Diffusion of Innovation & Adoption of Solar Energy Technology: Indian Insights

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Abstract
There has been significant research on solar energy technologies in recent years. It is observed that very little has come out of this research in terms of commercially interesting solar energy technologies. The long term perceived potential of solar energy is the key driver for technology innovation in solar industry. Earlier solar energy industry was more capital intensive. Deep pockets were necessary for manufacturing of Solar PV cells by electronics industry, but the research & development across world has now evolved into commercially available technologies. Technological development of solar photovoltaic field has been experiencing growth and now-a-days various commercially applicable solar technologies have been emerged. Two major available technologies are being used today on commercial scale are: Solar Thermal and Solar Photovoltaic. The shortage of silicon and high capital cost of photovoltaic systems has been a major driving force for these advancements. Today, the coordinated policy at national level in India is a major encouragement for development of solar industry rapidly. The launch of Jawaharlal National Solar Mission in 2009 has acted as the Flagship Project which has earned the confidence of industries in the context of seriousness of government towards development of Solar Energy in India. This paper shall primarily look into the diffusion process of new solar energy technologies in the Industry and shall analyse its business and marketing implications. The paper shall study the business and marketing practices of select national and international companies in terms of their technology enabled market offerings and shall comment on the sustainable business and marketing approach.

Keywords
Diffusion of Solar Energy, Technology, Sustainable Business & Marketing

Introduction
Developed countries are sensitive to conserve the environment while in pursuit of the faster growth of their economies and industrial expansion. The industrial growth of the country cannot be compromised at any cost; and this causes genuine concerns for the conservation of environment in the midst of all ensuing industrial growth. There are many developed countries that have been very eco-friendly in their industrial undertakings, and have made tremendous strides at the front of green industrial operations, without affecting their profits and other organizational objectives in a negative way (Sheetal Soda & et al., 2015).

The marketplace for solar is exploding as more and more companies are entering for the investment in solar technology and projects. Government of India (GoI) has brought the solar economy in the main stream. Jawharlal Nehru National solar Mission- the flagship project launched in 2010 by GoI. The objective of this mission is to achieve 20 GW of grid-connected solar power and 2GW of off-grid solar power by 2022 and is aimed at reducing the cost of solar power generation in the country through
   a) long term policy
   b) large scale deployment goals
   c) aggressive R&D
   d) domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022

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The main purpose and strategy to start this project to provide: (i) consultative process to finalize the guidelines, (ii) enabling policy and regulatory frame work, (iii) supporting utility scale power generation, (iv) expanding off-grid applications, (v) accelerating research and development, (vi) enhancing domestic manufacturing base.

<table>
<thead>
<tr>
<th>Application segment</th>
<th>Target for Phase I (2010-13)</th>
<th>Cumulative Target for Phase 2 (2013-17)</th>
<th>Cumulative Target for Phase 3 (2017-22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid solar power incl. roof top &amp; distribution grid connected plants</td>
<td>1,000 MW 100 MW</td>
<td>4,000 MW 10,000 MW</td>
<td>20,000 MW</td>
</tr>
<tr>
<td>Off-grid solar applications</td>
<td>200 MW</td>
<td>1,000 MW</td>
<td>2,000 MW</td>
</tr>
<tr>
<td>Solar collectors</td>
<td>7 million sq meters</td>
<td>15 million sq meters</td>
<td>20 million sq meters</td>
</tr>
</tbody>
</table>

(Source: Ministry of New & Renewable Energy-MNRE, India)

The Roadmap of Solar Energy-India

Solar radiation, which is received as heat and light, can be converted to useful thermal energy or for production of electricity either through solar photovoltaic route or through solar thermal route. Availability of reliable solar radiation data is vital for the success of solar energy installations in different sites of the country. For solar collectors, which are flat in nature, solar radiation data in the form of Global Horizontal Irradiance (GHI) is useful whereas for solar collectors which are concentrating in nature Direct Normal Irradiance (DNI) data is required. Solar thermal power plants are essentially Concentrating Solar Power (CSP) units. For designing solar thermal power plants, DNI data is a pre-requisite (MNRE, India).
As per the National Renewable Energy Laboratory (NREL), India map, the maximum solar resource is available to Gujarat, Maharashtra, Rajasthan, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka.

