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SolarWorld Amidst Uncertainty

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Executive Summary

Solar energy is turning out to be a widely accepted renewable energy alternative. It is considered as the cleanest and abundantly available source of energy. Adoption of this source for energy generation has been made possible by technological advancements. The United States has realized the potential of the solar energy but hasn't been able to exploit the technology until recently. Since 2009, the US has seen a significant growth in consumption of solar energy. Efficiency of solar cells, tax credits, state policies, increasing public awareness on environmental pollution have resulted in increasing use of solar energy. Although a key reason for this growth has been declining prices facilitated by cheaper and efficient imported modules. American solar cell manufacturers are unable to compete with cheap and efficient imported modules and have sought the help of the International Trade Commission (ITC) to impose tariffs on them. Although tariffs would help these two failing manufacturing companies, it could negatively impact the growth of the solar industry as whole. This report studies the impact of the ITC verdict on the solar industry and SolarWorld and also proposes the direction of the outcome considering social, technological, environmental, economic and political aspects.

Introduction to Solar Energy

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis [1]. Our sun is a natural nuclear reactor. It releases tiny packets of energy called photons, which travel the 93 million miles from the sun to Earth in about 8.5 minutes. Every hour, enough photons impact our planet to generate enough solar energy to theoretically satisfy global energy needs for an entire year.

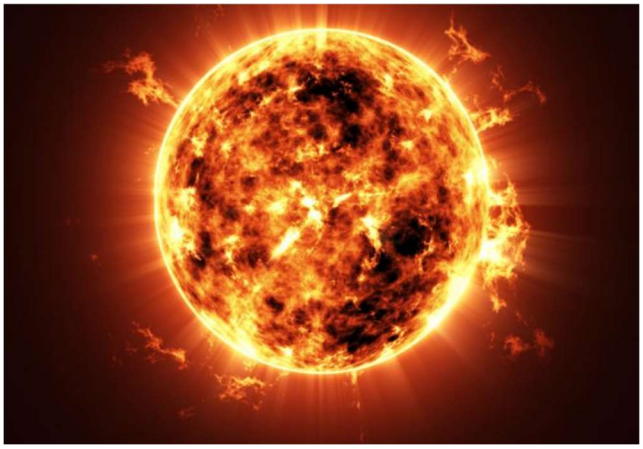


Figure 1 Sun – the most abundant energy source

It is an important source of renewable energy and its large magnitude of solar energy available makes it a highly appealing source of electricity. The United Nations Development Programmed in its 2000 World Energy Assessment found that the annual potential of solar energy was 1,575–49,837 EJ. This is several times larger than the total world energy consumption, which was 559.8 EJ in 2012 [2]. A 2017 report from the International Energy Agency shows that solar has become the world's fastest-growing source of power – marking the first time that solar energy's growth has surpassed that of all other fuels. In the coming years, we will all be enjoying the benefits of solar-generated electricity in one way or another.

When photons hit a solar cell, they knock electrons loose from their atoms. If conductors are attached to the positive and negative sides of a cell, it forms an electrical circuit. When electrons flow through such a circuit, they generate electricity. Multiple cells make up a solar panel, and multiple panels (modules) can be wired together to form a solar array. The more panels you can deploy, the more energy you can expect to generate.

Introduction to SolarWorld

SolarWorld Americas (Referred to as SolarWorld) is a Solar PV Module manufacturing company in America with a state-of-the-art headquarters facility in Hillsboro, Oregon. They are credited to be the longest solar manufacturing company in the US operating for more than 40 years. The company is responsible for the production of hundreds of megawatts of solar cells and panels each year. Since 2008, SolarWorld purchased more than $1.5 billion in equipment, parts, services and supplies all over the US, mainly in California and Oregon [3].

Figure 2 SolarWorld

SolarWorld Americas was a subsidiary to SolarWorld Ag which is a German company headquartered in Bonn, Germany and is a pioneer in the manufacture of solar cells, wafers, PV modules and systems. The parent company filed for insolvency in May 2017 but was bought by Qatar Solar Technologies to form SolarWorld Industries GmBH with assets being re-acquired by the owner Frank Asbeck, making it the first solar energy industry to be completely free of debt and liability. The company has production facilities and distribution in Europe, Asia and Africa [4].

SolarWorld has seen a decline in their sales and distribution due to heavy competition from foreign companies flooding the market with cheaper alternatives. The Economist quotes that solar-panel installations in America climbed by 350% from 2012 to 2016, but imports rose by 500%. (The Economist). As a result, the company reduced its headcount from 800 to 300 in June 2017 as it was on its way to but was rescued from its parent company who agreed to provide $6 million [5]. SolarWorld joined Suniva in May 2017 to petition for adding tariffs on imported goods, mainly from China and Malaysia. The company officials mentioned that they were unable to compete on price and even the most loyal customers were cautious due to the financial uncertainty.

Solar Energy trends in the US

Traditional fossil fuels remain dominant source of energy generation in the US. Renewable energy sources such as wind, solar and other account for less than 20% of total energy generation. Although solar energy consumption shares a very small portion in energy generation (less than 1%), the growth in solar sector over past eight years has been significant. As shown in the graph, solar energy consumption has remained steady since 1985 to 2008. From 2009, solar energy consumption has grown ten folds. The growth in solar sector has been attributed to different factors such as State policies, tax credits, public awareness. Although one of the key factor that has led to an increased solar energy consumption is reducing cost of solar panels. As per a report from Solar Energy Industry Association (SEIA) the cost of PV price has reduced from $7.5/watt to $.46/watt. The reduction in the prices has resulted an increase in PV installation capacity from 700 MW in 2009 to over 14000 MW in 2016.

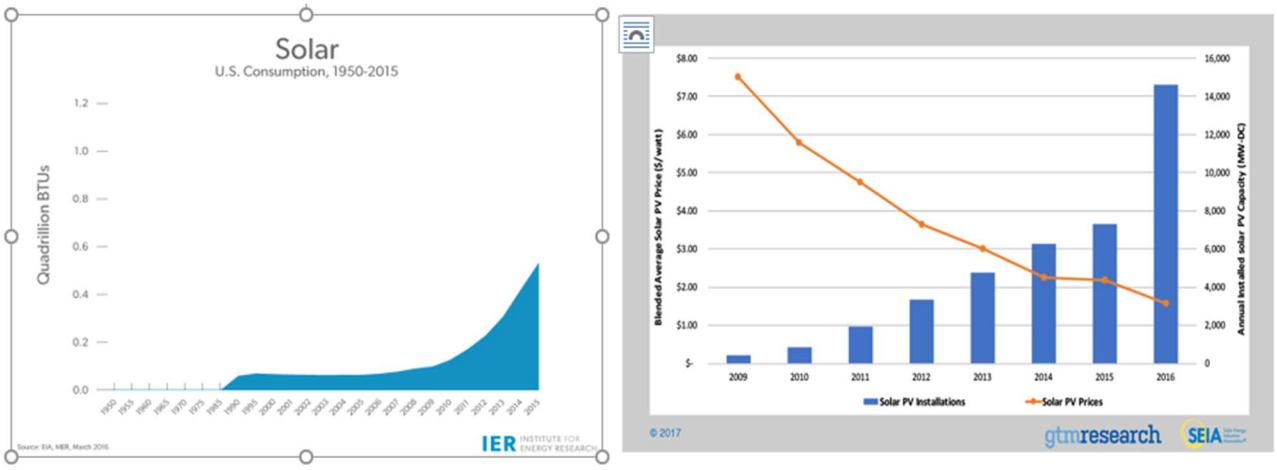


Figure 3 SolarEnergy trends

Among growth in solar energy consumption, residential sector which involves roof top (small scale) solar installations has shown significant growth over industrial sector. Solar energy consumption reached 0.15 quadrillion BTU in 2015 from 0.08 quadrillion BTU in 2012 [6]. California leads in residential (Small scale) solar energy generating 684GWh of electricity. Industrial consumption has almost doubled since 2012 although shows less consumption than residential solar. Projections made by US Energy Information Administration show an increased consumption of solar energy [7].

