ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

Regulations, Policies and Innovation in Photovoltaic Industry

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1. Introduction

Reflecting concerns over the environment, health, and security stemming from the consumption of conventional fossil fuel energy sources, such as gas, oil, and coal, has been raised in the world, which increases the expectation of replacing fossil fuels with renewable energy [1]. In addition to these concerns, rising prices of fossil fuels has forced many countries to support the developent of renewable energy sources, such as, solar, wind, biomass, and geothermal[3]. Among these renewable energy sources, solar photovoltaics (PV), which is also known as solar electric system, has long been considered as a clean and sustainable energy that directly converts solar radiation into current electricity by using semiconducting materials [4]. A PV system comprises a PV module and other electrical components, such as charge controllers, inverters, and disconnects. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation, which significantly protects the environment. Meanwhile, it has been well proved that PV installations can operate for no less than 100 years with little maintenance, thus extremely reducing the operating cost [4]. As the figure 1 shows, this report begins with a detailed analysis of policies and regulations influencing the current innovation activities of solar PV. In particular, this study pays attention to the government policy supporting technological innovation and market creation. In addition, this report profited substantially from the knowledge of a few experts and research leaders in the industry and academic field who made themselves available for interviews and other queries. Then followed with several case studies on three countries: Germany, Japan, and the United States, some data were collected to analyze how market entry, product safety, environmental policies, and incentives influence the innovation of PV industry. Finally, we provide conclusion and policy implications on the development of solar PV industry.

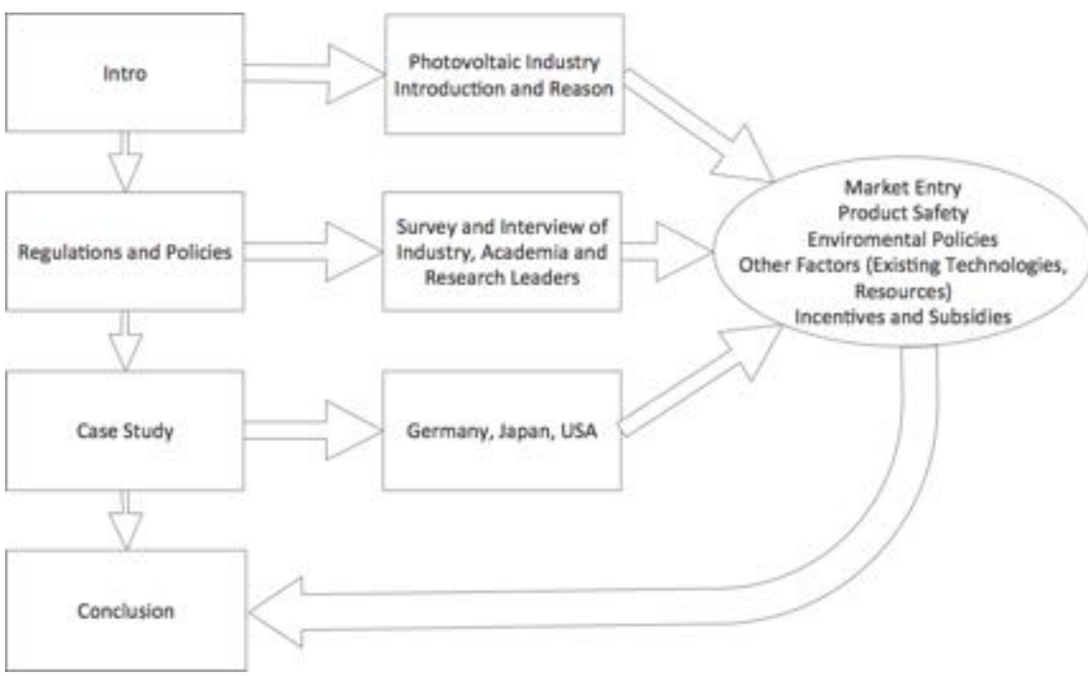

Figure 1. The Flow Chart of the Research

2. Market survey on regulations affecting PV industry

During this phase of the project the team got in touch with experts in this sector to gauge their feedback and discuss further on the factors that affect the growth of this sector. The experts that were contacted were from the industry, academia and Government laboratories. The list of the experts is given below:

Industry	Academia	Government Laboratories
- First solar - Accelerate solar - Midnite solar Inc. - Advanced energy - Solar world - Absolutely Solar Inc. - SEIA - Accord power	- Oakridge National Laboratory - MIT MECHE - WESRF (Wallace Energy systems & Renewables facility) - Portland state university – Sustainability - Penn State – Institute of energy and the environment	- NREL(National Renewable energy laboratory) - Argonne national laboratory - Brookhaven National laboratory - Berkeley Laboratory - Sandia National laboratories

Table 1 Expert panel from Academia, Industry and government laboratories

Telephonic conversations and email correspondence was done over a period of 3 to 4 weeks to discuss and analyze the information provided by the experts. The decision making on this sector was done by the team based of a survey results. The survey that was put together had 2 questions.

1. To rank the factors affecting the sector on a scale from 1 to 5. With 1 being the highest rank and 5 being the least. The factors that were listed were:
   a. Market regulations
   b. Product safety regulations
   c. Incentives and subsidies
   d. Environmental regulations
2. Any other factors affecting this sector.

The results of the survey are as follows:

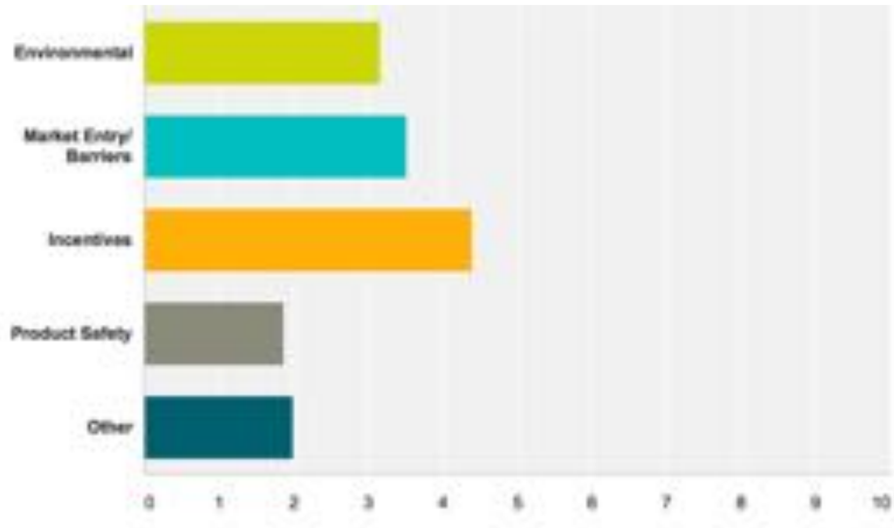

Figure 2 Market survey results

The main comments that were obtained from the survey with respect to each of the regulation is listed below. The majority of the comments were related to incentives and subsidies regulations and was in line with the survey results indicating that the Incentives was the factor that was having the most impact on this sector.

