

US-China Solar PV Trade War: Reasons, Implications & Recommendations

Ashfaqu Chowdhury

15th December, 2015

Abstract

Chinese solar manufacturing firms have been able to reduce price of solar PVs to a level which cannot be matched by manufacturers in USA and other places including Germany. However, this is beneficial to the growth of solar power throughout rest of the world. US firms who provide solar installation services (fitting, financing, etc.) are also beneficiaries of such reduction in price. A coalition of US solar manufacturers have alleged that low price of Chinese manufacturers is artificially created by illegal subsidies and high dumping margins. US Department of Commerce, responding to this allegation, imposed high tariffs on Chinese solar panels imports. However, this is not good news for solar energy expansion in United States as end users pay higher rates than most other places of the world. In this paper we try to examine the impact of the tariffs and if other policies can effectively protect US interests without raising solar power cost. We show that tariff barriers are unsustainable and US firms can hold technological upper hand by following the cooperative structure of global semiconductor industry's fabless-foundry model.

Contents

Background 4

Recent Solar PV Market Development 6

 Overheated Solar PV Market: The reason behind ‘unfair’ prices? 7

Stakeholder Analysis 8

 Solar Industry Value Chain 8

 Stakeholders 10

Litigation, Conflicts and Results 13

 First Petition 13

 Appeals after the First Petition 14

 Retaliation against US Basic Material Manufacturers 15

 China’s Request to WTO 15

 Relevant Laws, Chinese Complaints and WTO verdict on the Issue DS437 16

Evaluating the Scenario 17

 US solar market 18

 US Government 19

 Solar Jobs 21

 Maintaining R&D Advantage to fight Climate Change 22

 Winners and Losers from the Case 23

 Inferences from Evaluation 26

Future Actions 26

 Fabless-Foundry Model of Global Semiconductor Industry 26

 Policy To-dos 28

Conclusion 28

Background

Advent of new technologies in the last two centuries since industrial revolution meant the dependence on energy increased at very fast rates. Historically, fossil fuel dominated the supply of this energy. In 2014, 83% of world's energy output was produced by fossil fuels ("Renewable Energy," n.d.). Despite such usability, fossil fuels have major problems. First, world has a finite reserve of fossil fuel which will end at some point. Second, and probably much more relevant, is the issue of Green House Gas (GHG) emissions. Climate change science has shown that earth's atmosphere is vulnerable to GHG emission while burning fossil fuel produces GHG. This concern has led to renewable and clean energy sources like nuclear, solar and wind. Recent developments in solar industry (including cost drops and technological breakthroughs) have made it likely that solar will constitute a major chunk of our power consumption in the future. Under hi-ren scenario¹ International Energy Agency (IEA) expects in 2050 solar will be world's largest source of electricity (27%) with China and India leading solar energy consumption ("Technology Roadmap Solar Photovoltaic Energy - 2014 edition - TechnologyRoadmapSolarPhotovoltaicEnergy_2014edition.pdf," n.d.). It is also expected that almost 60% of all global solar energy will be produced from solar photovoltaics (PV).

The advantages of solar energy compared to other sources are highly visible. It is entirely clean and requires much less upfront cost than nuclear energy, another alternative to fossil fuels. Solar energy is widely available throughout the world with an advantage towards tropical countries where the sun is more abundant. The ubiquitous nature of solar power protects countries from price shocks and energy dependency. All these reasons, coupled with a global reduction of cost are incentives for governments to increase production and use of solar energy in large amounts.

Solar PV vs Solar CSP

Solar power is divided into these two forms. Solar PV uses photovoltaics to directly convert sunlight into electricity. Solar CSP uses concentrated solar power to produce electricity via a heat engine and power generator. Cumulative capacity of solar PV stands at 17.8 GW (2014) and solar CSP at 3.4 GW (2013)

Revisiting the development of Solar Power

1973 oil embargo and 1979 oil crisis are seminal events for energy sphere. These events stimulated global interest in alternative forms of energy and led to the establishment of National Renewable Energy Laboratory (NREL) in USA, NEDO in Japan, Fraunhofer-ISE in Germany. The issue gained momentum with

¹ Hi-ren scenario is a scenario where global temperature rise is contained within 2°C limit. This requires an investment of US\$4.5 trillion by 2050 in power generation.

widespread global warming concerns in mid 1990s. From this point onward, solar power generation was led by Japan and European countries. It is because of the effort of these countries that solar power, especially solar PV, reached economies of scale and turned into a viable energy alternative.

