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China's Growth in Residential Solar PV- A Booster for India

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I. Introduction

India ranks thesecond-largest market in solar deployment after China.It has accounted for highest capacity addition since 2017to the Indian electricity grid. All this was possible only after India decided to be called as 'Suryaputra' and entered into the International Solar Alliance heading 122 countries of the world and also presently adding the UN members. Having launched the Jawaharlal Nehru National Solar Mission in 2010, it has established itself as a global leader in solar energy, promoting ecologically sustainable green, clean energy and addressing India's security challenges. Its short-term objectives are to create an enabling environment for the penetration of solar technology throughout the country. The mission's layer is revised fivefold from its initial target of 20 GW to 100 GW to achieve in three phases – 1st phase 2010 – 2013, 2nd phase 2013 – 2017 & 3rd phase 2018 –2022.

The increased use of solar energy is outgrowing fossil fuels throughout the world as can be seen from Exhibit 1.

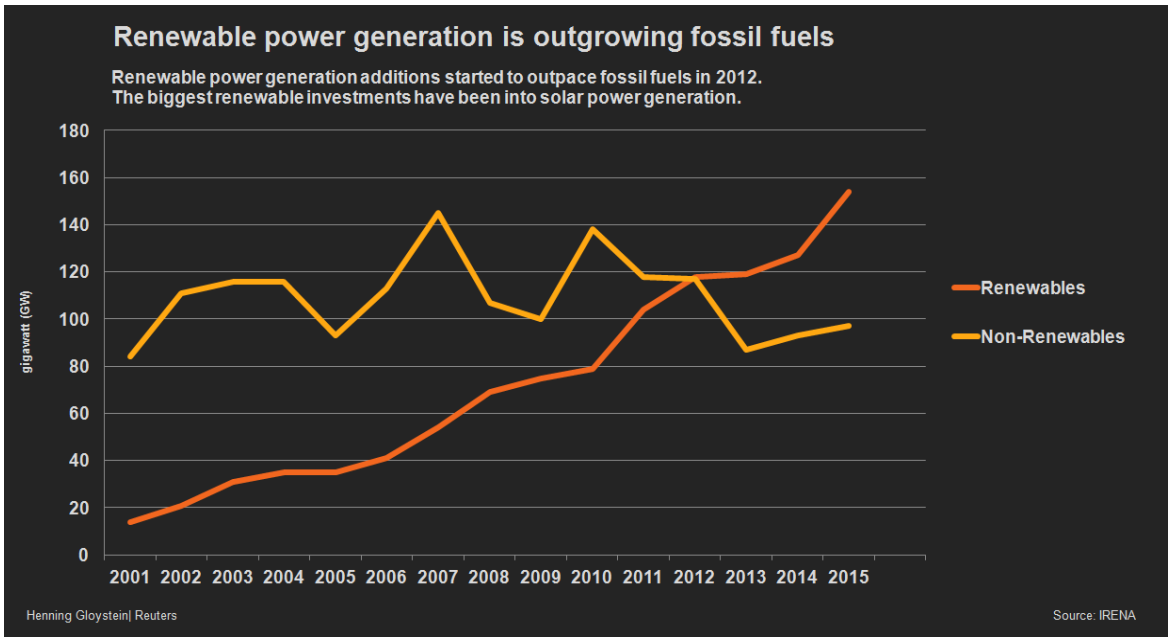

Exhibit 1: Renewable Power Generation Vis a Vis Fossil Fuels

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India's 300 million or a quarter of the population have no access to power, so RSTPV can be the best alternative if effectively harnessed.

a) Solar PV Concept

Photo voltaic effect: Scientists at Bell Telephone discovered in 1954, that silicon created an electric charge when exposed to sunlight. Initially, solar cells came to power space satellites and smaller items like calculators and watches. A single PV cell produces 1-2 watts of power connected in chains to form modular panels and severally connected to form arrays, one or more of these are connected to the electrical grid as part of a complete PV system. Thus, a modular scheme PV system can be built to meet any electricity need.

PV technology: The common materials used in PV technology are monocrystalline, polycrystalline, amorphous silicon, cadmium methionine, and copper indium gallium selenide. Each type of material has different attributes resulting in different effectiveness and efficiencies. In general, the efficiency of solar PV varies, ranging between 6 – 18 %at an average. A glimpse of this is seen in Exhibit 2.