The available solar potential to these states is 5.0-6.0 Kwh/m²/day.

To encourage the solar economy, MNRE has approved 33 solar parks in 21 states with 19.9 GW capacities.

(Source: Anthony Lopez, Billy Roberts, 2013, NREL)

As the energy basket of country consists of different energy mix, the GDP is affected by the choice of technology (Jyoti Parikh, Prabal Ghosh, 2009).

<table>
<thead>
<tr>
<th>State</th>
<th>Installed Cap - MW as on 31.08.2015</th>
<th>Installed Cap - MW as on 31.08.2016</th>
<th>Installed Cap - MW as on 30.08.2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tamil Nadu</td>
<td>142.58</td>
<td>1,061.82</td>
<td>1,555.41</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>942.20</td>
<td>1,269.93</td>
<td>1,294.60</td>
</tr>
<tr>
<td>Gujarat</td>
<td>1,000.06</td>
<td>1,119.17</td>
<td>1,136.32</td>
</tr>
<tr>
<td>Telangana</td>
<td>167.05</td>
<td>527.84</td>
<td>961.79</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>137.85</td>
<td>572.97</td>
<td>947.05</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>558.58</td>
<td>776.37</td>
<td>810.37</td>
</tr>
<tr>
<td>Punjab</td>
<td>185.27</td>
<td>405.06</td>
<td>571.20</td>
</tr>
</tbody>
</table>

(Source: https://www.mnre.gov.in)

India has the fifth largest power generation portfolio in the world with a power generation capacity of 304.76 GW. India has third largest installed capacity of concentrated solar power (CSP). Current renewable energy contribution stands at 44.812 GW which includes 27.441 GW of Wind power 8.062 GW of Solar power installed capacity in the country (MNRE, as on 31.07.2016)

Following are the major questions arise for this study:
1) What are primary solar energy technologies?
2) What are the factors influencing the diffusion of innovation of technologies in solar energy industry?
3) Who influence the acceptance of adoption of innovation technologies in solar energy industry?
4) What role does the innovation characteristics play in solar energy adoption process?

The broad objective of this study is to investigate the determinants of solar energy technology adoption. This study shall be beneficial:
1) To solar energy technology developers and adopters
2) To solar energy practitioners and consultants
3) To policy makers (Govt.) and
4) To academicians and future researchers

**Introduction to Solar Technology**

*Solar* is the Latin word for sun—a powerful source of energy that can be used to heat, cool, and light our homes and businesses. The most commonly used solar technologies for homes and businesses are solar water heating, passive solar design for space heating and cooling, and solar photovoltaic for electricity (NREL, India).

There are two primary technologies by which solar energy is commonly harnessed:
1. **Solar Photovoltaic Technology**

The sunlight is absorbed by the cells of the panel, which creates an electric field across the layers and causes electricity to flow. Photovoltaic (PV) materials and devices convert sunlight into electrical energy. A single PV device is known as a cell. An individual PV cell is usually small, typically producing about 1 or 2 watts of power. To boost the power output of PV cells, they are connected together in chains to form larger units known as modules or panels. Modules can be used individually, or several can be connected to form arrays. One or more arrays are then connected to the electrical grid as part of a complete PV system. Because of this modular structure, PV systems can be built to meet almost any electric power need, can be domestic or commercial.

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. as per Indian Solar Photovoltaic Industry Report (Aug 2014).

Crystalline silicon wafers are also categorized in three types-

a) Monocrystalline
b) Polycrystalline
c) Silicon ribbon

Monocrystalline is the most efficient on account of highest degree of purity but is also costly in comparison. Typically and the most widely used form is Polycrystalline. PV Modules are more labour intensive than capital and technology intensive, as compared to other stages of production. This is great opportunity for developing countries.

