax and duty structure

Taxes on local sales and duty free imports are creating price disparity between the Indian and international firms. This makes importing solar cells more economical for Indian module manufacturers, rather than buying from the Indian cell producers. The inverted duty structure imposes a duty of 12.8% on imports on inputs to manufacture cells / modules locally in India, while completely built modules attract nil duty. The import duty applicable on inverters is even higher, at about 21.5%.

The Indian industry is based on least "know-how" stage in entire value chain. The value addition in manufacture of solar products is low in India, which accordingly also affects the price realization.

Lack of infrastructure

The infrastructure in India lacks the support ecosystem required for solar PV manufacturing. Continuous power supply, water supply and utilities play a critical role for solar PV manufacturing. The industry needs special manufacturing zones where all the infrastructure requirements are met that promote solar PV production in India

Strengths of solar PV industry in India

Even though the industry operates at a smaller scale as compared to other solar PV producing nations, production in India is very cost effective as compared to global standards. The price competitiveness of Indian industry makes it a preferred vendor for end users in countries like Germany and Spain. This is despite the fact that India is importing all the raw material and offering only conversion services in India.

Availability of technical manpower is very critical for solar PV industry. The trend in the PV manufacturing sector is to go in for higher degrees of automation. However, plants are normally designed for three shift (24/7) operation calling for substantial requirement of trained manpower. Estimated direct manpower requirement for crystalline silicon technology is typically 90 technical persons for a plant of nominal capacity 50 MWp/year (wafers-to-modules) and for Thin Film technologies of similar capacity it is around 45 persons. India scores over other solar PV producing nations due to abundant availability of technical and skilled manpower.

With Government initiatives in place to support and develop infrastructure for solar PV production (refer to solar cities and SIPS scheme) and JNNSM to promote application of solar PV in domestic market, the Indian solar PV industry is likely to gain further edge over other solar PV producing nations.

5

Government initiatives to promote solar PV in India

Government initiatives to promote solar PV in India

Distributed / off-grid renewable power

Table 3: 11th Five-year plan summary

Programme Component	Physical target for 11th Plan (in MWe)	Proposed outlay for 11th Plan (in Rs. crore)
Wind/ hybrid power Small hydro power Bio power	950	1,900
Solar power (grid/ off-grid)	50	200
Total	1,000	2,100

Source: MNRE, Proposal for 11th Five Year Plan

The National Rural Electrification Policy, 2006

The policy aims at providing access to electricity to all households in the country and a minimum 'lifeline' level of consumption of 1 unit (KWh) per household per day. The policy also mentions that off-grid solar PV solutions may be deployed where the supply of grid electricity is infeasible.

MNRE is the key Government body engaged in driving the growth of solar industry and is also responsible for the implementation of JNNSM. The other Central Government ministries involved include - Ministry of Power (including CEA) and Ministry of Communications & Information Technology. The State Electricity Boards and respective agencies for renewable energy at the state level, play a key role in implementation at a state level.

IREDA is a public limited Government company established in 1987, under the administrative control of Ministry of New and Renewable Energy (MNRE), to promote, develop and extend financial assistance for renewable energy and energy efficiency/ conservation projects.

Semiconductor Policy (2007)

The Semiconductor Policy is meant to encourage semiconductor and ecosystem manufacturing, of which solar PV is also a component. It offers a capital subsidy of 20% for manufacturing plants in SEZs and 25% for manufacturing plants outside of SEZs. The subsidy is however, based on the condition that the NPV of the investment is at least US $ 212 mn (Rs 10,000 mn @ 1 US$ = Rs 47).

According to the latest update, the Government has received 15 applications, of which 12 have received in-principle approval. Further, 5 proposals have received financial closure exceeding threshold investment of Rs 1,000 Cr. The list of all 15 applications received by the Government is mentioned in Annexure 2 of this report.