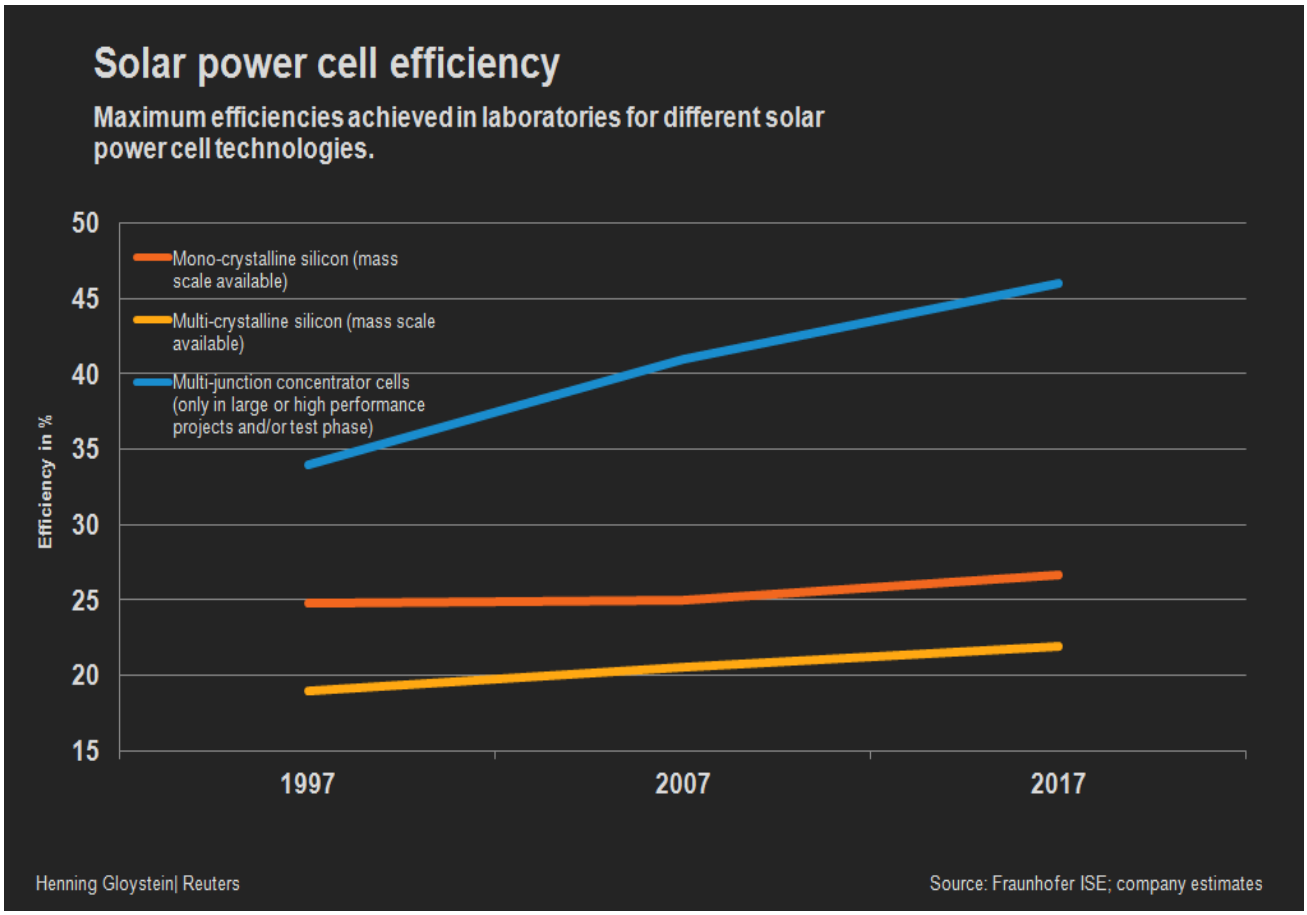

Exhibit 2: Solar Cell Efficiency

b) RSRTPV System Cost and Area Requirement

	Module cost	Installed cost	Efficiency	Levelized cost of Electricity 2010-USD/kWh
Residential C-Si PV system	1.02-1.24	3.8-5.8	14	.25-0.65
C-Si PV system With battery storage	1.02-1.24	5.0-6.0	14	.36-0.71