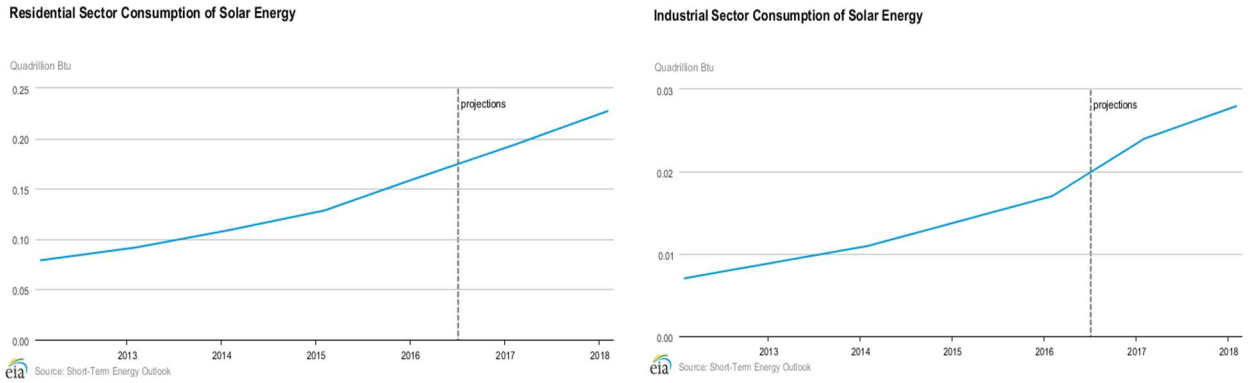


Figure 4 Solar energy consumption in the US

The booming solar industry has been facing a challenge in the form of tariffs. In 2017, International Trade Commission ruled in favor of Suniva and SolarWorld agreeing that import of solar panels is hurting US based PV manufacturers. As a result, tariff if imposed on these imported panels, will drive a price hike for these panels. Analysts are predicting that a price hike will double the price of PV cells and modules. Increasing solar market has created a rapidly growing industry: construction and installation. The industry has employed over 260000 jobs. The industry has created 25% new jobs in 2016 compared to its previous year. As per a study conducted by SEIA, a price hike in solar cells and panels will hurt the market and may lead to losing thousands of jobs in 2018 [8].

Overall, solar industry is going through volatile times. After seeing an accelerated growth in past eight years, it is facing tariff challenges by some manufacturing companies like Suniva, SolarWorld. Suniva and SolarWorld are struggling to compete with the reduced solar cells/panels prices which are imported in the US. Companies like Tesla, which are building largest solar cells and panel manufacturing plant in the US are not bothered by tariffs [9]. SolarWorld America's parent company SolarWorld AG has already filed for insolvency. As per a letter sent by SolarWorld to state department, SolarWorld had planned laying-off most of its employees at Hillsboro Oregon location, which were expected to be 711 [10]. This decision was taken before SolarWorld joined the petition for imposing the tariffs. On the other hand, if the tariffs are imposed a thriving industry in the form of construction and installation of solar panels will get affected. It is predicted to cost jobs for around 90,000 workers. The situation has divided solar industry into two parts. Panel manufacturers and installers. Policy makers must decide if they want to save handful struggling manufacturers or an entire growing industry! We aim to address this question "A company or an industry" though the present study.

"To Save a Company or an Industry?"

This report uses STEEP analysis to analyze the implications of the verdict on the fate of the booming industry and on the failing manufacturing companies.

STEEP analysis

The STEEP Analysis is a method used in marketing to analyze the macro-economy of the firm to determine which factors can influence its success. STEEP is an acronym for [11]

- Social
- Technological
- Economic
- Ecological
- Political

The STEEP analysis was used as a means of determining what perspectives mattered most while making the choice of saving a company or industry. All the five perspectives were chosen to focus on and briefly discussed and described as follows:

Social Perspective

The social aspect of STEEP analysis covers important factors like human's lifestyle, social benefits and consumer behavior. [11]

Technological Perspective

The technology aspect of STEEP analysis focus on the technological benefits in general. It is including factors such as innovation, transport, research and development. [11]

Economic Perspective

The economic aspect of STEEP analysis covers consumers' buying position. It is including factors like interest rate, international trade, taxes, saving, and availability of jobs. [11]

Ecological Perspective

The ecological aspect of STEEP analysis deal with environment developments. It is including ecosystem factors like pollution, environmental regulations, energy, water, wind and food. [11]

Political Perspective

The political aspect of STEEP analysis focus on factors like regulations of monopolies, political stability, tax policies, price regulations consumer protection and trade unions. [11]

In the next section, we look at each of these aspects and the implications on the industry and on SolarWorld.

Social Aspects

The social aspect section covers employment, public acceptance, energy independence and public health benefits.

Employment

Recent years have seen a boost in American solar industry jobs as a result of increased demand and lower costs. According to the Solar jobs census for 2016, solar industry employment growth creating over 51,000 jobs, one out of every 50 new U.S. jobs created in 2016 was in the solar industry. With the US government implementing policies to get the economy and employment in America back on track, this steep growth promotes their policy. While those numbers are staggering, the solar energy industry is at a crossroads in the West, with the petition for tariffs on imported solar panels under current investigation, and many opinions on both sides of the matter. [12] [13]

While SolarWorld claims that the requested tariffs will create over 100,000 new jobs in the solar industry, many other energy professionals and researchers have disagreed, stating that reduced prices from cheaper Chinese and other Asian imports have driven the recent growth. For example, the Solar Energy Industries Association estimates that the US solar industry would lose 88,000 jobs in 2018 if the tariffs are imposed. [12] [13]

A Goldman Sachs states that helping companies like SolarWorld at this point is protectionism, and could increase costs for utility projects by an estimated 30 percent, resulting in higher prices across the board. “We expect solar installations would fall precipitously in the U.S. on the back of lower returns,”. [14] Many Commentators have suggested that if we can focus more on *installation and maintenance*, and less on manufacturing and panel production, solar energy may grow well beyond its current 2% market share of the energy sector. With Eastern manufacturing making solar cheaper, employment in the West is at risk if we continue to compete at the production level. With cheap imports from Asia, western workers are still needed to plan projects, build and develop the facilities, and implement solar solutions. The challenge is to provide jobs in the long term, including those for displaced workers from other sectors. [14]

Public Acceptance

Public acceptance is needed to adopt any new development in energy, and for companies like SolarWorld, this is crucial for their continued growth and success.

