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Some aspects of Solar energy and its supply chain in India's Energy Security

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Abstract: In this paper the authors have discussed salient features of solar energy and its supply chain in Indian context. Recommendations are made for India's energy security which will benefit the whole nation in short term as well as in long term.

Keywords: India, Solar energy, supply chain, photovoltaic power.

I. INTRODUCTION

Solar Energy will have an important role to play in meeting India's energy security needs in the coming years. The growing energy needs of India and the focus on clean energy has created unique opportunities for the solar energy sector in India. India presents a huge market for the growth and penetration of solar energy.

Authors believe the creation of a strong and secure supply chain in India for thesolar sector which will enable creation of jobs, reduce foreign exchange outflow and lead to increase in investments and sustainable growth of the sector in the long run. There is a strong need to incentivize investments in creating the domestic supply chain with help from both domestic and global players, and to facilitate collaborative arrangements towardsenhancing research and development efforts. There is also a strong case for international companies with extensive technology and experience globally to participate in building a strong supply chain in India and be part of India's solar growth story.

We have discussed certain aspects of solar energy and its supply chain.India has become a big market for the growth of solar energy. Based on unconfirmed information central government has planned a target of 15GW of Solar energy until 2019 in three phases.To meet this demand it is important to find the requirements at various levels of supply chain and to secure a high quality and cost effective supply chain for the Indian solar Industry. Otherwise it will put tremendous pressure on foreign exchange outflow and loss of employment opportunities in India.

II. Types of solar PV technologies

Photovoltaic (PV) power is generated primarily based on two technologies, crystalline silicon (C-Si) and thin film (Thin-Film). Traditionally, C-Si has been used for bulk power generation, while various kinds of Thin-Film based bulk power generation capacities are relatively new. The category of C-Si can be further sub-divided into mono and polycrystalline, based on the crystal structure of the silicon used in power generation. The various Thin-Film technologies currently in the market are amorphous silicon (A-Si),cadmium sulphide-cadmium telluride (CdS/CdTe), Copper Indium Gallium Selenide (CIGS), etc. Apart from these, there are a number of new technologies, at various stages of development, still to reach bulk production stages. For off-grid rural electrification, photovoltaics is the most important technology. In India photovoltaics would be a great choice for electric power and economic development in remote rural areas.The main advantage of PV over other clean energy technologies is its virtually inexhaustible source of power i.e.,the sun.PV converts solar radiation directly into electricity.The geographical location of India enables it to harness solar energy because of high daily insolation and the low seasonal variation of solar radiation.The solar potential is greatest during the summer months of April to July. Conversely, the months with the weakest sunlight or between last week of December to middle of February and that to very limited places in India.

In addition, PV systems are modular and can be employed for both small and large-scale energy generation. Long lifetime, low maintenance cost, high reliability and zero fuel requirement of PV modules have made the technology a viable and cost effective option for remote site application where the cost of grid extension and maintenance of conventional power supply systems are often prohibitive.While PV technology is already considered commercial, cost remain high as the Industry struggles to make its transition from R &D level production to large-scale manufacturing. Nonetheless, the interest on PV has not waned; worldwide research and development on the technology have been sustained much of the work on PV is focused on increasing the efficiency and stability of different PV cell technologies and on reducing manufacturing cost.The development of PV cell technology have increased the attractiveness for rural electrification. Table 1 shows PV installations as on 31st March 2014 in different states under various schemes.

It is clear from the table that the growth of Solar power plants in India is mainly concentrated in the states of Gujarat and Rajasthan primarily because of the following reasons.