Generation based incentive scheme

In January 2008, MNRE formed guidelines for generation based incentives for grid connected solar (both thermal and PV) plants. The scheme was extended to all existing registered companies, Central and State power generation companies and public/private sector PV power project developers. The scheme promoted grid connected power plants in excess of 1 MW of capacity at a single location. The scheme was limited to 5 MW per developer across India and a maximum of 10 MW per state.

Under this scheme, MNRE offered to provide, through IREDA, a generation-based incentive of a maximum of Rs. 12 per kWh to eligible projects, which are commissioned by December 31 2009, after taking into account the power purchase rate (per kWh) provided by the State Electricity Regulatory Commission or utility for that project.

Apart from the Central Government, several State Governments have also taken initiatives to promote solar energy.

State level initiatives

Andhra Pradesh

The State Government of Andhra Pradesh is developing a solar farm cluster called Solar City on a 10,000 acre land at Kadiri in Anantapur district. Solar City is expected to attract investments worth Rs. 3,000 crore in the first phase. Four firms (Sunborne, Lanco Solar, AES Solar and Titan Energy) have signed a memorandum of understanding with the State to set up their units there. These companies will be the anchor units in Solar City and have a combined capacity of 2,000 MW.

Karnataka

Karnataka Power Corporation Ltd., has implemented two projects – each of 3MWp capacity and has awarded a third project of same capacity recently. The solar plants, located in Kolar and Chikkodi districts, have been implemented under the Arunodaya scheme for ensuring assured power supply to rural areas, especially irrigation pumpsets. These PV power plants are intended as tail end support / powering of irrigation pumps.

Gujarat

The State policy aims at promoting the generation of clean and green power in the state using solar power and wastelands, thereby engendering socio-economic transfer. Other objectives of the policy are promoting R&D and facilitating technology transfer, creating environmental awareness and favorable policies that encourage investment, promoting employment generation and skill enhancement of the local youth.

The Government incentives and schemes can be availed by any private organization, provided certain project criteria are met. The incentives would be offered to projects commissioned before March 2014. The State Government earlier fixed a target of cumulative capacity of 500 MW in the state, which was recently increased to 716 MW. At a project level, minimum capacity of the plant to avail incentives should be 5 MW for PV as well as solar thermal. It is proposed to charge 2 per cent of unit cost against wheeling of power, though the electricity duty is exempted. The incentive will be provided to solar power generators for a span of 25 years.

Assistance from Gujarat Energy Development uthority (GEDA)

- Identification of suitable locations for solar projects and preparation of land bank and the requirement of creation/ upgrading of connecting infrastructure to the project site i.e., roads etc.
- Facilitation in arranging Right of Way, water supply and in obtaining clearances and approvals, which are under the purview of the State Government
- Recommending the project (subject to qualification) to avail benefits under any policy declared, or to be declared by the Government of India
- Promoting research and development activities for cost effective, sustainable and environment friendly technologies, in collaboration with internationally and nationally reputed institutions
- Engaging the services of national/ global experts/ consultants for the research and development of solar and other renewable technologies
- Carrying out awareness campaigns on energy conservation and usage of renewable sources of energy at all levels i.e., village, taluk, district, etc., through schools, colleges, educational institutions, community centers and civil society organizations
- Along with project developers, develop appropriate manpower skills by tying up with training or educational institutions through Public Private Partnerships (PPP).

Table 4: Feed-in tariff offered by GEDA

Sl. No	Particulars	Tariff for PV projects (Rs / kWh)	Tariff for thermal projects (Rs / kWh)
1	Projects commissioned before 31.12.2010	13.00 (for first 12 years) 3.00 (from 13th to 25th year)	10.00 (for first 12 years) 3.00 (from 13th to 25th year)
2	Projects commissioned before 31.03.2014	12.00 (for first 12 years) 3.00 (from 13th to 25th year)	9.00 (for first 12 years) 3.00 (from 13th to 25th year)

Source: GEDA

Overall, about 716 MW of capacity was allotted to 34 national and international developers. This includes 24 projects in solar PV with cumulative capacity of 365 MW and 10 projects in solar thermal with cumulative capacity of 351 MW. For solar PV, the capacity of solar PV varies from 5 MW (7 projects with 5 MW) to 40 MW (developer – PLG power Ltd, Nasik).