Although public acceptance for solar energy is high, there are skepticisms regarding the adoption of solar solutions on a large scale, especially after a number of high-profile bankruptcies of solar

companies. To a degree, this is why solar still remains a small percentage of the overall energy sector. [15]

With the costs of imported panels decreasing, public acceptance will continue to increase as solar becomes more affordable. If the price goes back up as a result of tariffs, stagnation in the industry is likely. In addition, the public should look at the bigger picture of how overall solar growth can benefit public health, the environment, and the national economy. [15]

One example of this use of marketing is found on the SolarWorld website, where the copy reads, "Maximize your solar investment with proven, American-made quality, reliability and durability—the best solar panels made right here in the USA" (SolarWorld). This strategy will only go so far if the prices continue to rise for local production. The bottom line is that a new business model that focuses on installation and maintenance would still allow American companies to provide solar solutions, but without emphasis on production. [16]

Energy Independence

Another social factor of solar energy adoption is increased energy independence, both on a national level and in terms of individual homes and residences. The less we rely upon foreign and complicated sources for local energy needs, the more self-reliant we can become in the long run. The price of electricity has continued to rise over the years, and is expected to rise at greater rates in the years to come. Part of the reason for this is the maintenance and rebuilding of old power infrastructures. Adopting solar could offset some of these costs and provide a more independent future for energy consumers. [15]

Public Health Benefits

Public health benefits for adopting solar energy on a larger scale include everything from increased air quality and water preservation to lower cancer rates and longer lifespans. According to the U.S. Department of Energy, solar power could deliver $400 billion in environmental and public health benefits throughout the United States by 2050, as public health issues have direct economic impacts (DOE 2016). For health in particular, the most notable benefit, according to the DOE, "comes from reducing premature mortality from sulfate particles". This reduces overall respiratory and cardio health issues and creates a higher quality of life. In 2014, for example, the DOE determined that overall benefits from the 20 GW installed that year exceeded $700 million and had a potential range of $200 million to $1,000 million (DEA 2016). Again, while health benefits are quantifiable, they are also a qualifiable as the means to a healthier public overall. Whatever decision the government makes in regard to the petition, these health issues should be taken into consideration. [17] [18]

Technological Aspects

Types of Solar Technology:

Photovoltaics (PV)

Solar cells, also called photovoltaic (PV) cells, convert sunlight directly into electricity. The process of conversion is done by PV effect. The PV effect was discovered in 1954 at Bell Telephone when scientists discovered that silicon created an electric charge when exposed to sunlight [19].

Over the time, there were different types of solar cells. These variance in cells depend upon the purity of silicon used in its making. The more perfectly aligned the silicon molecules are, the better the solar cell will be at conversion. There are two major categories of solar cells namely, amorphous and crystalline solar cells.

Amorphous solar cells are made up of amorphous silicon which is the non- crystalline form of silicon. It is the well-developed of the thin film technologies having been on the market for more than 15 years. It is widely used in pocket calculators, but it also powers some private homes, buildings, and remote facilities. Major reasons which makes it popular is it requires much less silicon which makes it much cheaper in the market. But a coin have two faces, it is much less efficient and uses much more roof space. It's yet another advantage is that it performs better in low light conditions, when there is partial shading of the system or in extreme heat.

Coming over to the more widely used and first generation crystalline solar cells. It is the crystalline forms of silicon, either multi-crystalline silicon consisting of small crystals, or monocrystalline silicon, a continuous crystal. Crystalline silicon is the dominant semiconducting material used in photovoltaic technology for the production of solar cells [20]. Crystalline solar cells further have different composition of silicon which classify them into monocrystalline and polycrystalline solar cells.

Monocrystalline silicon is a form in which the crystal structure is homogenous throughout the material; the orientation, lattice parameter, and electronic properties are constant throughout the material [21]. Polycrystalline or also called multi-crystalline silicon is composed of many smaller silicon grains of varied crystallographic orientation, typically >1 mm in size.

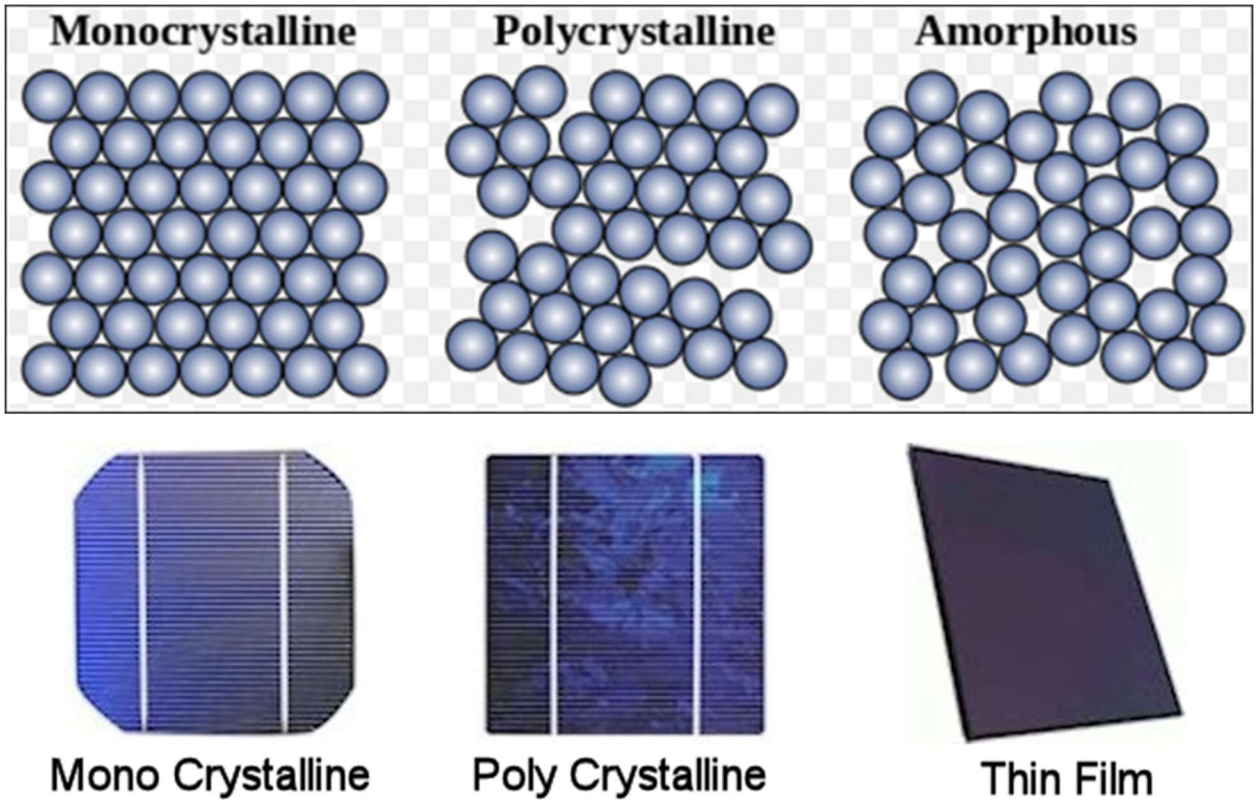


Figure 5 Schematic of allotropic forms of Silicon [20]

Each type has their own advantages and disadvantages over other. There are various factors which people need to consider while choosing the right product. However, as per the current market trend crystalline solar cells are much preferred over thin-film solar cells for various reasons. Some of them are discussed below.