2. **Solar Thermal : Concentrating Solar Power (CSP):**

Concentrating solar power (CSP) technologies use mirrors to reflect and concentrate sunlight onto a single point where it is collected and converted into heat. This thermal energy can then be used to produce electricity.

Concentrating solar power systems are generally used for utility-scale projects. The mirrors in CSP plants focus sunlight onto a receiver that heats a high-temperature fluid, which is used to spin a turbine or power an engine that drives a generator. The final product is electricity.

Smaller CSP systems can be located directly where power is needed. For example, single dish/engine systems can produce 3 to 25 kilowatts of power and are well suited for distributed applications.

There are four types of CSP systems available:

a) **Linear Concentrator System**

Linear CSP collectors capture the sun's energy with large mirrors that reflect and focus the sunlight onto a linear receiver tube. The receiver contains a fluid that is heated by the sunlight and then used to heat a traditional power cycle that spins a turbine that drives a generator to produce electricity. Alternatively, steam can be generated directly in the solar field, which eliminates the need for costly heat exchangers.

b) **Dish/Engine System**

Dish/engine systems use a parabolic dish of mirrors to direct and concentrate sunlight onto a central engine that produces electricity. The dish/engine system is a concentrating solar power (CSP) technology that produces smaller amounts of
electricity than other CSP technologies—typically in the range of 3 to 25 kilowatts—but is beneficial for modular use. The two major parts of the system are the solar concentrator and the power conversion unit.

c) **Power Tower System**
In power tower concentrating solar power systems, a large number of flat, sun-tracking mirrors, known as heliostats, focus sunlight onto a receiver at the top of a tall tower. A heat-transfer fluid heated in the receiver is used to heat a working fluid, which, in turn, is used in a conventional turbine generator to produce electricity. Some power towers use water/steam as the heat-transfer fluid. Other advanced designs are experimenting with high temperature molten salts or sand-like particles to maximize the power cycle temperature.

d) **Concentrating Solar Power Thermal Storage System**
The widespread use of solar energy is reduced or curtailed energy production when the sun sets or is blocked by clouds.
It is a concentrating solar power (CSP) system in which the sun's rays are reflected onto a receiver, which creates heat that is used to generate electricity that can be used immediately or stored for later use. This enables CSP systems to be flexible, or dispatchable, options for providing clean, renewable energy.
Several sensible thermal energy storage technologies have been tested and implemented since 1985. These include the two-tank direct system, two-tank indirect system, and single-tank thermocline system.

Solar Energy Centre (SEC) near New Delhi under the MNRE is the lead Centre for testing and training in solar energy in the country. SEC has National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited testing facilities for PV module qualification as per Indian and International standards. SEC is imparting training in solar energy at various levels. SEC is regularly conducting international training programme in solar energy. Demonstration of several solar PV and thermal applications including setting up of 1 MW capacity solar thermal simulation and validation facility at SEC is under progress.

Global investments in renewable energy in 2010 reached US$211 billion representing a year-on-year increase of 32% as per Green Economy Report, UNEP (2011b).

**Diffusion of Innovations and Technology**

Diffusion is kind of social change. Diffusion is a special type of communication, in which the messages are concerned with a new idea. It is this newness of the idea in the message content of communication that gives diffusion its special character. The newness means that some degree of uncertainty is involved (Everett M. Rogers, 1983).

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers and Kincaid, 1981).

According to Rogers (1983), there are four main elements in the Diffusion:
1. Innovation
2. Communication Channels
3. Time
4. A Social System

An innovation is defined as an idea, practice or object that is perceived as a new by an individual or other unit of adoption. Relative advantage, Compatibility, Complexity, Trialability, Observability- are five characteristics of innovation.
According to the Roper theory, ideas diffuse in circles, much as ripples on the water after a pebble have disturbed the surface.