Haryana

The Haryana Government has signed 6 MoUs with private players to set up solar PV power plants in the state, the details of which are given below:

Table 5: List and status of solar PV plants application in Haryana

Sl. No	Name of the IPP	Proposed capacity	Status
1	Azure Power India, New Delhi	2 MW	DPR under preparation
2	RS India Wind Energy Pvt. Ltd., New Delhi	3 MW	-do-
3	Epuron Renewable Energy Pvt. Ltd., New Delhi	2 MW	-do-
4.	Astonfield Renewable Resources Pvt. Ltd., Kolkata	3 MW	-do-
5	Selecto Systems Pvt. Ltd., Faridabad	1 MW	-do-
6.	Omax Autos Ltd., Gurgaon 122001	1 MW	-do-
	Total	**12 MW**	

Source: HAREDA

Rajasthan

The Rajasthan State Government has announced 3 schemes to promote solar energy applications in the state. Under the Remote Electrification Scheme, domestic lighting systems are distributed to remote villages under MNRE's scheme. MNRE will provide 90% of the benchmark cost (Rs 12500 per DLS) i.e. Rs. 11,250, where the Operation & Maintenance cost for 5 years is also included in the benchmark cost. The balance 10% cost is to be borne by the State Government (Rs 3335) and beneficiary (Rs 1500) against the total cost of Rs 16,085.

The Rajasthan Rural Electrification Program (RREP) aims at the distribution of street lighting systems, domestic lighting systems in the remote areas and ensures financial assistance from the State Government, Government of India and MNRE. RREP provides SPV pumping systems with financial support to beneficiaries under the program of MNRE, Government of India.

Subsidy support under the SPV Water Pumping Programme of MNRE, Government of India at Rs. 30 per watt of SPV module capacity, subject to a maximum of Rs. 50,000 per pumping system, is being provided by MNRE under SPV Pump Programme 2007-08.

6

Jawaharlal Nehru National Solar Mission (JNNSM)

Jawaharlal Nehru National Solar Mission

Background and objectives

The National Solar Mission program was initiated by the Government as one of the 8 programs under the National Action Plan for Climate Change by the Prime Minister of India in 2008. In the month of November 2009, the Mission document was released as Jawaharlal Nehru National Solar Mission (JNNSM) and the Mission was formally launched by the Prime Minister on January 11 2010.

The JNNSM is neutral to solar technologies and has provision for the development of all viable technologies. Apart from solar PV (crystalline and Thin Film), the already existing technology in India, JNNSM has the provision to develop solar thermal technology for large scale grid connected power plants.

The document emphasizes on the development of grid-connected applications, by offering feed-in tariffs for the power producers. The feed-in tariff is proposed to be extended to 25 years from the earlier duration of 10 years under the GBI Scheme. Some new applications highlighted in the JNNSM includes power computers to assist learning in schools and hostels; Management Information System (MIS) for better management of forests; powering milk chilling plants in Gujarat; empowering women Self Help Groups (SHGs) involved in tussar reeling in Jharkhand and cold chain management for Primary Health Centers (PHCs).

JNNSM introduces Renewable Purchase Obligation to ensure business viability of grid connected solar power plants. Growth enablers for the domestic solar PV industry include zero import duty for capital equipment, raw material and excise duty exemption, low interest rates, incentives under SIPS, solar manufacturing tech-parks, etc. The policy also lays emphasis on R&D strategy across 5 categories as mentioned earlier under section 1.5.

Realizing the growing demand for skilled manpower for solar applications, JNNSM has drawn out a roadmap for manpower development at every level with specialized courses on solar power – engineering colleges, ITI and a short term training module for technicians, in association with the Ministry of Labour and Employment.