Firstly, crystalline modules need far less surface/roof area – and roof space is very valuable real estate when it comes to solar energy related electricity production. Secondly, some amorphous thin film panels actually need more mounting rails and take longer to install; adding to the overall cost of the system. Also, thin film offers a lower level of embedded energy per panel, the fact that more panels are needed somewhat negates this aspect, especially given the extra mounting rails sometimes needed. Embodied energy refers to the amount of energy required to manufacture and supply a product. Thirdly, some thin film solar products uses cadmium telluride (CdTe). Cadmium is a heavy metal that accumulates in plant and animal tissues. So, disposal of such toxic waste creates environmental problems.

Moving further into crystalline modules gives us two choices to choose on – mono and poly. It is important to understand both sides of each modules.

Monocrystalline Solar Cells	Polycrystalline Solar Cells
Advantages: Ø More Efficient Ø Space Efficient Ø Longer lifespan	**Advantages:** Ø Cost Effective Ø Temperature tolerance
Disadvantages: Ø Expensive Ø Temperature tolerance Ø Shading Issues	**Disadvantages:** Ø Less Efficient Ø Less Space Efficient Ø Shorter lifespan

Figure 6 Advantages and Disadvantages of solar cell types

Monocrystalline solar panels are slightly more expensive, but also slightly more space-efficient. If you had one polycrystalline and one monocrystalline solar panel, both rated 220-watt, they would generate the same amount of electricity, but the one made of monocrystalline silicon would take up less space. Both monocrystalline and polycrystalline solar panels are good choices. It would be nearly impossible to recommend one or the other by not examining the solar panels and ones situation closer.

Concentrated Solar Power (CSP)

Concentrated solar power systems generate solar power by using mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Electricity is generated when the concentrated light is converted to heat which drives a heat engine connected to an electrical power generator or powers a thermochemical reaction [22]. Heat storage in molten salts allows solar thermal plants to continue to generate after sunset and adds value to such systems when compared to photovoltaic panels [23].

Solar Power Storage

One of the main limitations shared by solar power is that there is no control over when the system will be producing energy. In the case of solar power, investors also know beforehand that their asset will only generate energy during daytime. Thus, it is important to store the solar power generated in order to use it at odd times too. There are three emerging technologies that could become viable energy storage solutions for solar power in the near future namely smart batteries, heat-based energy stored and hydrogen fuel cells [24].

The principle behind smart batteries is that surplus production from solar power systems is stored in batteries and used when it is needed or when it is considered convenient. Batteries equipped with automation technology and installed throughout multiple homes and businesses could be used

in a coordinated fashion to mitigate peaks in grid demand. Lead-acid batteries currently dominate the market.

Heat-based energy storage technology is commonly used in thermal solar power plants, which are based on heat concentration through mirror arrays rather than on photovoltaic panels. Then, the stored heat is used to vaporize water and drive a steam turbine and electric generator set [24]. Whereas hydrogen fuel cells consist on using the electric output from a renewable energy system for a process called electrolysis, in which water is separated into hydrogen and oxygen.

Consequences of pending Verdict

Currently there is an intense competition by cheap imported solar panels from China and other Asian manufacturers to US manufacturers. Due to significant price difference between imported and US solar panels of identical technologies, the market is captured by the imported goods. This is bankrupting US manufacturing companies as they cannot stand in the market against such artificial lower prices. Due to this, they cannot even finance the future technological advancements in the manufacturing process of panels.

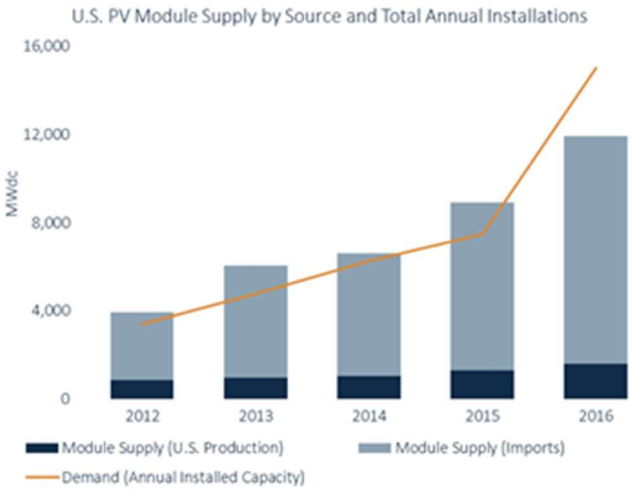
So in order to stand in the market on the fair basis, this petition should be approved. This will help these companies to progress and invest more in the technological advancements. If this petition fails, it will be an uphill task for US manufacturing companies but will have bright skies for solar ecosystem. Though US solar installation and leasing companies are not much impacted with this petition as they are not much concerned about the manufacturers of panel, they are just getting the panels and doing their job done.

Economic Aspects

This section highlights the economic implications of the tariffs on the solar energy market in the US. There are 3 key points to be considered – demand, jobs and government involvement.

Demand

The United States renewable energy market is booming. 2016 saw a remarkable growth in renewable energy generation and consumption in the US, accounting for around 15% in energy consumption and 10% in electrical consumption. Out of this, 2% was comprised of solar energy. Even though it does not seem significant, solar energy market has grown substantially as highlighted in the Solar Energy trends earlier in the report. Studies by SEIA indicate that solar energy capacity in the US has reached almost 40 GW as of Q2 2017 [25] with experts forecasting the capacity to rise up to 72 GW within 2022.



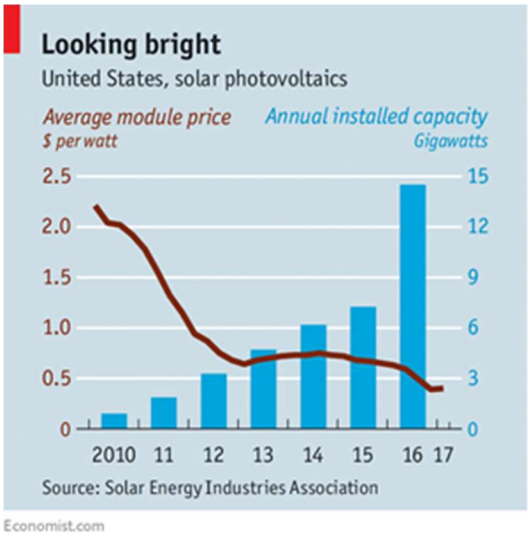


Figure 7a Falling prices and growing demand

Figure 7b: Supply vs Demand [26]

The main reason for the growth of solar energy over the past few years is due to the demand and the demand is a direct consequence of a substantial decrease in the solar panel prices. Since 2010, the price has reduced from around $2.25 per watt to less than $0.5 per watt as shown in the statistic from the Economist.