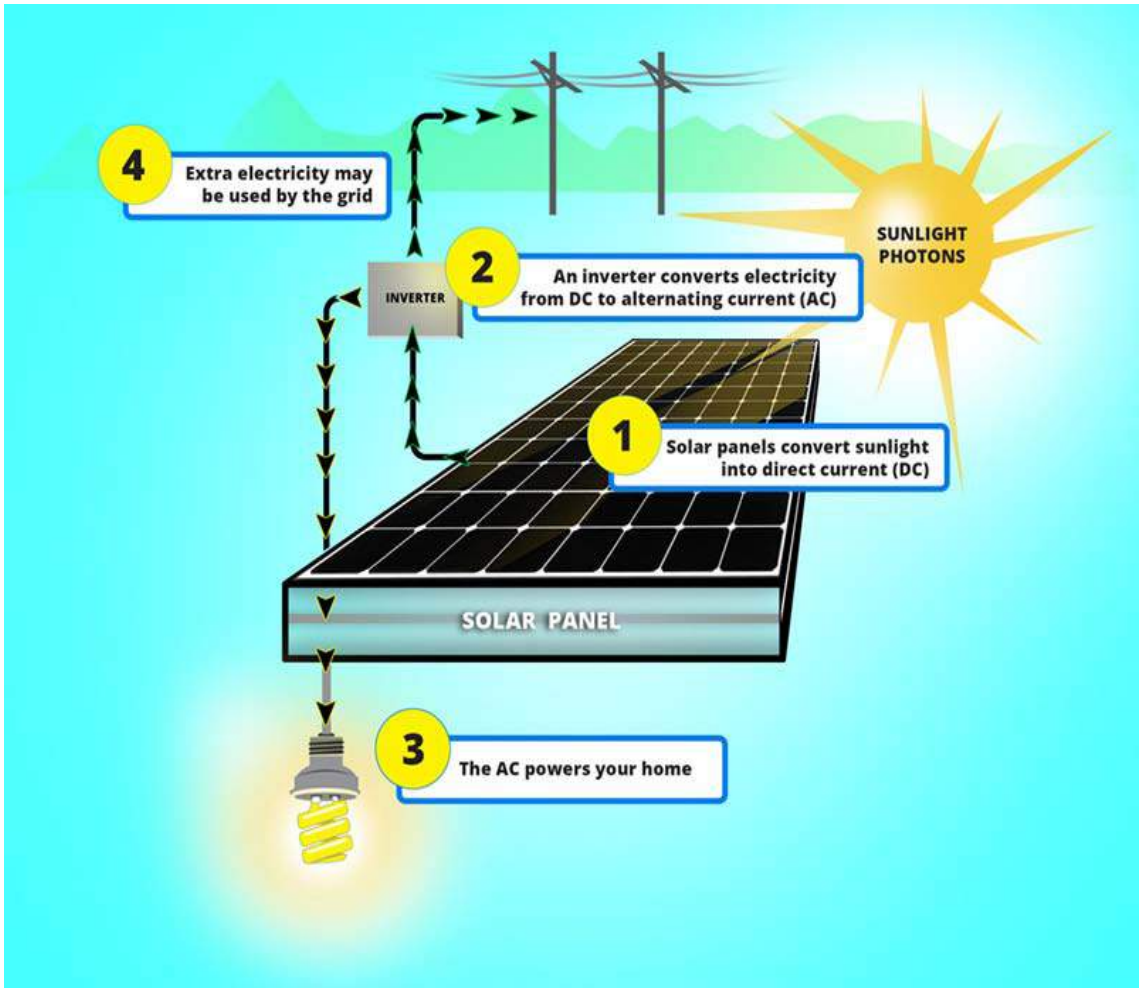

Exhibit 3: Solar Panel

Indicators of cost of RSRTPV:

- Equipment cost (Factory gate/FOB-free on board, and delivered at site CIF-cost, insurance, and freight.)
- Total installed project cost, including fixed financing cost.
- Levelized cost of electricity.

c) *RSRTPV Advantages*

- The potential of residential solar rooftops PV is not yet fully developed in India though RSRTPV is a mature technology.
- They can be set out on the rooftops in varying capacities from a few watts to several megawatts. Maximum 20 KW when the load is less, the power to surplus and this surplus power is sent to the grid, and in case of more power requirement, the same is drawn there from.
- The distribution network already exists, and no new connection is required.
- The cost of RSRTPV is within the limits of many residential owners as the space for mounting structures already exists, and no additional land is required.
- As power generated is used at the same place, the involvement of transmission and distribution is very much less and the excess generated can be fed into the system of utility selling electricity not required in day hours and purchasing when needed.
- An arrangement is made for backups/storage when utility supply fails.
- RSRTPVs generate clean, cost-effective power whenever the sun shines, require no water and fossil fuels for the production of electricity, and help develop entrepreneurship, and employment besides involving public participation, and creation of a large number of jobs.
- Moreover, they have no emissions, no moving parts, no noise.
- The PV module panels are high temperature resistant with long service life, 100% recyclable having a higher yield being P1D free with anti-soiling, anti-reflux, and sand storm-resistant characteristics.
- The residential owner becomes conscious of the generation and consumption of electricity.
- Residential Solar Roof Top PV, being green power, it is cheaper than grid power by 10-25%and even up

to 30-40%. taking into account the AT&CL losses (Aggregate Technical and Commercial Losses).