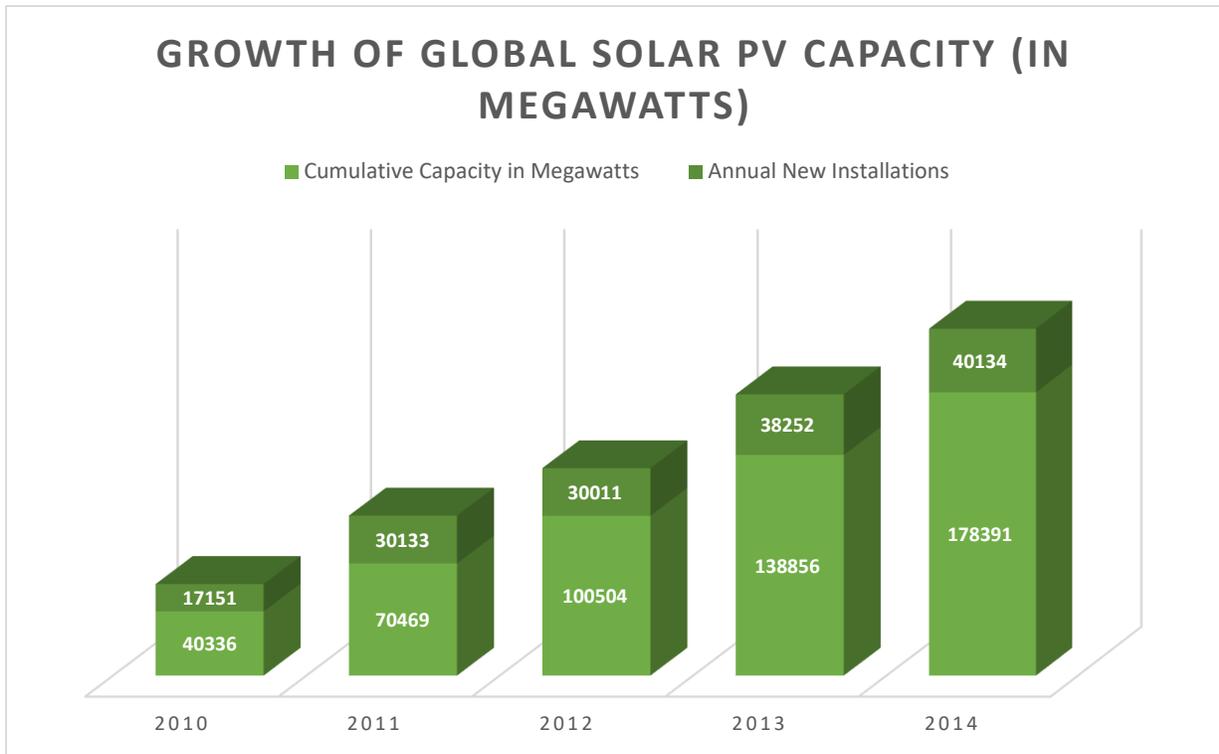


Figure 1 Growth of global Solar PV capacity (in megawatts) (“iea-pvps.org - Statistic Reports,” n.d.)

Apart from technological development and economies of scale, another significant factor in solar power development is the policy environment it operated in. Different countries have supported fuel alternatives and solar power has benefitted heavily from such initiatives. Feed-in-tariffs (FIT)² is one such policy tool.

USA today have a variety of policy tools to promote renewable energy. These tools include (but are not limited to) Renewable energy Investment Tax Credit, Net Energy Metering in California and Arizona and various other incentive programs.

We can see in figure 1 and 2 that both solar PV and solar CSP have seen incredibly fast growth rate in recent times. We will shortly analyze how this tremendous growth rate has impacted solar prices. Figure

² FIT was developed in Germany as a response to the need of reducing the share of nuclear energy in national power generation. FITs involve long term purchase contract with renewable energy plants. The price of renewable energy in these contracts reflected the cost of electricity generation. For example, if producing solar power at that point of time was more expensive than oil based power generation then a solar power generator could charge more than an oil power plant.