The improvement in prices (in terms of price per watt) over the last few years can be attributed to 2 factors – the efficiency has significantly improved over the last few years as highlighted in the Technology implications subsection of this report and also that the market has been flooded with cheaper imports. A study by GreenTech media concludes that in 2016, 87% of the installed solar energy systems were using imported modules [26].

A key component of the demand uptick in the recent years has been the fact that big businesses are investing in solar energy with most of them installing solar panels on the roof of their facilities. These businesses are "turning to the sun" for their energy needs citing declining costs of solar energy. In 2016 alone, solar energy consumption rose from 300MW to 1GW. The top 5 corporations that have adopted solar energy are Target (147 MW), Walmart (145 MW), Prologis (108 MW), Apple (94MW) and Costco (51 MW) [27]. Walmart was leading the pack until 2016 when Target took over the top spot. Target's goal is to increase its number of buildings with rooftop solar panels to 500 by 2020. The retailer currently has 300 buildings equipped with panels.

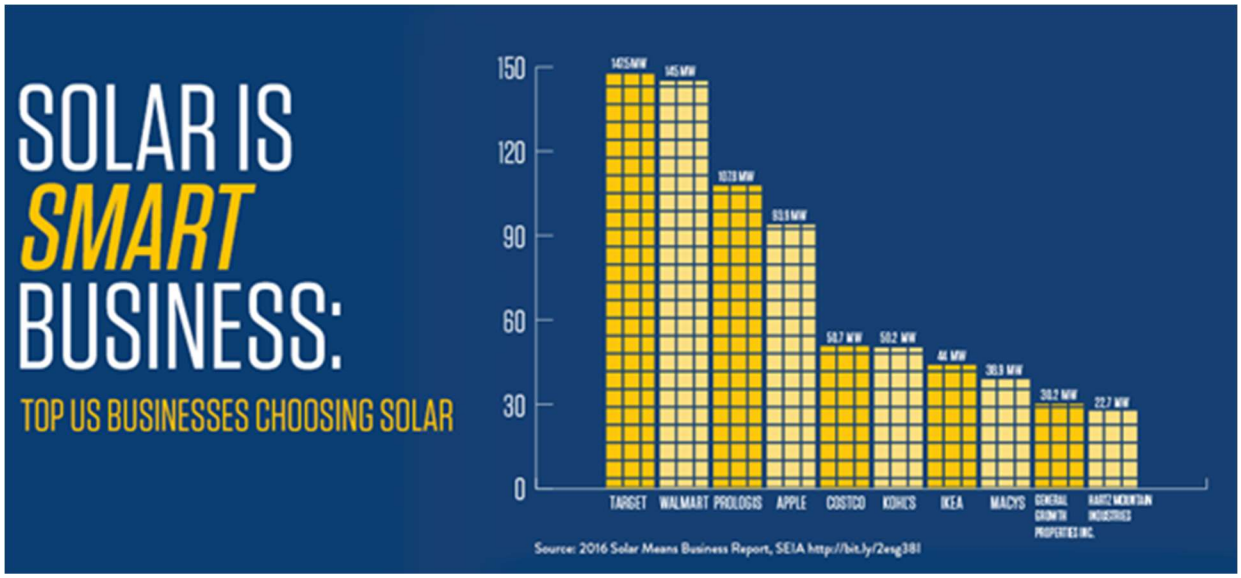


Figure 8 Top 5 businesses adopting solar energy

But, the future looks bleak due to the outcome of the verdict. It is estimated that the panel prices are expected to rise up by around 15% which would cause the demand to reduce by as much as 66% [28]. GreenTech media reports that if these tariffs are imposed, the forecast for solar energy installation in the US in 2018-2022 would drop from 72.5GW to 25 GW.

Jobs

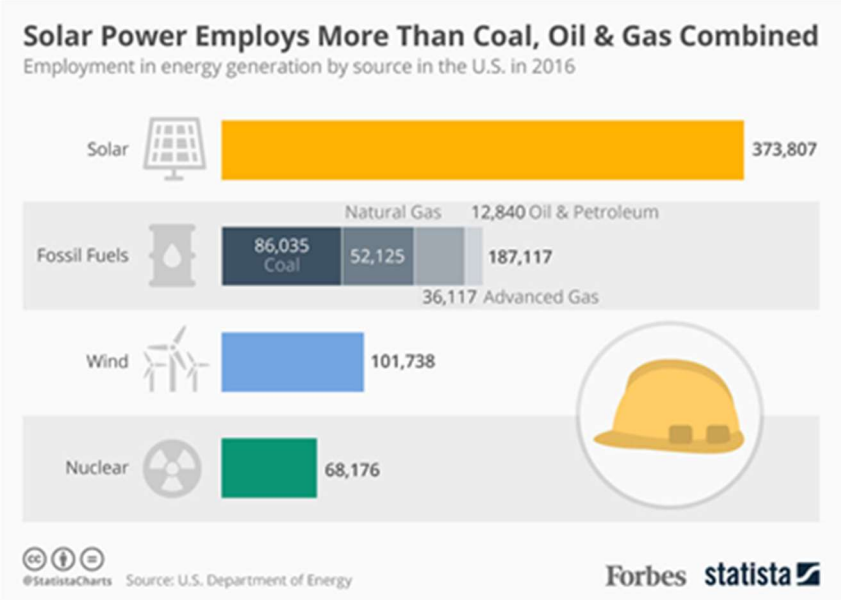


Figure 9 Jobs in energy 2016

A direct consequence of the rising demand of solar energy in the US is the rise in jobs. A study revealed that in 2016 Solar industry employment growth outpaced that of the overall U.S. economy

by 17 times as it increased by over 51,000 jobs, for a total of 373,807 U.S. solar workers [29]. Of the 374,000 workers employed in solar firms, 260,000 spend majority of time on solar while the rest of them work part-time. This was a 25% increase from the previous year. One out of every 50 new U.S. jobs that were created in 2016 was in the solar industry. The number of solar jobs increased in 44 of the 50 states in 2016 with California employing the most solar workers, followed by Massachusetts, Texas, Nevada, and Florida as shown in the figure [30]. Women represented a greater proportion of the solar workforce than in previous years, rising from 18.7% in 2013 to 28% in 2016 [31]. A survey conducted by the University of Massachusetts found that a $1 million investment in solar yields 14 jobs whereas the same investment only yields around 5-7 in coal or natural gas [32].