Comments related to Market regulations:

- 'This can be a major problem when talking about grid tie equipment in Hawaii. The utilities throw up road blocks that make it hard for manufacturers to meet their requirements. The features that the utilities demand are in addition to UL and NEC standards. The utility companies are not solar friendly. What they say is not what they do. On the mainland there are utility companies that make it hard to have battery backup grid tie. They think people are going to sell their stored battery power to the grid. This doesn't make sense as it wears out the batteries. Batteries cost more than the utility power', Robin Gudgel, Midnite Solar.

Anonymous comments from the survey related to market regulation:

- Rate mechanisms (different than financial incentives) 4-Grid integration technology
- Permitting fees
- Access to transmission lines is a barrier. I'm not sure where this fits into your classifications.
- regulation of electric utilities
- One of the largest challenges is the inconsistency of local jurisdiction on code requirements.

Comments related to Product safety regulations

'This is a huge cost issue. The NRTL's go overboard on things that don't matter, but they have little choice. The people that make these standards set the rules. There are factors at work that sometimes have little to do with safety although it is rare. We have seen this happening first hand though on emerging standards. We spend a great amount of time and money on agency approvals. We have to do things that are not required in other countries. You have to wonder why? It affects cost of every installation, but we have no choice but to follow the rules. Standards are subject to interpretation and this also costs money needlessly. Standards change and that forces us to spend even more time and money to upgrade our products. That is senseless and wasteful', Robin Gudgel, Midnite Sola

Comments related to Incentives and subsidies

'These things help the solar and wind industry. There wouldn't be much of a solar industry without them. Conservative politicians do not see the benefit of solar so they continue to attempt to kill subsidies. They do not realize how much the oil industry is subsidized. The subsidies are not as visible. I would be all for no subsidies to any industry, but politics will never allow this. Big oil money talks big money. Solar cannot compete in the political arena. My company is heavily involved in the off-grid market where subsidies are not important. If you really need a solar system to light your house, you will get it with or without subsidies. I personally think that every house in America should have a battery based grid tie system installed. People would have more control of their power usage and would be more mindful of waste', Robin Gudgel, Midnite Solar.

Survey results of panel experts related to this regulation:

- Commitment to research funding
- Support both basic and applied research at universities.
- Investment in research and development
- Uncertainty affects growth because it potentially changes the rules. Implementing large incentive programs that flood the market with Renewable Energy Credits waters down the price of credits for those who invested before the "free money" and is lingering disincentive after the "free money" is used up.
- Availability of low cost solar financing
- Research funding
- Standards, Regulations
- Renewable Portfolio Standard (RPS), Interconnection Standards, Solar access laws, training and support, building codes, solar community organizations, utility rate structures, emission requirements, R&D investments, import vs local (e.g. China vs US).

3. Regulations affecting the PV industry

From conducted survey and interview of panel experts it was confirmed original theory of specific policies and regulations affecting growth and innovation in photovoltaic energy. As some policies have direct impact due to involvement of governments by providing subsidies, incentives and research funding, others may provide indirect impact by regulating other traditional sources of energy (such environmental regulations), therefore making photovoltaic sources more cost competitive. Other regulations, which may act as financial burden for new companies entering the market, were also looked at: such as barriers for market entry and product safety requirements. Lastly consideration was also given to countries' available natural resources from existing competition as well as available solar insolation perspectives, infrastructure, and public perception to have a complete picture on a countries competitive position in regards to photovoltaic energy. The data was gathered and comparative research was performed for Germany, Japan, and USA. Regulations and policies in the following areas: market entry, product safety, environment, other factors (existing competition, resources, and infrastructure), incentives and subsidies were looked into.

3.1 Market Regulations. The product market regulations were categorized using the index developed at the OECD (Organization of Economic Cooperation and Development) on a scale from 0 to 6, with higher numbers being associated with policies that are more restrictive and stringent [5]. For each sector, the index combines information on state control (such as price control and ownership) figure 1, barriers to entrepreneurship and administrative regulations (such as licenses and permits, administrative burdens, and legal barriers) figure 2, and barriers to trade and foreign direct investment (such as tariffs and ownership barriers) figure 3. It is evident from figure 4 that all three countries under evaluation have total index scale below 1.3 with USA being the least restrictive at 0.8.

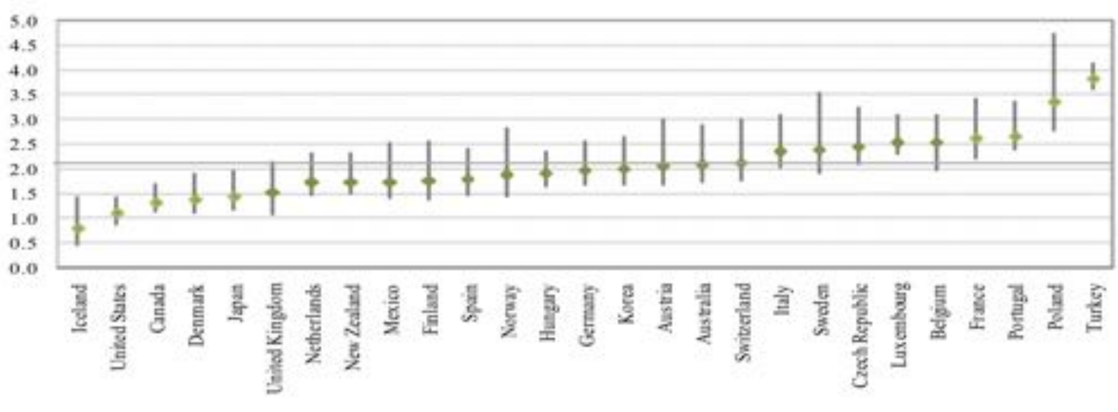

Figure 3. State control [5]

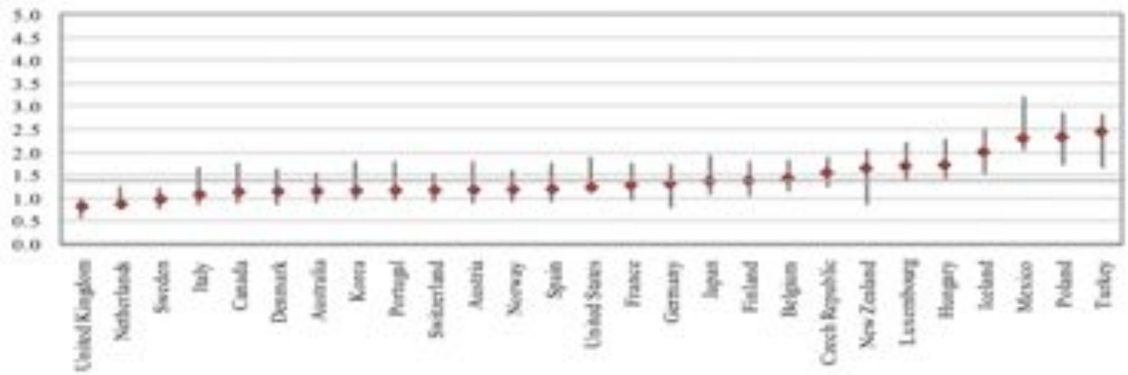

Figure 4. Barriers to entrepreneurship [5]