An autonomous Solar Energy Authority will be established to implement the National Solar Mission. This would include a Mission Steering Group to approve projects and a Mission Executive Committee to monitor implementation of National Solar Mission. The JNNSM proposes setting up of the following institutional framework for implementation of the Mission:

a. Autonomous Solar Energy Authority and/or an autonomous and enabled Solar Mission, embedded within the existing structure of the Ministry of New and Renewable Energy

i. Monitor technology developments

ii. Review and adjust incentives

iii. Manage funding requirements

iv. Execute pilot projects

b. Mission Steering Group, chaired by the Minister for New and Renewable Energy and consisting of representatives from all relevant Ministries and other stakeholders

i. Approve various schemes/ projects/ policies and the related financial norms for all schemes covered under the National Solar Mission (JNNSM)

c. Mission Executive Committee, chaired by Secretary, Ministry of New and Renewable Energy, will periodically review the progress of implementation of the projects approved by the Mission Steering Group.

i. Solar Research Council

Development in post JNNSM scenario

Post the JNNSM launch, on December 3 2009, CERC launched the first set of generic tariff for projects to be launched in FY 2009-10. For solar power, the tariff period has been specified for 25 years. The normative capital cost for solar PV projects has been defined as Rs 17 Cr/MW. CERC has determined generic tariff of Rs 18.44 per kWh for solar PV for projects commissioned in FY 2009-10. CERC is in the process of finalizing the tariff for FY 2010-11.

On December 9 2009, 1.2 MW grid connected solar thermal plant was inaugurated in West Bengal. The developer has signed a power purchase agreement @ Rs 5 / kWh from state utility. In addition, it is also entitled to GBI @ Rs 10 per kWh from MNRE. Another plant, the first 2 MW grid connected solar PV plant was inaugurated in Punjab on December 15 2009.

Two projects of 3 MWp each have also been commissioned in the state of Karnataka. The solar plants, located in Kolar and Chikkodi districts, have been implemented under the Arunodaya scheme for ensuring assured power supply to rural areas, especially irrigation pump sets.

The Haryana Renewable Energy Development Agency (HAREDA) recently launched "Solar Rooftop Scheme" to motivate commercial and industrial establishments like hotels, hospitals and housing complexes to replace DG sets installed for captive requirement during load shedding. Under this scheme, HAREDA approved 2 standalone solar PV projects of 100 kW each in Gurgaon to demonstrate application of solar PV for industry power back-up. The State Government has agreed to offer financial assistance of Rs 75 lakh for each project.

7

Emerging trends in Indian solar PV industry

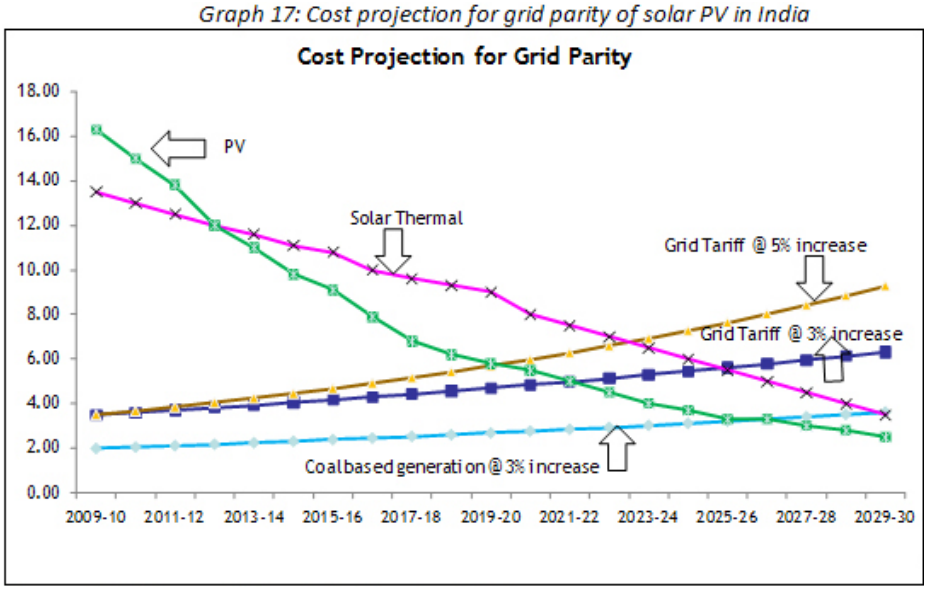
Emerging trends in Indian solar PV industry