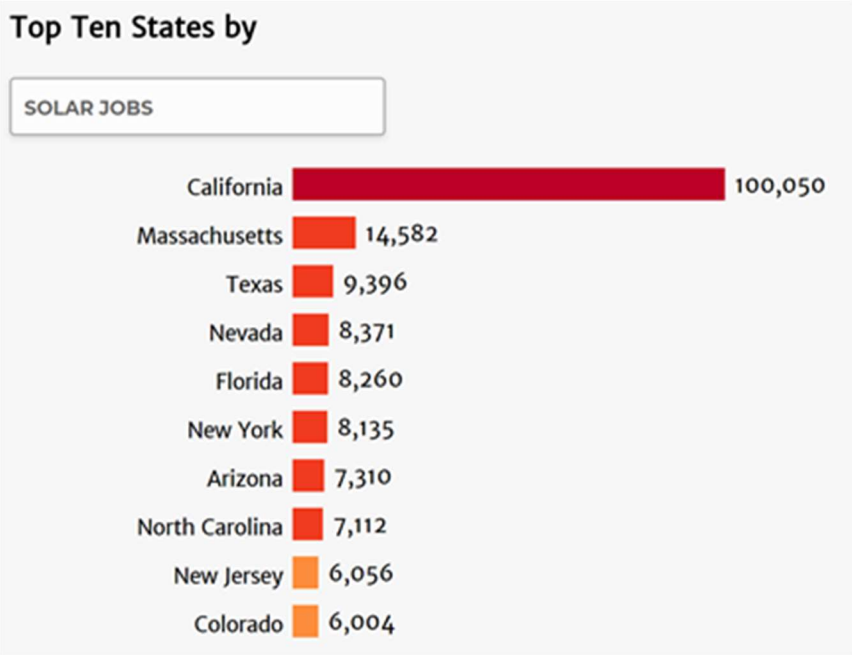


Figure 10 Top 10 states employing solar workers

Of the 260,000 workers in the industry, workers who install rooftop solar panels made up the largest share employment in the sector at 137,133 jobs [33]. Manufacturing was a distant second with 38,121 jobs, followed by 34,400 in project development, and 32,147 in sales and distribution according to the report [29].

As with demand, there are dark skies ahead. SEIA estimates that the US solar industry would lose 88,000 jobs in the next year alone if the tariffs are imposed on “the deluge” of imports [34]. Although Suniva and SolarWorld claim that their trade case would create more jobs, with the installation market making up more than 50% of the solar energy industry and demand expected to fall, the verdict is expected to have a severe negative impact on the solar energy job market in the United States as predicted by SEIA.

Government involvement

With the increase in demand for renewable energy resources, especially solar energy, it is critical for both the US government and the consumer to ensure that the growth is supported by the government. For the consumer, it is essential for government involvement to ensure tax relief. For the government, in addition to job creation and economic stability, it is essential to meet carbon emission targets to address environmental and other externalities [35].

There has been a heavy reliance on tax credits for adoption of renewable energy sources in general. In the realm of solar energy, tax credits have played a vital role in adoption in the US as systems were initially expensive. But even though solar energy systems are more cost-effective today, residential and commercial usage still receive government subsidies in the United States. The Renewable Energy Tax Credit decreases the tax liability of solar energy users. A taxpayer can claim a credit of 30% of qualified expenditures for systems that serve an occupied space. The U.S. government applies the same credit to wind and geothermal systems [36] but with the demand for solar energy steeply increasing, tax credits could help maintain the speed of adoption.

Carbon emission targets

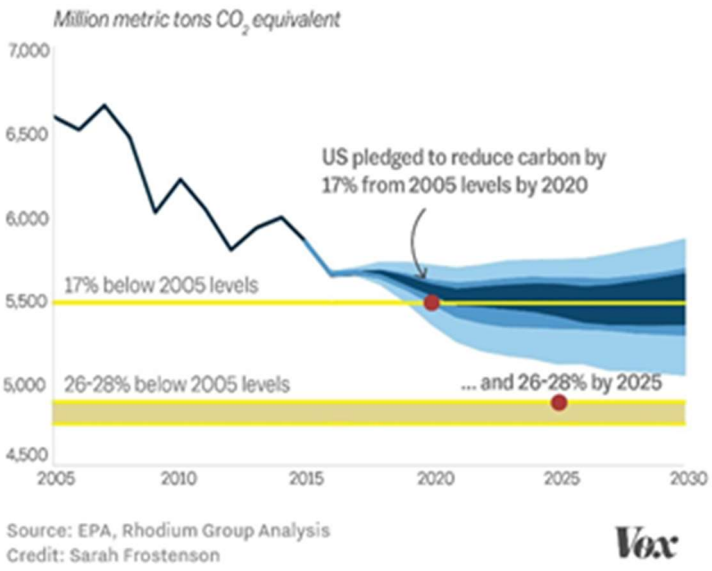


Figure 11 Carbon emission targets set by America in the Paris climate agreement

Most governments have set reduced carbon emissions targets. The economic damage caused by carbon emissions is measured by a metric called the "social cost" of carbon. It is a very influential figure that is used by policy makers to articulate the value of steps taken to stop climate change. A study conducted by Stanford University estimated the value to be $220 per ton, 6 times higher than what the US government estimated [37]. Not only does solar energy help achieve carbon

emission targets but it also cuts down on the "social cost" of carbon. This can save a lot of outgoings which can be used elsewhere [38].

Like every country involved in the Paris climate agreement, the United states had also pledged carbon emission targets – 17% reduction from 2005 levels by 2020 and 26% reduction by 2025 [39]. While there has been a momentum built due to various policies in the past, America is likely to meet its target for 2020 as shown in the graph with the blue shading representing uncertainties in the forecast.

With the current President of the United States backing out of the Paris climate agreement, it seems highly unlikely that the United States is going to achieve its 2025 carbon emission targets. The demand declines forecasted for tariffs being imposed could transform the situation from improbable to impossible. As highlighted by Steve Cohen in his article on Huffington Post, "It's a great paradox that the moment the United States needs government the most, we don't seem to have one anymore." [40]