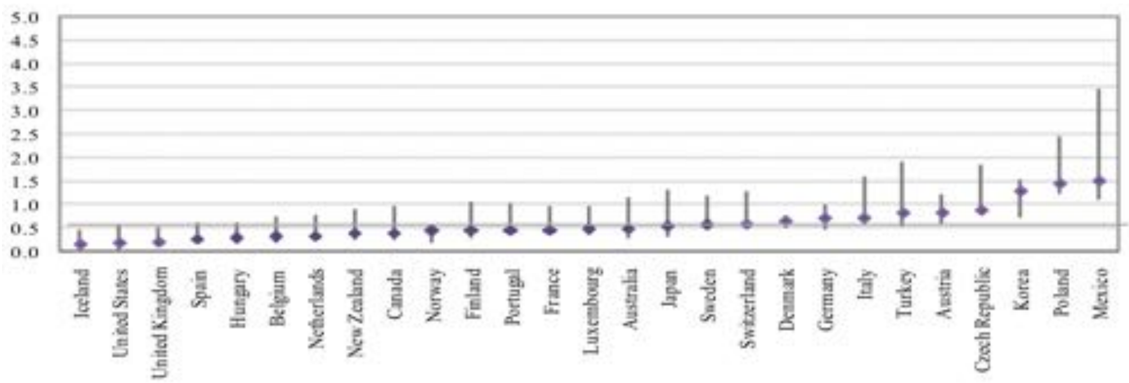

Figure 5. Barriers to trade and investment [5]

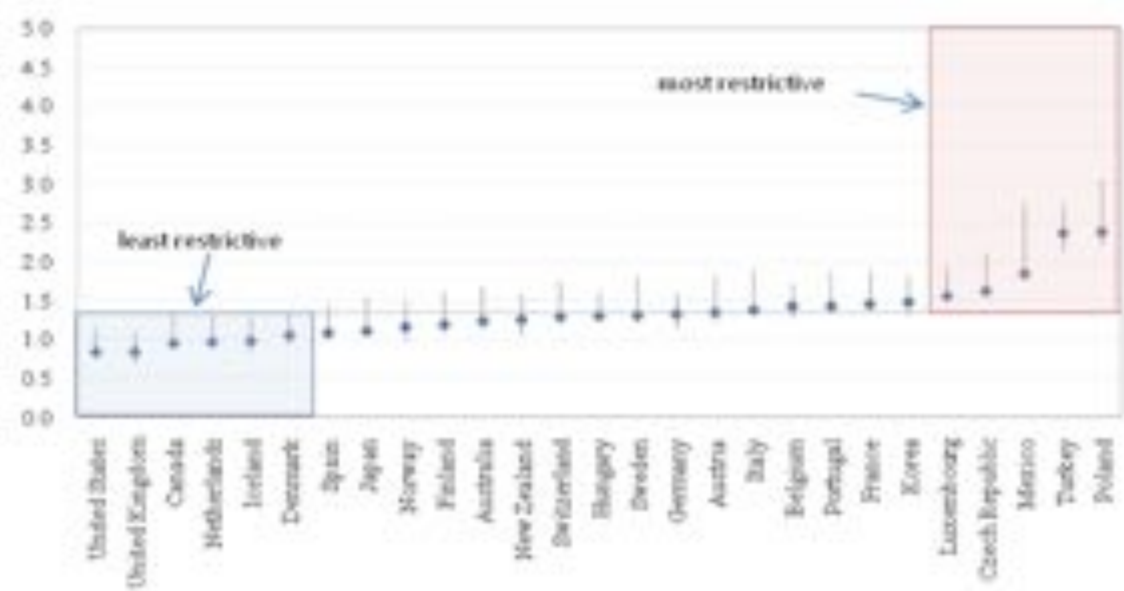

Figure 6. Total index scale for OECD countries [5]

3.2 Product Safety Regulations. Product safety requirements in regards to hazards of electric shock, fire, electromagnetic capability and hazardous substances exist in each country under evaluation. Manufacturer's Declaration of Conformity (CE marked) to applicable directives and national standards with countries deviations is a minimum requirement for all products in the European Union and Japan. Furthermore in Germany and Japan more stringent compliance standards (tested by accredit third party agency such as TUV, VDE, and SEMKO) may be required by the distributors, which is particularly true for photovoltaic products including: modules, inverters and other energy interconnecting equipment. In USA similar requirements being governed by the National Electric Code, and authorities having jurisdiction for all electrical permanently installed products. The code requires that such products (modules, inverters, switchboard panels, charge controllers) to be listed by NRTL (National Recognized Testing Agency: UL, ETL, CSA).

Countries	**Requirement**	**Standards**
USA	OSHA Accredited NRTL: UL, ETL, CSA.	UL 1703, UL 1741, UL 6142, IEEE 1547.
Germany	Self-Declaration CE mark: Low Voltage, EMC, and Machinery. RoHS. Volunteered accredited by GS: TUV, VDE, SEMKO	IEC 60904, IEC 62109, IEC 61400, IEC 61727, IEC 62116, IEC 60364-7-712 With applicable Germany deviations.
Japan	PSE: Safety + EMC	IEC 60904, IEC 62109, IEC 61400, IEC 61727, IEC 62116, IEC 60364-7-712 With applicable Japan deviations.

Table 2. Breakdown of compliance requirements per country.

3.3 Environmental Regulations. Environmental regulations provide indirect positive contribution to photovoltaic industry by setting standards and regulating those sources of energy that produce carbon emissions as their byproduct. According to OECD Environmental Directorate, a broader use of environmental taxation or emission trading system would be one of the most efficient and effective ways of promoting green growth [6]. Taxes on pollution provide clear incentives to polluters to reduce emissions and seek out cleaner alternatives [7]. Figure 5 summaries data of environmental regulations based on revenues generated from environmental taxes. Although it may appear from the Figure 5 that Germany (out of three countries under evaluation) is most regulated in regards to environmental regulations, it's important to note that this graph is based on revenues from taxes, therefore countries energy usage from all sectors need to be taken in consideration. Next section discussed other factors in regards to existing competition, available resources and infrastructure.