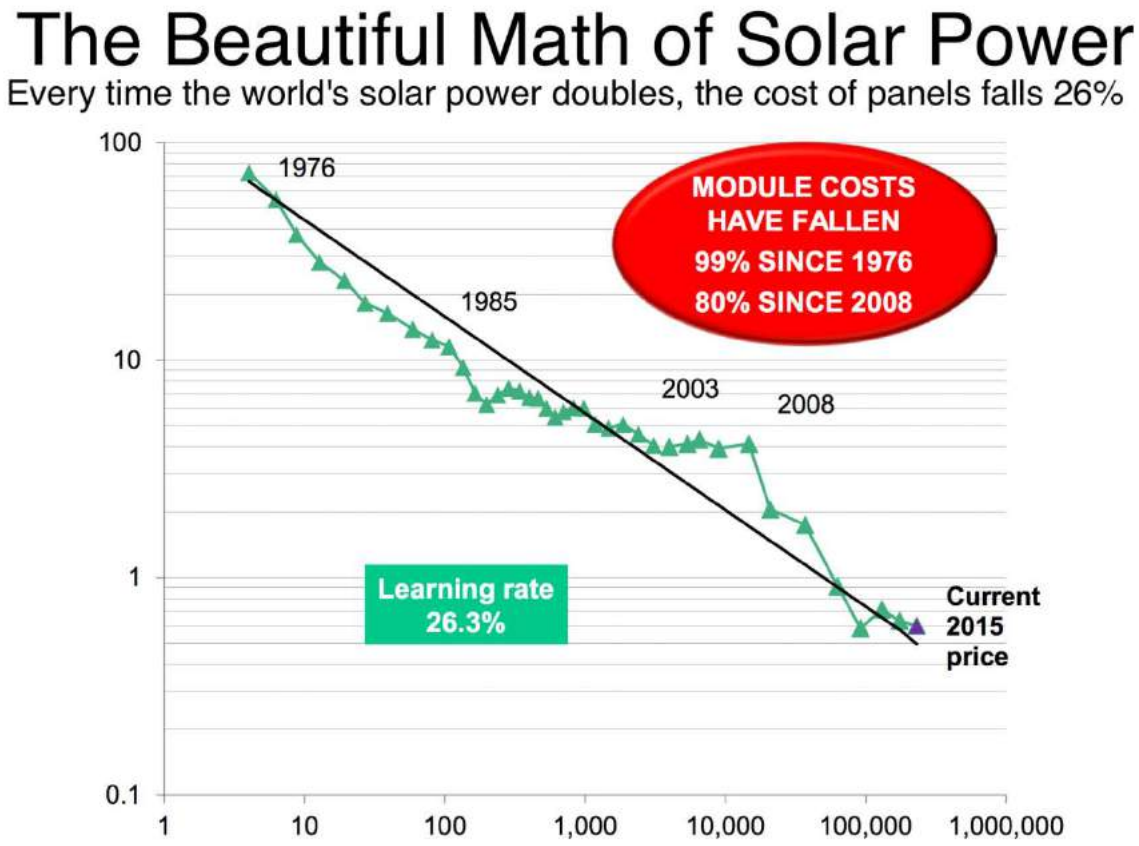

Exhibit 4: Cost of Solar Panels

II. Literature Review

A. M. Barnett, (1996) research work discussed at length about solar electric power for a better tomorrow and that this user-friendly energy is used when components and system costs reduce, as the size of the PV market is price elastic. New solar cell development, product improvement, increased current, process improvement, improved electrical contact system, and improved performance can reduce the cost of PV.

Y. Zhao, (2001) analyses the present status and future of PV in China and shows that the government supports the PV market initiative. PV in China is playing a significant role in improving people's living conditions and will make more contribution to sustainable development in the next century.

Marigo & Candelise (2013) have explored the reasons for the reduction in PV prices in China. The development of a local free market is more successful. Production capacity expansion is a strategic tool to reduce costs and gain market share. A fair industrial policy boosted by credit availability is a driver in the growth of the Chinese PV sector and competitiveness.

H. Carwell (2013), in his research on the future uncertainties of the PV market, and examining the opportunities for new, has explored the Chinese PV market, observing that China had less than 1% of the solar panel manufacturing market in 2001, and now it has 62% of it. China's focus on solar panel products at significantly reduced costs, allowed it to lead the market. Germany and China were less impacted by the crisis, and gained an edge. China used its financial advantage as the second-largest world economy to rapidly expand its manufacturing capability. Solar is seen as one of the biggest industries and it exports 99% of its products. Five out of the four hundred manufacturers are among the top ten in the world. China manufactures 62% of the world's PV modules. Chinese panels are the cheapest. China supplies 74% of the solar panels used in USA and 30% of those used in Germany.

Y. hua Wang, et al., (2014) discuss the reasons for overcapacity in PV in the early growth stage in China. The development of China's PV in market industry mainly relies on European market, impacted by US financial crisis and European debt crisis, market demand shrinking and overcapacity. Chinese government wanted domestic PV market to absorb the overproduced PV products owing to the insufficient development and uncoordinated incentive system.

*H. Sun et al., (2014)*reports on the several challenges facing the PV industry, the international trade conflicts, market competition, domestic problems, vicious competition between enterprises, financial issues such as loan withdrawing, and stint loans by banks, and business triangular debts, market forces acting as catalysts, for transforming solar energy development.

China's Energy Policy (2016) discusses the main drivers for PV technology transfer from the global innovation system to China are market formation policy, international mobilization of talent, and flexibility of manufacturing in China, and belated policy incentives for China's government. The development trajectory of PV industry in China indicates that innovation in clean energy technology, can occur through both national, and international innovation processes, and knowledge exchange transfer along the global PV value chain.

A. Jaffe, (2016), in his research work, portrays China as a green giant in PV power. He emphasizes that solar energy will help both the global fight against climate change and China's ambition to replace the US as the most significant player in the regional alliances, and trading relationship. Rejection of the Paris climate accord by the US is helping pave the way for China to become the super power of the future.

III. Objectives of the Research

This researcher intends to study the trend of developments made by China, and India in the Residential Solar Roof Top PV segment. The study is broken down into sub hypotheses as follows:

- Solar energy growth trends in China.
- Solar energy policies of China.
- Challenges faced by China in PV industry.
- Factors for slow growth of RSRTPV in India.

IV. Materials and Methods

Secondary data is collected from Research journals, renewable energy journals like Akshay Urja, Renewable watch, EQ International Modern Power Systems, Soft Disc India, Renewable Energy Booster, Energy Summit reports, websites of MNRE,TERI, NISE, SECI and other articles on solar energy from the internet with a view to review literature on solar energy development and draw a comparative analysis of China and India with reference to growth of Residential Solar Roof Top PVs.

V. Data Analysis and Interpretation

a) Growth Trends in China's Solar Energy Development

Today India and China have become leading Asian giants surpassing the developed countries in solar energy production. India needs to concentrate on RSRTPV segment and convert its residential consumers into prosumers who can individually contribute to the electricity production, and bring in capacity addition to the grid, and improve India's national economy. Examining the slackness of growth in India's RSTPV sector, the focus is to emulate China's solar energy development, policies, trends, challenges, and road map to success. As India has put solar energy on top of the agenda for the country, and announced just ahead of the COP21 Climate Conference in Paris of its intention to harness 40% of its energy mix from alternative sources like solar, India can learn to charge ahead in Residential Solar Roof Top PV, and provide 24 x7 power to all households by 2022, making India's small scale solar industry poised for growth.