The diffusion is the special type of communication, in which the messages are concerned with new ideas. Communication is a process in which participants create and share information with one another in order to reach a mutual understanding. This definition implies that communication is a process of convergence (or divergence) as two or more individuals exchange information in order to move toward each other (or apart) in the meanings that they ascribe to certain events. Communication is a two-way process of convergence, rather than as a one-way, linear act in which one individual seeks to transfer a message to another. The Rate of adoption is the relative speed with which an innovation is adopted by members of a social system. When the number of individuals adopting a new idea is plotted on a cumulative frequency basis over time, the resulting distribution is an s-shaped curve (Rogers, 1983).

Katz (1961) has stated, "It is as unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located as it is to study blood circulation without adequate knowledge of the structure of veins and arteries."

According to Birol (2011), “The technology is improving at a rapid rate and business models are maturing”. Wong (2012) has stated that “easy access to credit for users as well as a robust complaint system to address some of the maintenance and supply chain failures associated with Solar Home Systems (SHS) technologies”. SHS in India has identified the need to create a strong ecosystem with greater information flow in order for the SHS sector to scale rapidly in India (CEEW, 2013). Cases of technology deployment have been unsuccessful when companies have not established a proper supply chain to provide the maintenance and replacement parts for the technologies (Bairiganjan and Sanyal, 2013).

The first and perhaps most obvious attribute that adopters seek in new technology is relative advantage: “the degree to which an innovation is perceived as better than the idea it supersedes”. There are decisive social factors: user satisfaction and prestige that influence an individual’s perception of the relative advantage of innovations (Greenhalgh, 2004).

Technology Life Cycle

(Rogers (2003) defined that Rate of adoption is defined as “the relative speed with which an innovation is adopted by members of a social system” and Social system is “a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal”. Compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters. There is a lot of diffusion research on the characteristics of the adopter categories, there lacks research on the effects of the perceived characteristics of innovations on the rate of adoption.
One of the most important gaps is between the early adopters and the early majority, defined as the chasm. This occurs when a new product or service cannot be translated into a significant benefit. Early adopters can create bad references for the early majority (Moore, 2012).

Innovators are those who want a certain product as soon as it becomes available and are willing to take risks and also have financial capabilities. They are cosmopolites who act and have contacts regionally and globally. Early adopters are a larger group who also seek new products but are less sensitive to “hype”. The early majority is the first mass of people to adopt a product, and this is where the curve reaches maturity. The late majority adopts when the majority of the market is already familiar with the product. Sales tend to slow during this phase according to De Groot & Steg (2010).

According to Rogers and Prahlad (2009), relative advantage as the degree to which a technological factor is perceived as providing greater benefit for firms or individuals. It is reasonable that firms take into consideration the advantages that stem from adopting innovations. The innovation-diffusion process as “an uncertainty reduction process” attributes of innovations that help to decrease uncertainty about the innovation.

**An Enhanced Adoption Process Model**

![Diagram of the Enhanced Adoption Process Model](Source: Diffusion of Innovations, Fifth Edition by Everett M. Rogers, 2003)

**Technology Acceptance Model**

![Diagram of the Technology Acceptance Model](Source: Davis & Bagozzi, 2009)

According to Troncoso et al. (2013), perceived usefulness and perceived ease of use, which were theorized to be fundamental determinants of system use and better measures for predicting and explaining system use would have great practical value, both for vendors who would like to assess user demand for new design ideas, and for information systems managers within user organizations who
would like to evaluate these vendor offerings. Solar Technology is seen as a mature and proven technology and barriers to widespread individual households.

Perceived usefulness is also influenced by perceived ease of use because if other things are equal, the easier the system or technology, the more useful it can be as per Morris & Davis, (2000).