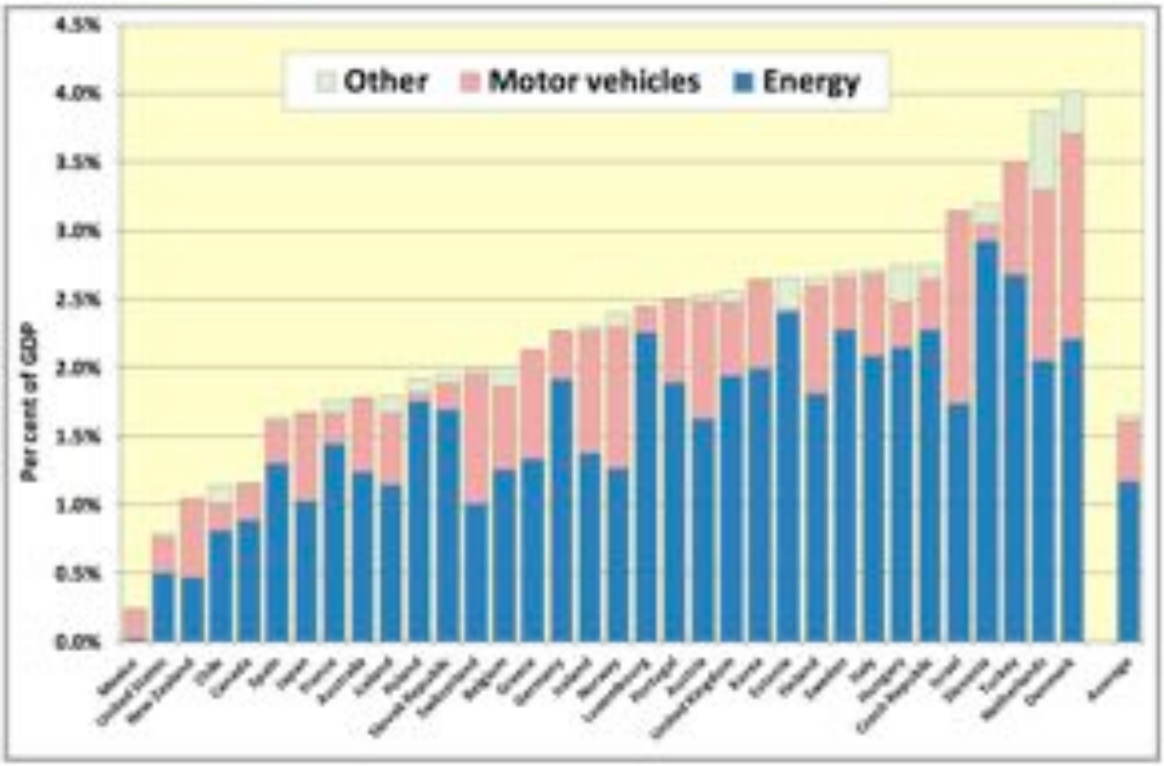

Figure 7. Revenues from environmentally related taxes, in percent of GDP, 2009 [7].

3.4 Existing competition and available resources. Energy available resources, public perception and energy cost playing a significant role in government direction as well as public interests. Table 2 shows countries energy consumption per source, while Table 3 shows net export of fossil fuel energy sources. It's worth to note that although USA net export for petroleum and natural gas is in minus, it is the largest producer of petroleum and natural gas in the world (12,343 Thousand Barrels per Day for Petroleum and 29,542 Billion Cubic Feet of Natural Gas) [8]. From the tables below is evident that USA has overall energy independence comparing to Germany and Japan in regards to natural resources, putting these last two countries in the position to be more aggressive for search of alternative energy resources. Also, negative public perception for nuclear power (which is relatively a large source in Germany and Japan), adds to the trend of renewable energy, making PV more attractive source in Germany in Japan.

Energy Source	**USA, %**	**Germany, %**	**Japan %**
Coal	39	43	21
Natural Gas	27	9.6	17

Petroleum	1	0.6	46
Nuclear Electric Power	19	15.9	11
Hydroelectric Power	7	3.4	3
Geothermal	<1	4.3	<1
Solar/PV	<1	5.8	<1
Wind	4.13	8.6	<1
Biomass	1.48	7.0	<1

Table 3. Energy consumption per source in 2013 [8].

Energy Source	**USA**	**Germany**	**Japan**
Petroleum Net Exports (Thousand Barrels per Day)	-5,137.350	- 2,224.62	-4,559.24
Coal (Million Short Tons)	+919	-56.068	-192.852
Natural Gas (Billion Cubic Feet)	-1,311	-2,400.25	-4,294.69

Table 4. Energy Net Exports per source in 2013 [8].

3.5 Incentives. Incentives are direct policy aim to stimulate the competitiveness and growth of Renewable Energy technologies. Most recently, policy makers have looked to the fast-increasing demand for goods and services associated with renewable-energy as an engine of economic growth. To help boost the rate of development of renewable energy in general or photovoltaic in particular, all three countries under evaluation use market – based instruments that favor electricity generated from renewable energy [9]. Table 4 shows applicable methods of incentives per country with explanation below. In addition to direct subsidies for installation and growth, governments of countries under evaluation have other forms of incentives in regards to funding research and development in an effort to raise the efficiency of renewable energy, improve its reliability, and reduce its costs, which more discussed in the case studies below.

Countries	Feed-in-tariff	Feed-in-premiums	Quota obligation	Tradable Green Certificates	Tax Incentives	Net Metering
Germany	Yes	No	No	No	No	Yes
Japan	Yes	Yes	Yes	Yes	No	Yes
USA	No	No	Yes	Yes	Yes	Yes

Table 5. Available Incentives per country.

Feed-in Tariffs - Renewable energy power investors are paid for the power they supply to the grid. They are offered a long term contract which pays for the power they supply at a rate higher than the rate for traditional sources of energy [10].

Feed-in premiums - Payment level is based on a premium offered above the market price for electricity; this premium can either be constant, or it can vary based on a sliding scale. Developers can enjoy high rewards when market prices increase, but also run a corresponding risk when they decrease; in order to avoid a large divergence between profits and losses, it can be designed with payment caps and/or floors [10].

Renewable Portfolio Standards/Quota Obligation - Regulation set by government where utility companies are obligated to generate a certain percentage of their power from renewable sources [11].

Tradable Green Certificates - These are tradable certificates awarded for the generation of a given amount of power from solar sources [12].

Tax Incentives – Federal Tax credits for development and deploying of renewable energy technologies.

Net Metering - A billing Mechanism where electricity generated by consumers and fed in to the grid is used to offset electricity consumed by the consumer [13].

4. Case study: Photovoltaic sector in Germany, USA, Japan(1990-2015)

To look further into this sector the overall ranking of the countries based on Solar Energy generation activities by MW and other factors such as solar intensity, GDP, and population was considered. Patent activities in the Green patent family EPO (European patent office), PCT (Patent Cooperation Treaty) and USPTO (United States Patent and Trade mark office) were looked into. The country that emerged as the leader in the solar photovoltaic energy generation was Germany by producing nearly 27% of the total power generated using this technology. The 2 other countries that were studied were United states as the country leads in patent activity in this domain and also contributes to 11% of the total solar power generated globally and Japan which falls close behind US with a contribution of 10% of the total solar power generated from photovoltaic.