China's rise began in 1990, when Germany overwhelmed by the domestic response to a government incentive program to promote RSRTPV, provided the capital, technology, and expertise, to lure China into making solar panels to meet German demand.China leapfrogged from running a tiny rural oriented solar program to becoming a global leader with a full-fledged solar panel industry,making solar panel prices drop by 80%-a stunning achievement in a fiercely competitive high tech market.They fundamentally changed the economies of scale all over the world.The data collected shows the tremendous development made by China over the years.

Table1: Solar PVs installed in China in MWs

Year	Capacity	Installed
1999	16	3
2000	19	4.5
2001	23.5	8.5
2002	42	10
2003	52	10
2004	62	10
2005	70	8
2006	80	10
2007	100	20
2008	140	40
2009	300	160
2010	800	500

2011	3300	2500
2012	8300	5500
2013	17,800	9500
2014	28,199	10560
2015	43180	15130
2016	77420	34540
2017	130250	52830
2018	174630	44380

Source ://en.wikipedia.org>wiki>Solar_power_in_China

By 2017, the total PV capacity increased over 130.25GW and, it became the first country to achieve this cumulative installed PV capacity. China is the world's largest manufacturer of solar PV panels since 2008 and, since 2016, it has produced the majority of global PVs on an annual basis. A comparison of the world's solar capacity with China's is shown in Exhibit 5.

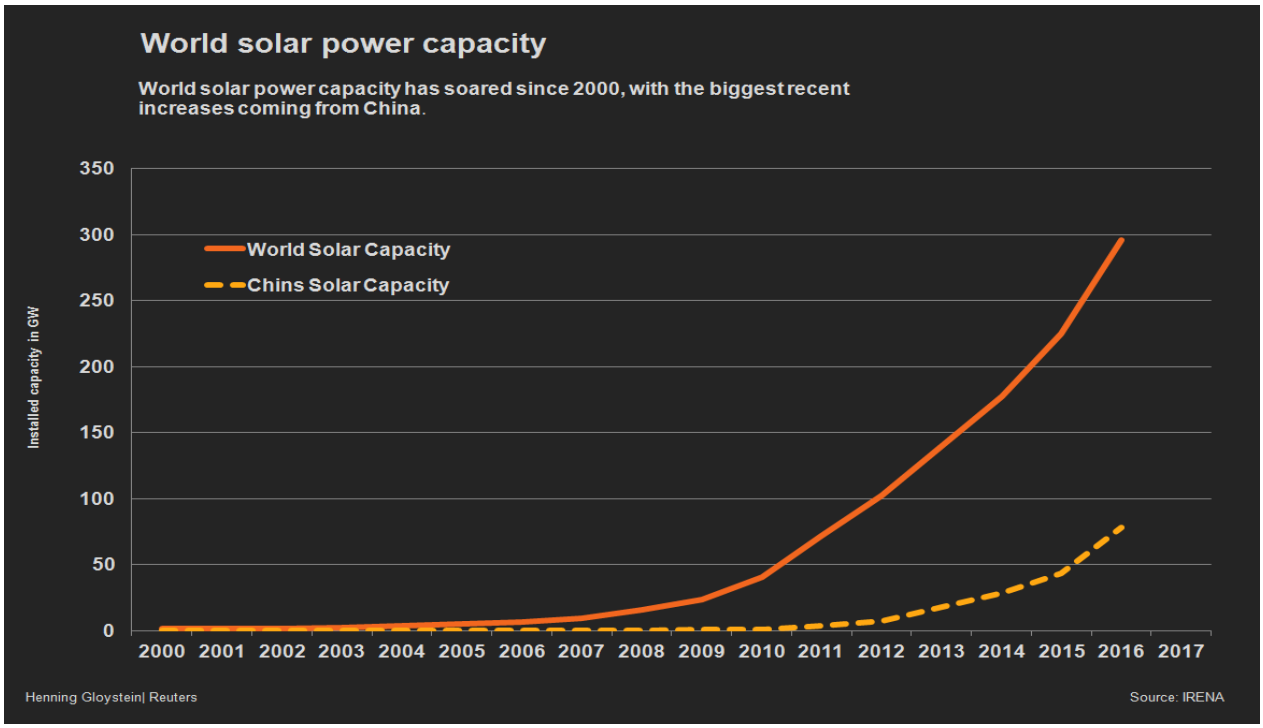

Exhibit 5: Solar Capacity- China and the World

China has enough manufacturing capacity to produce 40-50 GW of PVs per year, an amount of price as large as2010s global production of 24 GW. Today the industry is dominated by manufacturers likeCHINT Group Corp, JA Solar Holdings, Jinniu Energy, Suntech Power, Yingli China Sun Energy, and Hanwha Solar One with exports to developed countries.