Ashok Upadhyay and Arnab Chowdhury (2014) have stated that “The capital cost of the solar power system is higher than the conventional source of energy. Barriers which limit the rapid growth of such technologies include (a) Technical barriers such as low-efficiencies, challenges with energy storage, reliability of balance of system components; (b) Institutional barriers such as lack of information, outreach and regulatory structure”.

Govt. subsidy regime is not helping the ecosystem of off grid solar technologies. Business innovation have found a way to operate in an environment that lacks access to formal banking systems and requires strong supply chains and after sales networks in order for technologies to be maintained post deployment according to Kartikeya Singh (2015).

According to Ashok Gulati, Stuti Manchanda, Rakesh Kacker (2016), the PV Module prices have fallen by more than 80% since 2008. This has lowered the total system costs due to reduction in poly silicon prices, cost reducing technological innovations; fall in price of consumables, economies of scale. The efficiency of commercial wafer based silicon modules has increased from 12% to 17% in the last decade.

Major Market Players in Solar Technology in India
1) Tata Power Solar Systems Limited (Tata Power Solar)

Tata Power Solar is India’s premier ISO 9001:2008 and ISO 14001:2004 certified integrated cell and module manufacturing facility. Tata Power Solar, India’s largest integrated solar company, has been ranked No. #1 rooftop player among EPC companies (India Solar Rooftop Map-2016 report by BRIDGE TO INDIA). According to the report, the total installed capacity in the rooftop segment is 1020 MW as of September 2016. In terms of market share, Tata Power Solar leads by nearly four times over its closest competitor in the market.

Tata Power Solar was founded in 1989 as a joint venture between Tata and British Petroleum and currently operates independently as a wholly owned subsidiary of Tata Power. The core of Tata Power Solar is focused on harnessing solar energy to bring electricity to the masses. It operates primarily in three key segments- large utility projects, industrial solutions and standard products & systems for mass markets.

• A wide range of innovative solar systems and solutions for rural and commercial markets, supported by a network of 150 dealers and service centers
• The expertise and capabilities to provide complete EPC solutions for large grid-connected solar power plants
• A sophisticated 84 MW solar cell manufacturing facility and 125 MW module manufacturing facility
• A competent green workforce of over 600 employees, with deep expertise in solar

The company is engaged in manufacturing and EPC services. The company is trying to increase solar awareness in the remote parts of India. The company has commissioned 175 MW of EPC projects, 43 MW of solar rooftop projects, and exported 600 MW of modules till date. Tata Solar has presence in industrial, commercial, both on-grid and off-grid solar projects and residential. The solar panels consist of 36, 60 and 72 six inch multi-crystalline cells and have a 25-year warranty, with power range varying from 0.3 W to 305 W.

Tata power solar has module manufacturing lines; having in-house production capacity of 300 MW for modules and the cell manufacturing lines with a capacity of 180 MW can process both mono and multi-crystalline wafers of 125mm and 156mm sizes.

With over 976 MW of modules shipped globally in the past 20 years, our modules power some of the biggest industry and utility scale projects in North America and Europe. Landmark projects
include an 8.8 MW installation in Madridehos/Toledo (Spain), 3.8 MW for British Gas (UK) and a 6 MW project in Geisetalsee (Germany).

Modules are available in two types:
i) Standard modules – TP250, TP300 and TS 250 series, ideal for rooftop installations and utility scale projects.
ii) Specialty modules – Tata Solar Gold and Platinum series, ideal for indoor, outdoor, street, billboard lighting, remote telecom sites and standalone systems for home.

2) Su-Kam Power Systems Ltd

Su-Kam is also the leading solar panel manufacturer company based in India. The company is the largest solar inverter manufacturer in the country. Su-Kam also has a presence in the residential EPC market in India. Su-Kam Solar panels come in a wide range from 10W – 250W. This extensive solar range is suitable for the smallest residential home systems up to multi-megawatt solar power plants. These panels come with 25 years warranty and are designed to withstand the extreme weather conditions in India. These panels are shock resistant with thick iron glass and an anodized aluminium frame. They can generate a maximum of ~16V-30V, depending upon the wattage.