Environmental Aspects

Environment and Solar Energy

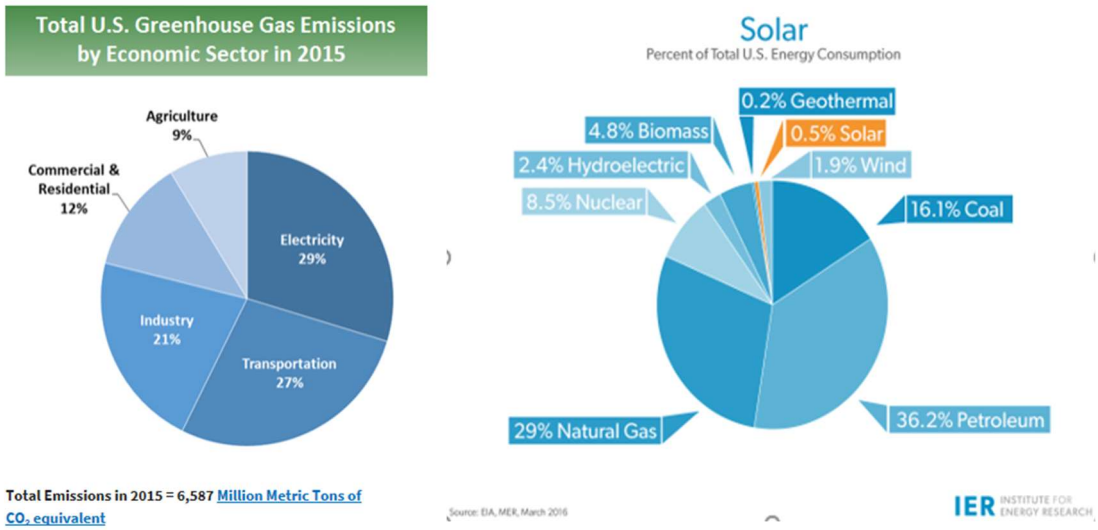


Figure 12 Consumption vs emission charts

Energy sector is leading in greenhouse gas emissions (GHG) in the United States. In 2015 energy sector led to 29% of total GHG emissions. Currently 67% of the energy is generated using fossil fuels such as coal, natural gas, petroleum [41]. Burning fossil fuels come with a price which is increasing levels of GHG in the environment. The US is the second leading GHG emitter in the world. With increasing population and increasing energy demands from emerging economies such as China, India it has become necessary to consider increasing share of renewable energy sources in overall energy generation. Solar is one of the renewable energy resource which can generate electricity with reduced harmful emissions in the environment.

Currently solar energy generation share is less than 1% in the US [42]. The trend in solar energy consumption has been increasing in the US especially since 2009 [7]. Reducing cost of solar panels and government policies have played a big role in increasing trend solar energy consumption [6]. As described in earlier sections, Suniva and SolarWorld have successfully filed for a petition to impose tariffs on imported solar panels. In this section we will discuss the environmental effects of the decision.

Under the scope of the present study, effects of solar energy on the environment will be mainly analyzed for GHG emissions in the environment. We have followed following steps to assess the effect of solar energy on the environment.

1. Reviewing Life Cycle Assessment (LCA) on PV technology
   a. LCA on crystalline silicon solar panels
   b. Comparison with LCA outcome from coal
2. Estimation of emission reduction by switching to PV solar energy
   a. Estimate carbon emission using solar technology and fossil fuels
   b. Estimate emissions that have been prevented using solar energy

Review of LCA of PV Solar Energy

PV technology is considered virtually free from fossil fuel consumption and GHG emission during its operational phase. Although a comprehensive life-span ranging from raw material extraction to recycling after decommissioning has shown some carbon footprint associated with the PV technology. LCA is a helpful tool which can assess different phases in the life of a solar cell and evaluate overall carbon footprint for the technology [43]. For the present study the authors are comparing carbon footprint from energy generation using PV technology and fossil fuels. The focus of LCA is PV technology using crystalline silicon, the most commonly used PV technology in the US (~77%) and is target for increased tariffs.

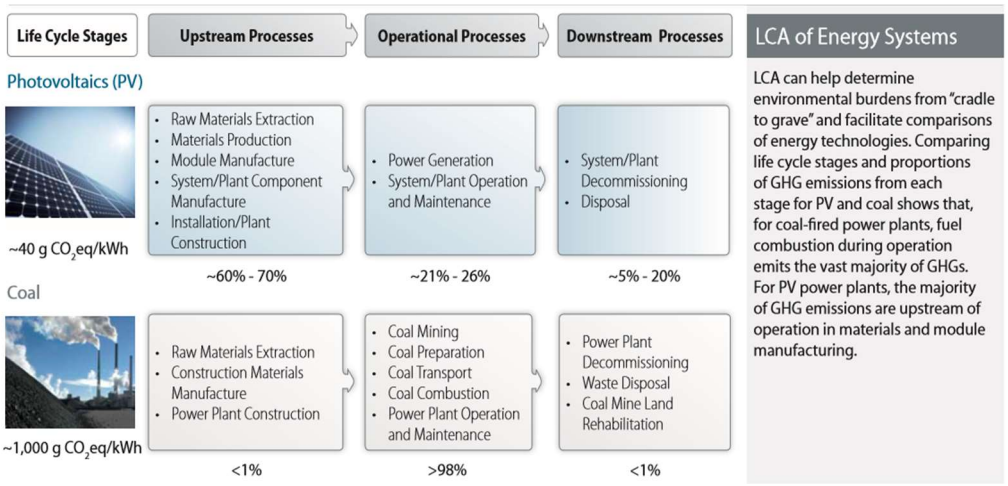


Figure 13 Life cycle analysis of PV cell

A variety of studies have been conducted performing LCA on PV technology. Although the results vary significantly depending on type of technology, efficiency, manufacturing methods, and more parameters. Considering variability in the results, a comprehensive study conducted by National Renewable Energy Laboratory (NREL) was considered for comparing results from LCA studies. The study conducted by NREL harmonizes the parameters such as an irradiation of 1700kWh/m2/y, system lifespan of 30 years, module efficiency of 13.2% to 14% and performance ratio. The different phases in the life span of a PV module were differentiated as: Upstream Processes, Operational Processes and Downstream processes. As shown in figure upstream processes such as raw material extraction, material production, plant construction lead to maximum carbon emission accounting for 60-70% of total carbon footprint. Operational phase emissions are much lower than upstream processes.

Coal on the other hand generates 25 time more carbon equivalent (1000 g CO_2eq/kWh). The results from the study mentioned here are associated with crystalline silicon technology and are more suitable for an irradiation of 1700kWh/m2/y, a value representing region such as Southern Europe. If similar approach is applied for Southwestern US irradiation values will change to 2400kWh/m2/y leading to an even further reduction in carbon footprint. Thus, considering overall phases in the life-cycle of coal and PV, PV propose an environmentally sustainable mode of energy generation [43].

Estimation of emission reduction by switching to PV solar energy in the US

As we discussed in the paper earlier, since 1985 use of solar energy has increased ten folds [44]. In this section, we will estimate how much carbon has been prevented from emitting in the environment because of solar energy consumption in the US. Considering scope of the study we have made following assumptions: Firstly, calculations are limited for CO2 and no other greenhouse gases. The carbon emission does not take into account losses occurring in lines, thus

Carbon footprint using PV technology = 40 gCO2/kWh

Carbon footprint using coal = 1000 gCo2/kWh

In 2015 1.46×10^{11} kWh of electricity was consumed using solar technology.

Carbon emissions in 2015 using PV technology

(40 gCO2/kWh) x (1.46×10^{11} kWh) x (10^{-6} metric tons/g)

5.85 MMT

(1000 gCO2/kWh) x (1.46×10^{11} kWh) x (10^{-6} metric tons/g)

146.0 MMT

Thus, in year 2015 emissions prevented from emitting in the environment can be estimated to be (146.0 MMT – 5.85 MMT) = **140.15 MMT of CO_2**

Figure 14 Carbon footprint estimation

assuming that all the energy conversion is without any losses. We are assuming that all the electricity generated by solar technology is using crystalline silicon solar cells

Let's do some math using results from previous section on carbon footprint for coal and solar. For simplicity let's limit carbon footprint only for year 2015. Chart below describes calculations performed for estimation of prevented carbon emissions using PV technology.