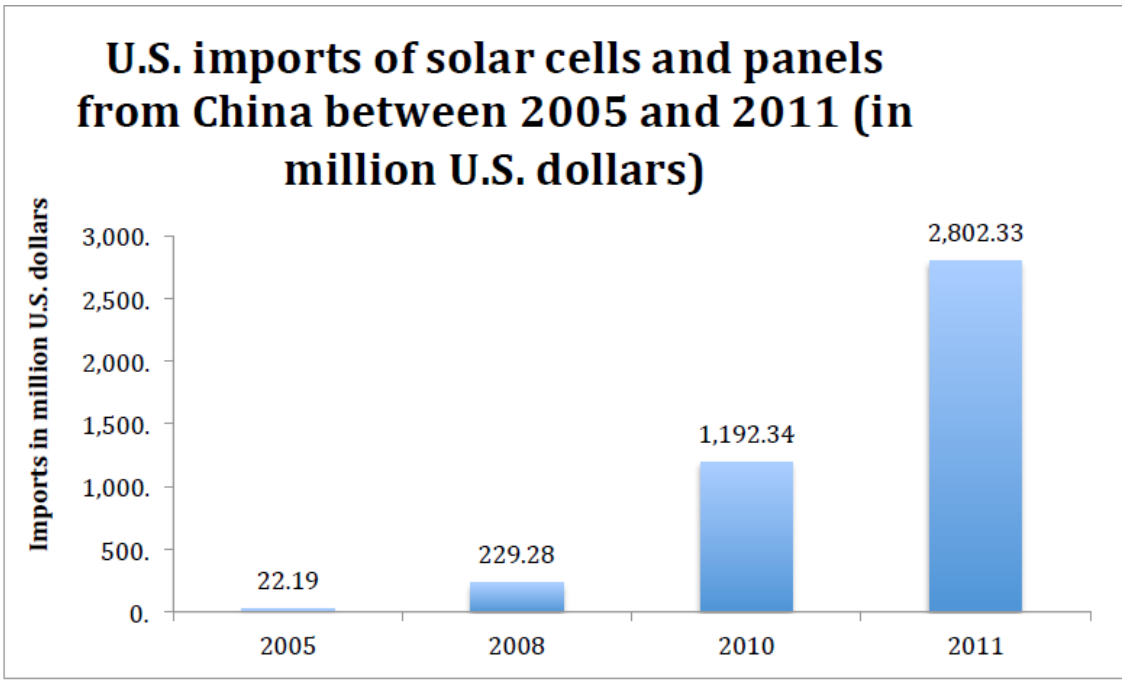

Exhibit 6: US Imports

i. *China's Solar Energy Policies*

The Chinese government owns all land, hence acquiring roof rights is difficult. Thanks to subsidies and falling manufacturing costs, China has started installing solar power on roofs, sufficient to service their own needs. China's National Energy Administration (NEA)has enabled a plan to use solar PVs by 2 million Chinese households and villages below the poverty line (BPL) will have RSRTPV panels rated @3-5 kW installed on their roof tops becoming shareholders in village solar power stations with a generating capacity of 60-100kW. The solar panels will help earn each family (US$430) in extra income each year -3000 residences in 182 villages were identified eligible for below poverty line solar energy generation, thereby reducing energy bills, and selling surplus solar energy generated into the grid. Families share ownership of solar pay back loans, and solar park construction fees. Solar power generation surplus brings down rates. With the yo-yo effect, the Chinese created more and more capacity. Chinese companies have shareholders who want profit. Chinese built solar manufacturing into a strategic industry-creating factory, and jobs. Cheaper solar panels resulted, and China created a wide glut. Chinese made two panels for every solar panel ordered by an overseas customer. China followed Germany's lead in developing its own feed in tariff that paid handsome prices for electricity generated from Residential Solar Roof Tops, surging its domestic demand.

Chinese put their whole government system into the manufacturing of solar panels, thereby wiping out all competition in the world solar panel market, demonstrating their incredible staying power. The impact of Chinese solar panel manufacturing on US competitors was drastic which made most of the solar companies bankrupt.