Emerging trends in Indian solar PV industry

JNNSM addresses all the major issues currently faced by the industry and also acknowledges the key challenges in achieving the Mission objective. Grid connected solar power generation is a key thrust area of the JNNSM. The appointment of NVVM to implement RPO and execute PPAs is a major step to boost domestic demand. For PPA, the proposal to extend the duration to 25 years will improve the financial feasibility for the projects / entrepreneurs.

It is projected based the trend of reducing cost of Solar PV that the solar PV based power will achieve grid parity in year 2019-20 (refer to graph below) and will be comparable to coal based power generation cost by year 2025-26.

Graph 17: Cost projection for grid parity of solar PV in India



Source: MNRE presentation, Solar Conclave 2010

Under JNNSM's approach, a roadmap for technologies to achieve target of 20,000 MW capacity by 2022, would be drafted post 2012. The first phase (up to 2013) will involve experimenting with all technologies and applications before deciding on subsequent steps. The JNNSM is neutral to technology and the roadmap defined for research & development and targets to develop knowledge on technology, thereby reducing dependence on international markets.

The existing Government polices offer incentives for production (SIPS), generation (GBI, PPA & feed-in tariff) and usage (capital subsidy for certain products) of solar PV technology. The private sector has lined up investments to increase module & cell capacity as well as to set-up solar power plants. With 5 projects for polysilicon planned under SIPS, the solar PV value chain in India will expand to raw material as well. Polysilicon manufacturing capacity will add further strength to Indian solar PV industry. Though polysilicon production infrastructure is a prerequisite for growth of C-Si, the sourcing of technology for the same will be a key issue of concern in this direction.

Tax rebates and capital subsidy offered through SIPS enables Indian companies to operate on a level playing field with international counterparts, especially China. Growth of domestic industry will be very critical for success of JNNSM. Initiatives in direction to gradually increase sourcing from domestic sources will help industry achieve production scales which will further rationalize cost. Lower costs will boost exports of solar PV from India and will generate higher manpower demand, which is in line with the JNNSM objectives.

Addressing issues related to manpower, JNNSM proposes the participation of premier institutes like IIT, Ministry of HRD and Ministry of Labor in the development of skilled manpower across various levels.

For solar PV, household lighting in villages covered under REC, border areas, railway signaling in remote areas, irrigation pumps, street lighting systems and powering telecom towers will be the key application areas, besides the grid connected power supply. There is a need to organize this industry and regulate the quality standards.

Annexure:

Annexure 1: Prevailing tariffs for solar power across states in India

State / Agency	Order dated	Tariff period	Counter period	Tariff (Rs/kWh)
Chhattisgarh	08.09.2008	Levelised for 10 years	08.09.2008 to 31.8.2018	Applicable for plants commissioned up to 31.12.2010 Tariff – Rs 15.84 per kWh Incentives to developer / licensees – Rs 3.84 per kWh
Gujarat	Draft order – 23.07.2009	Levelised for 25 years		1-12 years of operation – Rs 14.0 per kWh 13-25 years of operation – Rs 4.0 per kWh
Haryana	25.04.2008		2008 – 09 to 2012 – 13	Applicable tariff for Solar PV plants only commissioned up to i) 31.12.2009 – Rs.15.96 / unit ii) 31.12.2010 – Rs.15.16 / unit Generation based incentive from State Government for plants commissioned up to i) 31.12.2009 – Rs.12.00 / unit ii) 31.12.2010 – Rs.11.40 / unit Only net rate after deducting Incentive amount shall be payable by Discoms. Tariff to remain constant for a period of 5 years
Kerala	Draft Regulations, 2008 – 27.08.2008	Levelised tariff for 10 years		Tariff – Rs.15.18 / kWh Developer to provide energy to the Discom @ Rs.3.18 / kWh (for 10 years) & collect incentive @ Rs.12 / kWh from IREDA
Maharashtra	8.5.2009	10 years		Applicable for plants commissioned up to 31.03.2010 and under Generation Based Incentive scheme