3) Vikram Solar

Headquartered in Kolkata, Vikram Solar is a manufacturer of PV solar modules. The manufacturing plant has a 150 MW installed capacity in West Bengal. They manufacture polycrystalline modules and are available in six series under the name Eldora. Read more details here.

i) Micro series – 18/36 celled having applications in Home and Street Lighting
ii) Mini, Core, Ultima and Grand series – 48, 54, 60 and 72 celled respectively, used in On-grid rooftop domestic and commercial systems & Off-grid residential systems.

4) Waaree Energies Limited

The company has a 250 MW solar panel manufacturing unit in Surat, having presence across the solar power value chain. These are monocrystalline/multicrystalline silicon solar panels. The company has an experience with solar thermal and EPC utility grid projects. Waaree manufactures a wide range of solar products ranging from solar modules, to solar water pumps and rooftop solutions.

- High conversion efficiency based on leading innovative photovoltaic technologies
- High reliability with guaranteed 0--+4.99 Wp power output tolerance, ensuring best ROI
- Withstands high wind pressure and snow load (passed 5400Pa mechanical loading test), and extreme temperature variations
- Each PV module is provided with RF identification tag which are to be used in solar power plant projects
- Cell- High Efficiency Cells by globally known and certified suppliers such as Gintech - Hareon and Indosolar
- Variant- Modules in the Power class of 3Wp to 400Wp with 240Wp family for 60 cells Modules and 280Wp family for 72 cells
- Type- Manufacturing Poly Crystalline as well as Mono-crystalline modules
- Efficiency- Current module efficiency in excess of 16%

i) Surya series – with either 18 cells or 36 cells. These modules can be used in solar chargers, solar gadgets, solar lanterns and other home lighting solutions
ii) Arka series – with 36 cells. These modules can be used in home lighting solutions, street lighting, and water pump and off grid systems
iii) Ravi Series – with 36 cells or 72 cells. These modules can be used in home lighting solutions, street lighting, and water pump and off grid systems
iv) Marica series – either 54 cells or 60 cells, used in off grid and grid tied systems
v) Aditya series – 60 cells, 72 cells or 80 cells modules, used in utility scale, off grid and grid tied systems
vi) Color & flexible series – 36 celled modules and BIPV modules

5) Indo Solar

Indo solar is a manufacturer of solar cells and modules, located in Greater Noida Uttar Pradesh. The current manufacturing capacity is 450 MWp, with an average efficiency rating of 17.4%. They manufacture 36 celled polycrystalline silicon panels, with 5 years workmanship warranty.

Indo solar offers reliable, innovative and affordable super solar solutions to our customers. Indo solar is India’s largest solar manufacturer having the world class manufacturing facility within India, with state of the art production lines from Germany with a capacity of 450 MW.

Company offers solutions, which include:-
1. Residential Rooftop Systems for Home consumers
2. Solar Street Lightning solutions
3. Engineering, Design and construction for Grid- Connected Commercial and Industrial solutions
4. Turnkey Utility scale installation services

Indo Solar offers two types of modules: ISL 40W – 100W and ISL 120W – 150W.

Other international suppliers in India:

The hot climate of India is ideal for its thin film modules. According to Bridge to India report, Trina Solar and Canadian Solar were top selling international brands in India in 2014. Others like Jinko Solar, ReneSola and Yingli Green Energy are also selling panels in India. These international panels are of good quality and also less expensive, than the domestic ones. The average selling price in India is still ~60 cents per watt, whereas Jinko Solar panels will be available to at approximately 40-45 cents per watt. However with India’s new solar target of achieving 100 GW of solar power by 2022 as per Jawaharlal Nehru National Solar Mission and the Prime Minister’s “Make in India” initiative, we hope to see more of such India panels in the market.

There are numerous small companies also engaged in the manufacturing and supplying of solar panels in India. Look into this space to find out more about the state wise solar panel distributors present in India.