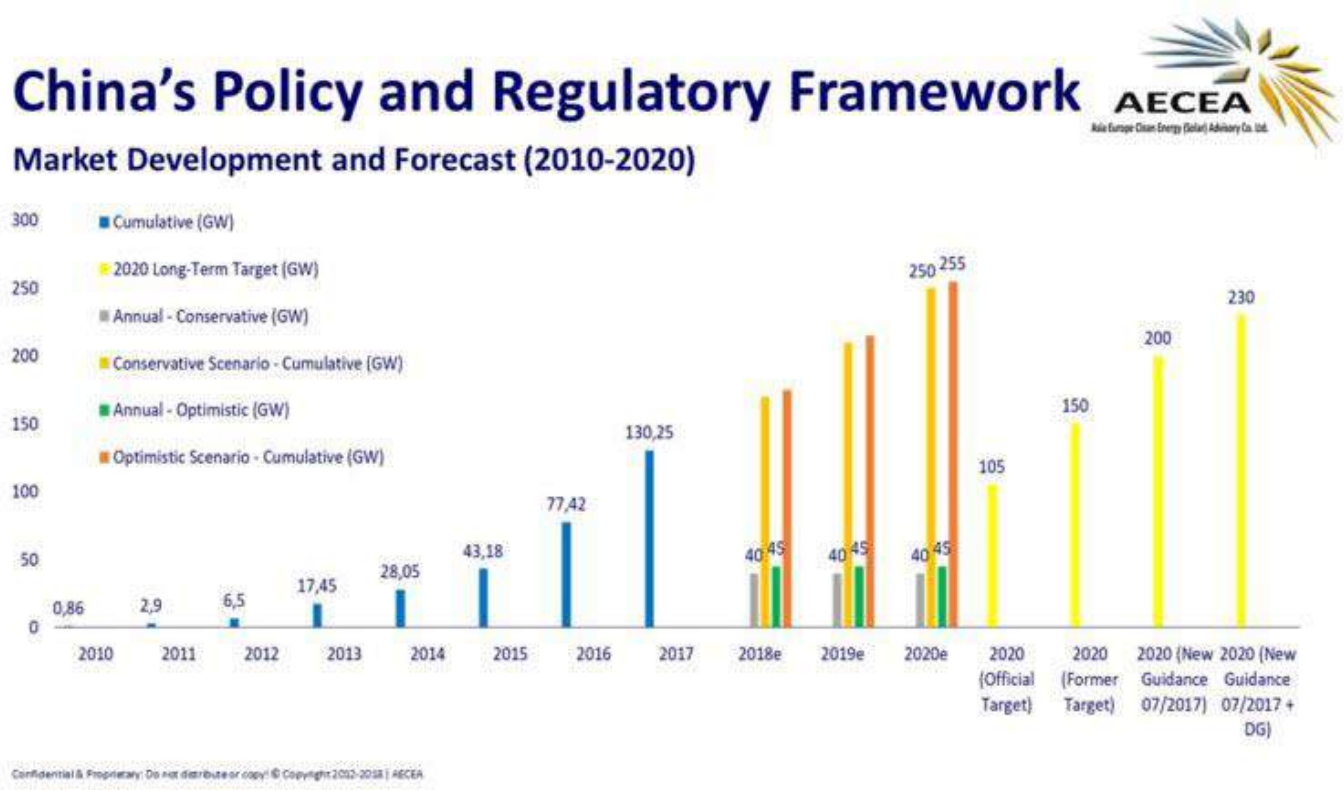

Exhibit 7: China's Policy and Regulatory Framework.

China's solar energy sector is growing faster than in fossil fuels and nuclear power capacity. In 2017, China became the world's largest producer of PV power, ramping up both manufacturing capacity and solar project development.

ii. *China's Central Government Policies*

China's Central Government established the first two levels of policy.

- First level policies-Local governments, including provincial, municipal, and county governments, provide general direction and guidance.
- Second level policies- specify goals, objectives, development plans, and focus on rural electrification, renewable energy-based technologies, standardized direction, focal points, and departments play a significant role in promoting renewable energy technologies.
- Third level policies-practical, and specific incentives, and managerial guidelines provide crucial support to develop solar energy with its early growth stages.

iii. *Various Measures Adopted By China*

The State Economic and Trade Commission (SETC) proposes the five-year plans for Sustainable Development of Renewable Energy and Non-Renewable Energy Commercialization and Development. The CETC- China Energy Technology Policy, in 1994, the Brightness Programme,1995-the SSTC-State Science and Technology Commission, was set up. The electric Power Law, the Energy Saving law in 1997.Non-Renewable Energy Development Projects were concentrating from 1996-2010.During 1998-incentive policies for Renewable Energy Technology by MOST (Ministry of Science and Technology).In 2010 a new feed-in tariff was introduced and solar energy projects were completed before September every year, and received 1.15 yuan per kWh which served as a great incentive.

b) Challenges Faced by China

- There was no Industrial Standard for residential PV, and this presented a lot of potential problems. Many owners were attracted by low prices, which meant inferior quality panels, making projects riskier. The government gathered a group including key players in the segment to generate a national industry standard to be mandatory to all market players addressing quality.
- Limitations of transformer capacity whereby in remote villages, transformer capacity is not large enough for RSRTPV. This problem was gradually solved by upgrading the national grid.
- The electricity price for individual users in China is quite low and public demand for PV is suppressed.
- Quality concerns are common in project design, components selection, installation, maintenance and after sales service.

- Because of the scattered nature of Residential Solar Roof Top PV installations in China, there is a distinct lack of suitable financing instruments, which greatly limits the sector's development.

c) *Residential Solar PV in India*

India's potential 3287240 sq. km area of land receives solar radiation worth 5000 trillion kWh every year with 2300-3200 sunshine hours depending upon location. If this natural and inexhaustible energy is captured, then a fraction can be useful to meet heat and electricity needs. The Government of India is providing much incentives including capital subsidies, tax holidays, and low investment loans through renewable IREDA (Indian Renewable Energy Development Authority) State Electricity Boards buy power through Renewable Energy Independent Power Producers, setting targets for Renewable Energy generation. From 2018 onwards, India is adding 8-10 GW an annual residential solar capacity.

i. *India's Regulatory Policies*

A large portion of capacity addition is done through Central Government policies. The Ministry of New and Renewable Energy implements large-scale grid-connected residential solar PV pilot projects with 30% subsidy support from National Clean Energy Fund to the Solar Energy Corporation of India (SECI). Thirteen States have already established policies regarding residential PV Solar installations.

ii. *Challenges Faced By India in RSRTPV Segment*

RSRTPV in India is cheaper than Commercial and Industrial solar PV according to BNEF (Bloomberg New Energy Finance). Costs halved over the last five years because of increased competition and lower solar panel prices. Residential Solar Roof Top PV systems have become cheaper than the global average between 39%-50%, yet Chinese firms dominate India's solar market, with domestic manufacturers accounting for only 10.6% of market share. Low electricity tariff-The electricity prices for residential consumers are cross-subsidized by industrial and commercial users. Small scale PV is far less competitive in residential homes. The Indian Solar Manufacturing Association has sought anti-dumping duties to safeguard the local industry, from the adverse impact of imports and dumping from China and other countries.