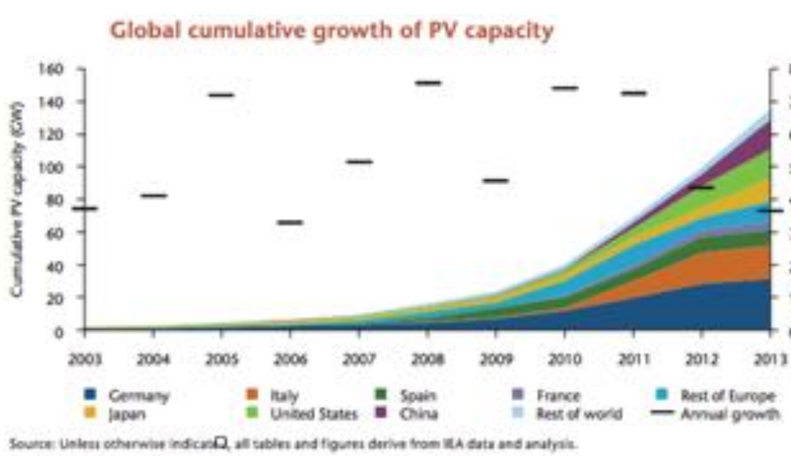

Fig. 8 Global cumulative growth of PV [14]

Fig. 9 PV contribution percentage [15]

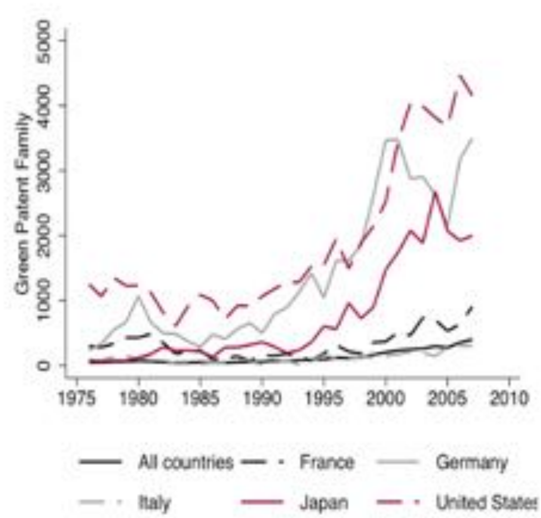

Figure 10. Patent activity [26]

4.1 Case study 1: Japan

The Japanese photovoltaic (PV) market is expanding rapidly. As can been seen in figure 2, by 2013, the installation of PV was over twice the amount in 2011, which places Japan among the world's largest PV markets, along with Germany, China, and the United States [2]. The national and local governments have implemented a variety of policy measures to support the innovation and diffusion of solar PV technologies in Japan (Major policies are summarized in table 1). These policies can be divided into two sections: demand-side and supply-side.

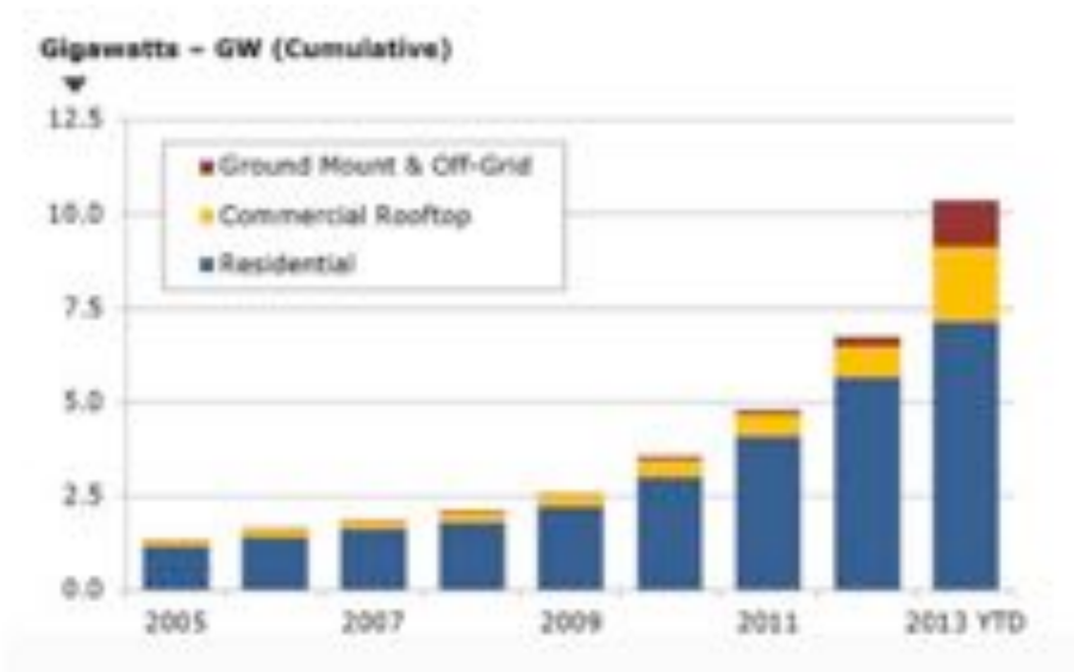

Figure 11. Cumulative solar PV installed in Japan at the end of August 2013 (shown as 2013 YTD) Source: NPD Solarbuzz Asia Pacific PV Market Quarterly

Demand-side policies could be used to "create a new market and develop demand for a new technology," including subsidies for purchase of "a particular product, tax breaks, and renewable portfolio standards." [1] For example, in July 2012, Japan introduced the Feed-in-tariff, which requires utilities to pay renewable energy producers a fixed price per kWh of production over a period of 10-25 years. Purchasing tariffs are reduced on annual basis but may be adjusted if deemed necessary. For PV systems smaller than 10 Kilowatt (KW), the government guarantees a purchasing rate of 37 yen (FY 2014) per each Kilowatt-hour (KWh) for a time period of 10 years while systems above 10 kW receive a purchasing tariff of 32 yen (FY 2014) per kWh (excluding taxes) for a contracting period of 20 years granted for the total electricity production. The Japanese Fit will remain in place until 2021 with a revision of the scheme conducted every three years [3].

Supply-side policies are used to encourage firms to directly conduct innovation activities, including subsidies for R&D, illustration, and sometimes in in early phases of commercialization [2]. For example, In the 1970s, the scarce local fossil fuel reserves and multiple issues associated with acquiring oil from foreign countries motivated the Japanese government to pursue the development of solar PV technologies. In 1974, the government launched the Sunshine Project, focusing on the development of solar cells and modules, which opened up an opportunity for most of the Japanese solar manufacturers, such as Hitachi, Toshiba, and NEC Corporation, to be involved in solar PV research and development (R&D). From 1993 to 2000, an additional R&D program, called the New Sunshine Project was launched to develop the BOS technologies with the funding from the Japanese government (BOS: balance-of-system, including inverters, mounting equipment, monitoring systems, and site assessment). As Figure 3 shows, the solar cells prodction had increased significantly since 1974. These national research and funding programs contributes to both the technological development and the growth of solar PV market in Japan.