As per EPA overall GHG emissions for year 2015 were 6587 million metric tons of CO2 equivalents [44]. The carbon emission prevented from releasing in the environment as calculated above are 2% of total emissions for year 2015. Currently solar energy consumption is approximately 1% of total energy generation. If a percentage of energy generation using PV technology can reduce 2% of total carbon emissions, expanding scope of PV technology can lead to a significant reduction in GHG emissions in the environment.

Tariffs and the environment

Solar energy shares a very small portion of total energy generation in the US, although its rate of consumption is increasing since 2009. Increase in solar share in energy generation so far has been attributed to State policies, tax credits, increasing efficiencies of solar cells, and reducing prices. Residential solar which involves roof top installation has grown more than triple since 2014 increasing PV capacity from 2.68GW to 8.5GW [6]. As discussed in the earlier sections if the tariffs are imposed on imported solar cells, their prices are predicted to double. Analysts are predicting that these increase in prices will distract people away from solar energy consumption and erode 75% of solar energy demands [9]. These actions will lead in collapsing solar industry's achievements so far and raise environmental emissions. In 2017 Climate Change Conference which occurred in Bonn, Germany scientists predicted that carbon levels reaching record high levels in 2017 [45]. In the backdrop of increasing carbon levels, it would be irresponsible to move away from energy sources like solar energy and switch back to traditional fuel.

Political Aspects

Figure 15 Earth's energy resources

The issue of resources has plagued nations since the realization that they are limited. There have been subsequent local and tragically global wars fought over resources ever since. Energy resources, which are vast yet finite have lead the stats on reasons for discord. Historically energy resources have been comprised of fossil fuels (oil, gas, and coal), nuclear power, and running water (hydroelectric). While the first two of these resources are nonrenewable. The last, water along with solar and wind are renewable and obtainable in some degree anywhere on our planet.

Financial gain, power and political influence have been indivisibly tied to non-renewable resources. However renewable resources have been viewed as a socioeconomic equalizer. As with any industry whether it's for humanitarian or profitable intentions, regulation and infrastructure are necessary. To harness the sun's energy, the wind's velocity, and water's kinetic energy you need tools. Tools cost money and profits are to be made. Enter that same age old controversy – where to make the most money and control the resources.

Figure 16 Solar installation industry

In the US, we've been leading solar research for 134 years. In 1883 New York inventor Charles Fritts created the first solar cell by coating selenium with a thin layer of gold, granted he was working with a margin of 1% efficiency. [46] Ever since, companies all over the world have been engineering and reengineering to and now working with a near similar much more efficient design of solar cells and are capitalizing on growing demand. In 2017, and for the past 35 years, SolarWorld has been America's leading solar leader.

Earlier this year, however the United States International Trade Commission ruled unanimously 4-0, in agreement with a petition brought by solar manufacturer Suniva & SolarWorld that the US Solar Panel industry had suffered harm from the global solar manufacturing industry.

Figure 17 American Lobbyists

The basis of the tariff is to add a .40 cent tax to any solar cells brought into the US. The case is unique because it relies on a rarely used section of federal trade law, known as Section 201 or a "global safeguard investigation," which gives the president broad authority to impose tariffs or other restrictions to help protect a domestic industry, especially anti-dumping. [47]

On one side are solar manufacturers; SolarWorld, being the leader, that say low-cost imports have made it impossible to be profitable. On the other side is the U.S. solar installation industry, which has benefited from low-cost panels that have led to explosive growth in rooftop systems on homes and commercial buildings as well as massive solar farms. [48] "The case is unique because it relies on a rarely used section of federal trade law, known as Section 201 or a "global safeguard investigation," which gives the president broad authority to impose tariffs or other restrictions to help protect a domestic industry. The prospect of such restrictions has set off a fierce backlash from industries and users of solar power, who argue that such measures would raise prices throughout the supply chain and ultimately cost more American jobs than they would save. They argue that cheaper solar products from China have actually been a boon to their businesses and accelerated the adoption of solar energy in the United States, where it now powers millions of American homes and businesses." [49]

The principle solar industry organization, Solar Energy Industries Association (SEIA), is against the tariff as it would both tax US exported solar cells and gut the US based solar industry. SEIA countered the proposed tariff stating that the Chinese manufacturers were in fact actually meeting the American demand — not flooding markets in an attempt to undercut pricing here. SEIA's

counter said the Suniva and SolarWorld were simply unable to compete with the Chinese solar modules and cells. [50]

Research shows that the U.S. solar industry is now creating enough jobs (hiring new workers 12 times faster than the overall economy) that it could actually absorb all the coal jobs that would be lost if the coal industry was completely shut down. As of Nov. 2015, the total solar industry employment was around 208,859 in Nov. 2015. The question for the White House now stake is to support American manufacturing or the American solar infrastructure industry. [50]

American president Donald Trump has leveraged his campaign and his first year in office as a proponent of American manufacturing. Trump continually speaks about bringing back the dominance of the coal/fossil fuel industries of the previous generations. To the chagrin of the efforts reduce the impact of global warming – President Trump pushes for greater investment in traditional energy sources. In tandem utility lobbyists are adding an additional angle to the solar fight by raising $22M in funding to push their agenda. Utility lobbyists support the solar cell tariff and contend that the higher priced solar cells would make the energy industry fairer to compete. [51]

In April, Mr. Rick Perry, the secretary of Department of Energy ordered an examination of how renewable energy may be hurting conventional sources like coal, oil and natural gas, a study that environmentalists worry could upend federal policies that have fostered the rapid spread of solar and wind power. [51] There are three factors to the lobbyists and the Department of Energy; the exploding desire for solar power, low cost equipment and the massively expanding supporting installation industry. Utility lobbyists argue that private solar installation and rules allowing private solar customers to sell excess power back to the grid at the retail price — a practice known as net metering — can be unfair to homeowners who do not want or cannot afford their own solar installations. [52]

Figure 18 US Department of Energy

Utilities argue that net metering, in place in over 40 states, turns many homeowners into free riders on the grid, giving them an unfair advantage over customers who do not want or cannot afford solar panels. The utilities say that means fewer ratepayers cover the huge costs of traditional power generation. Personal systems are prohibited in many instances in the U.S. because of outdated federal, state, and regional regulations. These encompass, for example, arbitrary fees or paperwork that make it harder for people to get permission to install these solar systems, and help utilities retain their monopoly on energy generation. [53]

The utility lobbyists and the efforts of the Department of Energy detract from the central issues concerning the massively successful solar industry and the ailing solar manufacturing industry.

There isn't the same power / profit structure in place for renewable energies so the old systems are concerned their share will be cut into. President Trump while maintaining his stance on building up American manufacturing will have to decide what is best for Americans vs what is best for two manufactures. President Trump is about to confront a policy dilemma that will test his commitment to U.S. job growth. [52]

Conclusion

With STEEP analysis, we are concluding that if the petition gets approved, there will be a negative impact on the growth and adoption of solar energy in the US energy market. Although Suniva and SolarWorld are expected to benefit from this verdict, but manufacturing only accounts for a small subset of the 374000-job market. Hence, in order for the booming solar ecosystem to progress, it can be acceptable to favor Solar Energy Industry Association (SEIA) and compromise on the success of the two failing companies. The onus is on the current President of the United States and he has until January 2018 to make the right decision.

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