Business and Marketing Implications:

The solar potential across Indian states is much higher at about 748 GW against a target of 100 GW given that India is a sunshine abundant country. Much emphasis on solar power is made due to three reasons: a) sunshine is a freely available, abundant and non-polluting source b) It can help to electrify remote villages where grid lines are absent or difficult to reach or suffer from sporadic supply and, c) with falling costs it is financially viable for industrial and commercial consumers according to Ashok Gulati, StutiManchanda, Rakesh Kacker (2016).

Improvements in cell efficiency, wafer thickness, manufacturing yields, diamond wire cutting, conversion efficiency etc. have brought down the use of silicon from 15 grams per watt in 2000 to about 5.2 grams per watt in 2014 as per Shyam Mehta, GMT Research (2014).

Solar economy is already influencing business investment. In consumption, a number of companies with large physical footprints and high power costs are installing commercial-scale rooftop solar systems, often at less than the current price of buying power from a utility. For example, according to McKinsey Report, 2014, Wal-Mart Stores has stated that it will switch to 100% renewable power by 2020, up from around 20 percent today. Mining and defense companies are looking to solar in remote and demanding environments. In the hospitality sector, Starwood Hotels and Resorts has partnered with NRG Solar to begin installing solar at its hotels. Verizon is spending $100 million on solar and fuel-cell technology to power its facilities and cell-network infrastructure.
Companies are involved in solar business to diversify their energy supply, to save money, and to appeal consumers that they are using the renewable energy to produce their products and services. The long-term contracts of power purchase agreements (PPA) and relative fuel-price fluctuations are proving the solar economy very attractive. The cost of capital is also falling. Institutional investors, insurance companies, and leading banks are becoming more comfortable with the risk associated with long-term ownership of solar technology and projects. A sharp decline in installation costs for solar photovoltaic systems has boosted the competitiveness of solar power.

Major players also are creating advanced financial products to meet solar’s investment profile. The best example of this to date is NRG Yield, and we expect other companies to unveil similar securities that pool renewable operating assets into packages for investors. Google has been an active tax-equity investor in renewable projects, deploying more than $1 billion since 2010. In 2015, Google has consumed 5.6 TW hours of energy which is capable to power the entire city of San Francisco. Google began buying renewable power under long-term supply contracts in 2010, and by 2015 had enough agreements in place to match 44% of its energy demand. Google has taken pledge to purchase 100% renewable energy for operations in 2017 which is the biggest commitment by a tech group to clean energy (Financial Times, 2016).

It will be also very interesting to track the emergence of solar projects financed online via crowdsourcing (Solar Mosaic, which brings investors and solar-energy projects together). This approach could widen the pool of investors while reducing the cost of capital particularly for smaller installations (David Frankel & et al., 2014).

**Conclusion and Future Scope of Study**

The utility sector represents a fascinating example of the potential for significant disruption after rapid commercialization of solar technology. The business model for utilities depends not so much on the current generation base as on installations of new capacity of solar. Emerging market of solar technology could seriously threaten the existing business of other energy resources because its growth undermines the utilities’ ability to count on capturing all new demand, which historically has fueled a large share of annual revenue growth.

Above study suggests that GoI Policy incentives are effective in increasing solar PV capacity at the county level and which has also altered the private market to create the technology driven market in solar sector. Innovation systems may be different in different geographies and one could assume that India's energy technology information system and solar energy technology information system are different. Policy incentives play a significant role in increasing the share of solar energy in the overall energy mix of India.

Domestic solar PV installations grew rapidly as they are benefitting from the favorable central/state Government policies. In addition, PV power tariff has fallen gradually because of the aggressive tariff bids of the project developers.

The long term growth of domestic PV manufacturing would be critically dependent on Government supported backward integration into polysilicon and wafer manufacturing, which would fundamentally help the industry become cost-wise as well as technologically competitive.

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