Source: - Compendium of Regulations and Tariff Orders, Central Board of Irrigation & Power, India

State / Agency	Order dated	Tariff period	Counter period	Tariff (Rs/kWh)
				Tariff under GBI scheme – Rs 3 per kWh Maximum incentive to the project developer – Rs 12 per kWh
Rajasthan	Regulations, 2009 – 23.01.2009	10 years		Total tariff inclusive of generation incentive: COD up to 31.12.09 15.78 31.12.10 15.18 Applicable for ten years only but PPA can be executed for life of plant
Tamil Nadu	11.07.2008	10 years		Rate for procurement of power by DISCOM: COD upto 31.12.09 3.15 Max. incentive of Rs.12 / kWh is admissible for COD up to 31.12.2009
Uttar Pradesh	Draft Regulation – 09.09.2009	20 years	5 years	i) For plants covered under MNRE scheme and commissioned up to 31.12.2009, Max. incentive – Rs 12 per kWh Projects commissioned after 31.12.2009 – Rs 11.40 per kWh ii) For plants NOT covered under GOI incentive scheme – Rs 15 per kWh
Uttarakhand	Draft Regulation, 2009 – 30.12.2009	20 years	2009 – 10 to 2012 - 13	For plants commissioned up to 31.03.2010: Rs 17 per kWh

Source: - Compendium of Regulations and Tariff Orders, Central Board of Irrigation & Power, India

Annexure 2: Status of applications related to solar PV manufacturing received under the Semiconductor Policy 2007 (as on December 2009)

S. No.	Name of the applicant	Investment		Items of manufacture
		In Rs. Cr	In US$ mn	
1	M/s PV Technologies India Ltd.	6,000	1,500	Solar PV
2	M/s Titan Energy System Ltd.	5,881	1,470	Solar PV and Polysilicon
3	M/s KSK Surya Photovoltaic Ventures Pvt. Ltd.	3,211	803	Solar PV
4	M/s Signet Solar Inc.	9,672	2,418	Solar PV
5	M/s Reliance Industries Ltd.	11,631	2,908	Solar PV and Polysilicon
6	M/s Phoenix Solar India Ltd.	1,200	300	Solar PV
7	M/s Tata BP SOLAR India Ltd.	1,693	423	Solar PV
8	M/s Solar Semiconductor Pvt. Ltd.	11,821	2,955	Solar PV
9	M/s TF Solar Power Pvt. Ltd.	2,348	587	Solar PV
10	M/s Lanco Solar Pvt. Ltd.	12,938	3,235	Solar PV and Polysilicon
11	M/s EPV Solar India Pvt. Ltd.	4,278	1,069	Solar PV
12	M/s Bhaskar Silicon Pvt. Ltd.	5,900	1,475	Solar PV and Polysilicon
13	M/s Vavasi Telegence Pvt. Ltd.	39,000	9,750	Solar PV and Polysilicon
14	M/s EMCO Energy Ltd.	9,902	2,476	Solar PV
15	M/s OptiSolar Inc.	5,424	1,356	Solar PV
Total		**130,899**	**32,725**	

Source: DIT, MCIT /Office of the Principal Scientific Adviser to the Government of India

List of graphs

Notes

Notes

India Semiconductor Association
UNI Building, Millers Tank Bund Road
Bangalore - 560052 India
Phone: +91 80 4147 3250 Facsimile: +91 80 4122 1866
E-mail: research@isaonline.org

www.isaonline.org