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1. Availability of large continuous piece of land at low cost.
2. Highest solar insolation in these states at 5.5 to 6 Kwh/sq-meter/day,which results in higher PV Power generation and consequently higher returns.
3. Overall attractiveness of the Gujarat solar power policy

Table-1

S.N.	State	PV installation (MW)
1.	Gujarat	920
2.	Rajasthan	736
3.	Madhya Pradesh	347
4.	Maharashtra	274
5.	Andhra Pradesh	142
6.	Odisha	32
7.	Uttar Pradesh	21
8.	Jharkhand	16
9.	Haryana	10
10.	Tamilnadu	92
11.	Karnataka	42
12.	Others	42

Geographical distribution of installation of new PV power plants continues to have a strongcorrelation with the incentives offered by the respective Governments through favourable taxbenefits, feed in tariffs (FIT), cheap financing, etc. Historically, European countries like Germany, Italy, Spain, etc have enjoyed favourable solar PV programmes, which resulted in a majority of the installations being located in these regions (refer Table 2). Although such support schemes in some of the European countries have been sizeably reduced, emerging countries, particularly from Asia, are coming up with new solar support schemes that are expected to support the PV market going forward. Additionally reduction in FIT in the Asian countries has beenmore or less in tandem with the drop in PV module prices, resulting in market conditions continuing to remain favourable, which supported new installations. In line with this for development of solar energy central government of India is giving financial help to the extent of 30% of the total cost of project or 20 lakhs per MW whichever is less.

Table-2

SS.N	**Name of Countries**	**Country wise distribution of PV Installations (%)**
1	Germany	26
2	Italy	13
3	China	12
4	Japan	10
5	USA	8
6	France	4
7	Australia	4
8	Spain	4
9	Belgium	3
10	Czech Republic	2
11	Others	14

In Figure.1 Solar supply chain framework is shown.The supply of raw materials is important for any Industry, it not only enhances the production process but rationalises inventory of raw materials and thus decreases overall product cost. Currently India's manufacturing base comprises mainly module manufacturing and PV cell with 1800 MW of solar modules and 1100 MW of solar cells with very limited and desperate assembly capacities and fabrication for solar thermal products and accessories. Indian solar industries has been mostly dependent on imports of critical raw material such as reflective glass,balance of system(BOS) for solar thermal,EVA back-sheet, PV and core machinary.As far as PV industries are concerned,It has exported major parts of its finished products to western markets Therefore there is a lot of scope for development of domestic production base for some of the important inputs to get and strengthen the supply chain to create direct and indirect long term employment and reduce the foreign exchange outflow.

The important elements in the solar energy supply chain consists of solar photovoltaic module, manufacturing of solar thermal system, raw material, component of solar PV module, balance of system which includes connecting wires, trackers, inverters and the integration of the different system. It is important to integrate with proper specifications and compatibility the different equipment's and components otherwise slight variation will result in loss of final output.

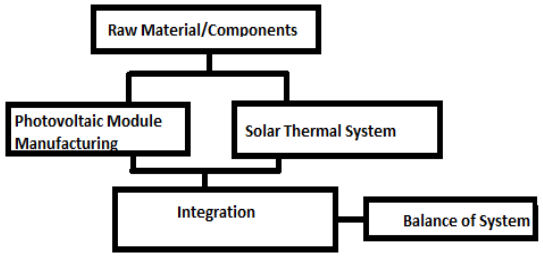

Fig1: Solar Supply chain Framework

Vital Issues

The change in global economic scenario has created demand -supply unevenness on many domestic manufacturers operating at a suboptimal capacity or having closed their production facilities giving opportunities for global manufacturers to operate in Indian market.

These needs to be addressed in deciding local supply chain model.With the announcement of many benefits by Indian governments,foreign players have diverted their resources to India to take advantage of new solar market.Foriegn manufacturers should be encouraged to take advantage of "Make In India" policy of government.

With the appropriate policy we can link foreign entrepreneurs with the Indian manufacturers thereby establishing a strong base for Indian Solar Industry. Following issues need to be addressed in Indian context as mentioned in Table 3.

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S. N	1	2	3
A	Quality Infrastructure(esp. Power)	Development of solar specific SME suppliers	Training and Development Infrastructure
B	Raw material supply	Access to effective sourcing alternatives	Network of system Integrators
C	Manufacturing Knowhow		
D	Technology Sourcing and Development		
E	Availability of machinery and equipment		
F	Trained Manpower		
G	Strong focus on Research and Development		
H	Correct Standards		

Table 3

III. RECOMMENDATIONS

Some of the following things need to be done for India's energy security.

1. Main Focus on Renewable energy generation especially solar and wind.
2. Smart grid which can connect renewable energy source faster when it is available otherwise it should connect energy produced by conventional means.

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