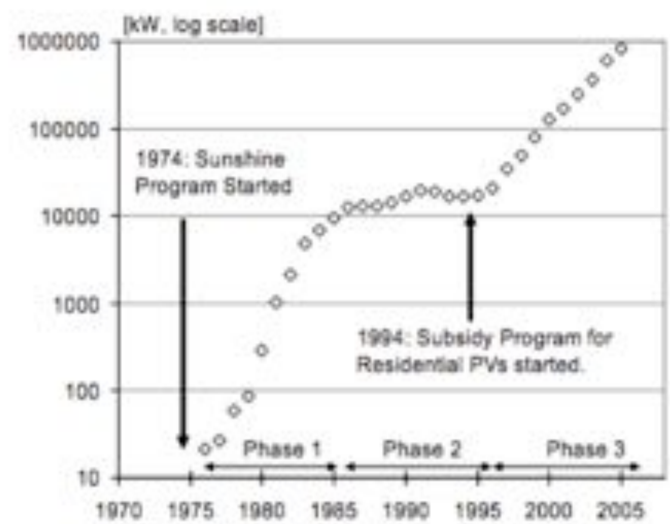

Figure 12. Trend of solar cells production in Japan, 1976-2005

Source: IEEJ (1985) and RTS Corp. (2006)

Demand-side policies		
Year	Policy	Notes
1974-2006	National residential subsidy	First phase: 1994-1996 Second phase: 1997-2001 Third phase: 2002-2006 (March)
1997	Act on special measures for the promotion of new energy use	Financial support for the business operators who use the new energy including solar energy

2003	Renewable Portfolio Standard	Requiring electricity retailers to supply a certain amount of renewable electricity to grid consumers
2009	National residential subsidy resumed	National residential subsidy will end in 2014
2012	Feed in tariff	Electricity utility companies are obligated to purchase excess electricity generated through PV facilities

Table 6: Summary of Major Policies related to Solar PV Technology (Demand side)

Supply-side policies		
Year	Policy	Notes
1974	Sunshine Project	A national R&D project for "new energy" including solar energy
1980	Establishment of the New Energy and Industrial Technology Development (NEDO)	Act on the Promotion of Development and Introduction of Alternative Energy
1993-2000	New Sunshine Project	The successor of the Sunshine Project
2001-2005	NEDO 5-year plan	Development of technology to achieve 482,000 kW of installation of PV by 2010
2004	NEDO Roadmap 2030	Direction of photovoltaic technology development toward 2030
2009	NEDO Roadmap 2030+	Update of the Roadmap 2030

Table 7: Summary of Major Policies related to Solar PV Technology (Supply side)

As seen in Fig 11 Japan's PNV industry witnessed a remarkable growth in 2013 after the establishment of the Feed in Tariff program in 2012. The Feed in Tariff has been known to result in rapid growth in the renewable energy market in areas where it has been implemented. The Japanese government had one of the most generous Feed in tariff rates in the world and they did not anticipate the growth that resulted as a result of the program. The infrastructure to handle the amount of solar power produced was not in place and as a result the utility companies were overwhelmed and have started blocking access to the grid for new power solar generation and the country has since reviewed the programs and reduced the support. [27]

4.2 Case study 2: Germany

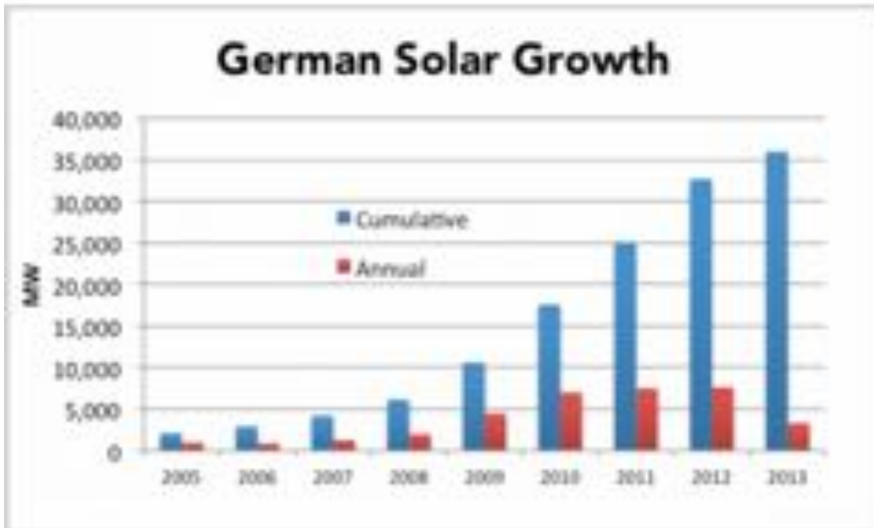

Figure 13. German solar sector growth [25]

Solar power in Germany consists mostly of photovoltaic (PV) and accounted for an estimated 6.2 to 6.9 percent of the country's net-electricity generation in 2014[15]

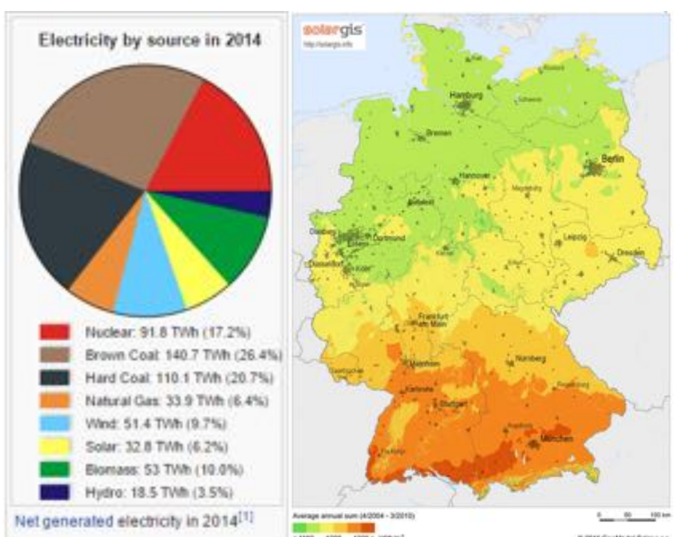

Figure 14. Electricity production in Germany and Germany Solar capacity [15]

Germany is the world's top PV installer with an overall installed capacity of 38,359 megawatts (MW). The renewable energy sector contributes nearly 31% of the total electricity produced in the country. The German government long term minimum targets of renewables' contribution to the country's overall electricity consumption are 35% by 2020, 50% by 2030 and 80% by 2050.

Factors affecting growth in solar sector:

There are three incentive mechanisms are used (often in combination) which include investment subsidies in which the authorities refund part of the cost of installation of the system, Feed-in tariffs (FIT) where the electricity utility buys PV electricity from the producer under a multiyear contract at a guaranteed rate and Solar Renewable Energy Certificates (SRECs). There is also a good public awareness of the PV technology in the country which also largely contributes to the success.

Government regulations in Germany:

Precursor of the Renewable Energy Sources Act was the Grid Feed-In Law (Stromeinspeisungsgesetz – StromEinspG). It only had 5 sections and did not even cover 2 pages in the Federal Law Gazette. It entered into force 1 January 1991, and was used as a model for many later feed-in tariff laws around the world.