d) *Factors for Slow growth of RSRTPV in India*

- Higher system costs-The average capital cost of RSRTPV systems is higher than commercial and industrial PV due to higher soft costs and the absence of economies of scale.
- Lack of awareness-Residential consumer still lacks awareness about RSRTPV policies, incentives, cost savings, equipment, quality, operations, and maintenance care, industry innovation and best practices.
- Challenges in net metering: Consumers often require multiple approvals to avail net metering, leading to delays in the implementation of grid connectivity.
- High customer acquisition cost – The costs associated with acquisition of residential customers leave less margins for the companies due to smaller market size.
- Lack of access to finance-lack of dedicated financial products from banks and reluctance of consumers to put their residences as bank collateral, limits the financing options for consumers to avail loans for RSRTPV.
- Government policies can drive growth-Central Government updated the model building bye-laws and Energy efficiency building code that suggests residential solar PV installation can lead to sustained growth of the residential PV market.
- The long term new residential installations can increase their share in RSRTPV markets driven by socket parity and a quest for unreliable self-generation with small scale PV rather than urban counterparts
- Net metering is far more a good enabler for small residential scale solar than for business. Businesses consume more power throughout the day. Residents draw less power when PV panels produce more electricity for self-consumption, and the surplus is fed into the grid.
- India has one of the world's highest rates of transmission and distribution losses, with more than 30% of generated electricity loss. Transmission and distribution losses can be minimized, if there is the proximity of power generation to usage.
- India needs to build effective distribution and retail networks, and assess consumer demand.
- Chinese solar panels imported by India have no quality certification, as 95% of the components are required for the installation of solar projects.
- High costs, poor after-sales service, and maintenance deter consumers. Upfront costs can be reduced by offering lease options, other cheaper finance options, and separating sales from after-sales service contracts, which can be offered at an additional cost, improving quality, and building customer loyalty.

VI. Results and Discussion

India needs a more competitive manufacturing policy together with the installation of smart metering, which can help individuals sell surplus power, and buy back cheaper electricity from the grid- a great incentive. India should protect the solar energy industry by focusing more on domestic manufacture to avoid competition, lower international prices impacting R & D efforts, affecting exchange rate fluctuations, price risk,

quality imports, lack of quality certification of imported products, and sudden price play by Chinese. If manufacturing is taken up under 'Make in India' initiative, we can help create employment, and assimilate, imbibe advanced solar power technologies. Indian manufacturers can partner with other global players for upgrading our solar power technology. Besides allowing liberal policies for MNCs would seem a reasonable venture, lest we will be allowing foreign suppliers to make all the profit with no scope for any advantage to India.

India needs to build distribution, and marketing channels, give incentives to local manufacturers, facilitate short term debt financing, encourage management expertise, and give access to business network laying the ground work for a profitable, long term future PV industry.

Educating about the various schemes, and the advantages can help. The demand is currently small, and it can grow when RSRTPV becomes more affordable. Financing and partnerships with non-profit, and micro finance institutions, can lower upfront costs.

To-day, India's policies, and procedures support solar Industrial and Commercial PV Projects and much emphasis is not given by the Central and State Governments to RSRTPV. Residential Solar PV is in a nascent stage due to its inability to convince potential clients to adopt this technology and save on power bills. India should assess consumer demand and raise awareness of RSRTPV –its health influencing impact by reducing the harmful emissions while using fossil fuels, economic benefits, and other positive attributes of a clean energy. Residential owners who have installed Solar PV systems can now sell power to distribution companies with several state governments allowing selling of solar power after connecting to the grid. This is expected to boost solar or green power generation across States, and encourage people to install PV systems.

VII. Implications of the Study

- The study can help emulate the Chinese road map to success in solar PV manufacture.
- The study is a pointer to show that Chinese put their whole government system into manufacturing PV.
- The study helps understand that economies of scale in PV can be achieved through capital, technology, and expertise as in the case of China.
- The study signifies the importance of a local free PV market like that of China.
- The study emphasizes on building distribution, marketing channels, and retail networks of PV.

VIII. Conclusion

The factors responsible for growth of Residential Solar PV in China can serve as an impetus for India to overcome the challenges faced in RSRTPV segment. The extent of grid parity achieved by China, it's solar PV technology, the quality, ease of finance, installation, connectivity to the grid, and the government support, and industry-friendly policies are enumerated. India can stay focused in promoting Residential PV owners as *prosumers* of solar energy contributing to environmental sustainability, thereby fulfilling the dream of owning PV panels on the idle, shadow free roof of every home. Generating enough power to reduce the country's fuel bill and dependence on fossil fuel can become a reality, when wholehearted efforts are made by all stakeholders, including the Government, to create knowledge, awareness of the beneficial environmental good of this technology. Government's role in incentivizing the adopters with affordable financial options, credit guarantees, quick loans, easy EMIs and attractive subsidies needs to be emphasized. Concluding on an optimistic note, by going solar, India can save considerable foreign exchange as it imports 89% of its fossil fuel requirement. Nevertheless, India can also look forward to a clean, green economy, becoming the world's second-largest population moving to a low carbon economy, taking a cue from China.

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