By 2000, the Stromeinspeisegesetz was replaced by the Renewable Energy Sources Act (EEG 2000), now containing 12 sections and an annex, covering 3.5 pages in the Federal Law Gazette. The remuneration in the EEG 2000 then was already quite differentiated. Its feed-in tariffs for PV systems were rapidly increased to further promote solar power. In 2004 the EEG was amended. A substantial modification was the improved legal status of operators of renewable power plants vis-à-vis network operators. Additionally, the feed-in tariffs were modified.

The next major EEG revision lead to the EEG 2009, which in turn was revised 7 times. Only three years later the again revised EEG 2012 entered into force. The amended EEG 2012 intended to encourage direct marketing. The EEG 2012 provided that producers of renewable electricity also had the option to market the electricity themselves, without receiving the fixed feed-in tariffs paid under the EEG. Instead they could claim a market premium (Marktprämie) in addition to the revenue obtained by the sale of the electricity. Boom period in Germany was during 2010-2012. More than 7 GW of PV capacity had been installed annually during this period. Due to the large amount of electricity produced the country is currently facing grid capacity and stability issues, The country is increasingly producing more electricity than it requires for consumption driving down spot-market prices and exporting its surplus of electricity to its neighboring countries (record exported surplus of 32 TWh in 2013 and 34 TWh in 2014)[16]. New installations of PV systems have declined steadily since 2011 and continued to do so throughout 2014. It's estimated that about half of the country's jobs have been lost in the solar sector in recent years. Proponents from the PV industry blame the lack of governmental commitment, others point out the financial burden associated with the fast paced roll-out of photovoltaic, rendering the transition to renewable energies unsustainable in their view. As of 2012, the FiT costs about €14 billion (US$18 billion) per year for wind and solar installations. The cost is spread across all rate-payers in a surcharge of 3.6 €ct (4.6 ¢) per kWh (approximately 15% of the total domestic cost of electricity). Amendments in the **German Renewable Energy Act** (EEG) post boom period has reduced **feed-in tariffs** and set constraints on utility-scaled installations, limiting their size to no more than 10 MW.

The legislative reforms stipulates a 40 to 45 percent share from renewable energy sources by 2025 and a 55 to 60 percent share by 2035. The current version of the EEG only guarantees financial assistance as long as the overall PV capacity has not yet reached 52 GW. It also foresees to regulate annual PV growth within a range of 2.5 GW to 3.5 GW by adjusting the guaranteed fees accordingly [15].

4.3 Case study 3: USA

US SOLAR INNOVATION TIMELINE

Innovation in Solar Technologies began as far back the 7th century and has continued down to this day. Just like with the PC industry, there has been development and milestones achieved that has opened way for new opportunities and growth in the industry. The US has recorded a tremendous growth in research and development in the PV sector, also noteworthy is the increase in the number of solar technology related patents in the US. The activities in the sector have been stimulated by the government's dedication to promoting growth in the sector by supporting research and development activities which would drive low cost and improve efficiency of Solar PV systems. A timeline of US Solar Innovation is shown below [22].

- 1955 Researchers at Bells lab overcome difficulty to create 6% efficiency PV
- 1959 Manufacturers hit 10% efficiency
- 1970 Western electric patents coating for solar cells
- 1972 Institute of energy conversion formed
- 1977 Department of Energy formed
- 1978 California passes solar right act
- 1980 Manufacturers break 1 MW barrier PV module in one year and IEC exceeds 10% efficiency
- 1985 Stanford produces 25% efficiency cell
- 1986 First commercial thin film solar module produced
- 1993 Utility company installs first PV distributed system
- 1994 NREL develops 30% efficient cell

- 1996 National Center for PV created
- 1998 Million Solar Roof initiative
- 2000 First Solar builds world largest PV manufacturing plant
- 2011 Sunshot initiative announced

PV Growth in the US

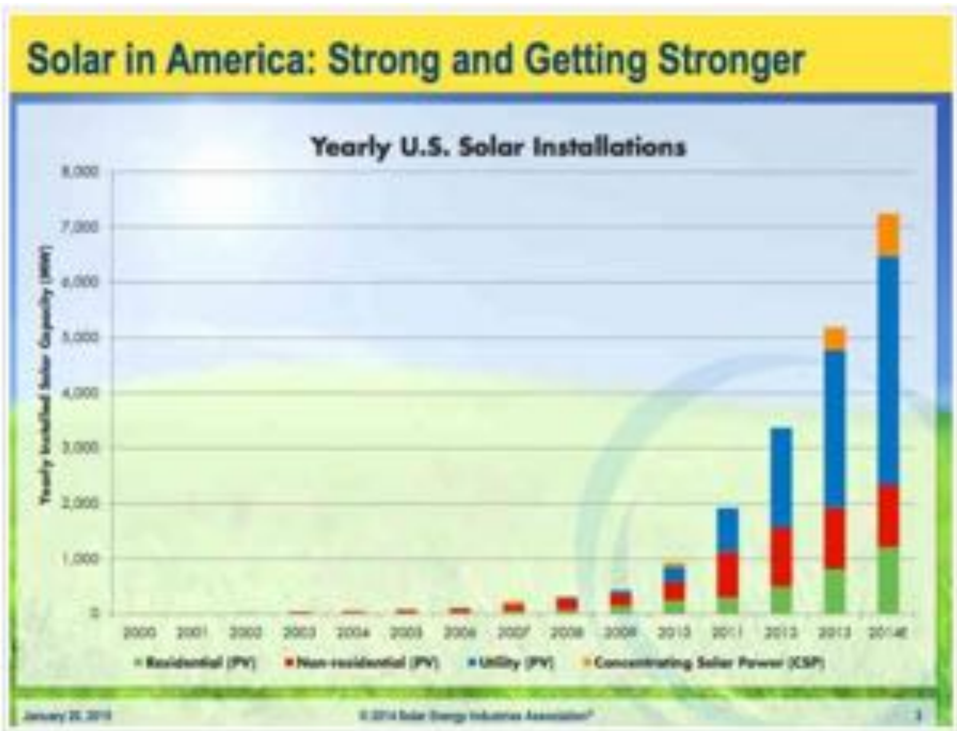

Figure 15. US PV MARKET GROWTH TREND [24]

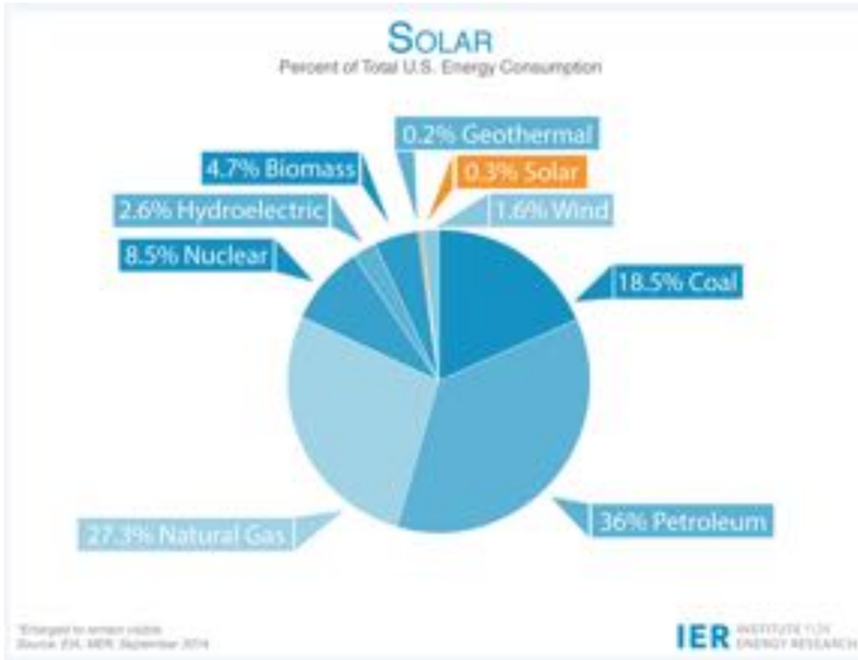

Figure 16. US Total Energy Consumption by Source- 2014[25]

Source: Institute for Energy Research

There has been tremendous growth in the US PV industry in the last 4 years especially in utility and residential PV installation. FIG 1 shows that 2014 witnessed a growth that was about three times what it was in 2011 and seven times what it was in 2010. In the first half of 2014 over half a million home owners and businesses had installed solar PV and solar represented 36% of new energy that came online in 2014 [17].

Solar energy accounts for 0.3% of the total energy consumed in the US. The capacity of utility scale solar has increased from 334.2 megawatts in 1997 to 6,220.3 megawatts in 2013[23]

One reason for the tremendous growth in the US PV sector in the last few years is the presence of low cost PV modules from Japan in the US market, although this has increased the installation of solar systems, US manufacturers have been impacted, the US government imposed tariffs on PV systems from China, leading Chinese manufactures to outsource PV manufacture to Taiwan.US manufacturer have petitioned the government to impose tariffs on Chinese PV systems from Taiwan , a local PV manufacturer in the Hillsboro Oregon area- Solar World is in the fore front of this struggle ,

Another reason for the growth in the sector is government Incentives .Most governments at the state and federal level offer incentives to spur investment in the renewable energy sector. These incentives make investment in the in renewable energy sector more appealing for public and private entities. Incentives are mostly financial and are in the form of loans, grants, tax deductions or exemption [18]

US Federal Incentives

Incentives offered by the federal government to encourage growth in the PV sector include

Grants

- Tribal Energy Grant program-provides funding for tribes to develop community and commercial– scale renewable energy projects
- USDA –Rural Energy for America Program (REAP) and Energy Audit an d Renewable Energy Development Assistance (EA/REDA)Assists agricultural and small rural businesses with development and setup of energy efficiency and renewable energy systems

_**Loan Programs**

- US Department of Energy –Loan guarantee Program-Provides loan for new or improved technologies that reduce air pollution
- FDA Power Saver Loan Program Provided by the Federal Housing Authority to provide assistance to homeowners for energy efficiency and renewable energy upgrades
- Qualified Energy Conservation Bands and Clean Renewable Energy Bonds- These bonds are used to finance renewable energy projects [19]

Tax Incentives

- Corporate Tax Credit
- Business Energy Investment Tax
- Renewable Electricity Production Tax credit
- Corporate Tax Exemption
- Personal Tax Credit
- Residential Renewable Energy Tax Credit
- Personal Tax Exemption
- Residential Energy Conservation Subsidy Exclusion

State Incentives

The United State is an amalgamation of 50 states with political processes, electricity prices and each state has developed their unique set of incentives and regulations to stimulate growth in their various PV sector state incentives Include

- FIT-The feed in tariff-This incentive has been proven to stimulate explosive growth in the renewable sector in areas where it is implemented, so much growth that the regulation has to be constantly reviewed, The feed-in tariff or some variation of it existed in California, Hawaii, Maine, Oregon, Rhodes Island, Vermont, Washington as at 2013[20]
- Rebate for purchasing Renewable Generation equipment
- Renewable Portfolio Standards to ensure that utility companies generate a percentage of power from renewable sources
- Net metering -Power produced by consumers and supplied to the grid is used to offset the power he consumes
- Tax Incentives

Another important factor promoting the growth in the US PV market is Research and Development

Research and Development

The US government has not been as aggressive as Germany and Japan in their use of Subsidies as Incentives. Although the Feed-in Tariff has been adopted in some states it has never been a Federal Initiative in the United States of America. The US have chosen a slightly different approach to pursue growth in the PV industry, given the fact that the cost of solar power is very high even in Germany and Japan where it has been widely adopted, the US is actively and aggressively involved in research and development in Solar Technologies to drive down costs and increase efficiency of Solar systems, A number of programs have been established to help with this

Sunshot Initiative

The sunshot initiative was established by the Obama administration in 2011, it involves a ten-year plan by the Department of Energy aimed at making competitive solar power a reality. The plan is to reduce the cost of solar power and bring it to par with other traditional sources of power by 2020.

They goal is to drive this through innovation in manufacturing, installation and market solutions. Less than halfway through the project lifetime over half percent of the goals have been accomplished and solar power had reduced to 11cents/kwh [5]. However the goal of 6cents /kWh by 2020 seems rather ambitious considering the fact the China currently has the lowest cost in the world and their low cost is driven by government subsidy rather than innovation. The solar industry in China is heavily subsidized by the government; this is a strategy by the government to make China the world leader in the PV industry. If the US is able to drive low cost by innovation, this would cause explosive growth in the US PV market.

5. Conclusion

In addition to standard differences in overall technological levels and life standards, reviewed regulations and policies although appear to be important do not completely explain cross-country differences in innovation.

The research showed that incentives and subsidies play major role in emerging technologies during the initial process of “jump starting” the industry, however on time transformation from directly subsidizing a somewhat mature industry to investments in Research & Development (Academia and Industry), and Public Education (Environmental Policies) is a critical step in innovation. As it appeared in case with Germany, a simple bulking up of capacity in installation of PV and other renewable energy sources, didn’t translate into patent growth or reduction in cost, but rather had an opposite effect (refer to summary table below), due to excessive feed-in tariffs and grid management problems. Additionally, Germany's carbon output and global warming impact is actually increased despite increased in PV energy capacity, due to utilities being forced to use of dirty coal power because it’s only a non-subsidized power source.

Country	Solar Energy Capacity in GW in 2011	Solar Energy Patents Global % in 2011	$/kWh in Cents in 2011	2009 – 2014 CO2 Emissions %
Germany	35.5	6.1	35	+1.2
Japan	13.6	34.1	26	+1.3
USA	12	14.1	12	-3.4

The combination of policies, market and product safety deregulation is very effective method of inducing innovation in emerging technology such as PV energy, however extent and aggressiveness of this policies should depend a country's resources, infrastructure and existing competition. Additionally, product safety regulations may set higher standards in efficiency, safety and reliability positively effecting innovation.

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