1 and 2 also shows that till date, solar PV is the dominant form of solar energy. Our case involves solar PV only as the dispute between China and USA is about price of solar PV modules.

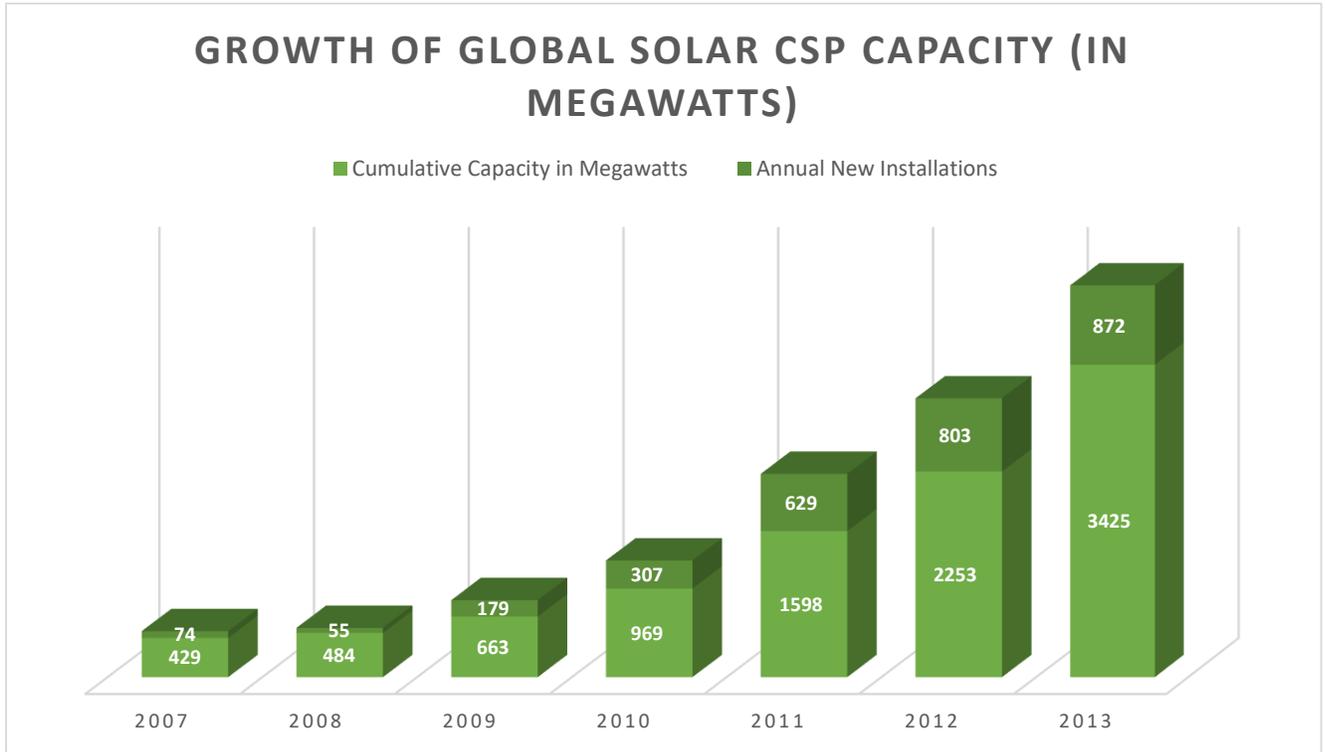


Figure 2 Growth of global solar CSP capacity (in megawatts) ("GSR2014_full report_low res.pdf," n.d.)

Recent Solar PV Market Development

As we mentioned in the last section, the first thing to notice in solar PV markets is the tremendous growth rate. Figure 3 breaks down this growth rate by country. As we can see, the historical leadership by Germany is now eroding, at least in terms of growth. China is the global leader in solar PV installation. Part of this huge growth in China can be attributed to the growing pressure of international community to reduce GHG emission. Another significant reason can be the fact that China is suffering from an overcapacity of solar PV manufacturing and it is partly in the country's interest to devour as much of the production as possible. Japan has also boosted up solar PV demand, possibly as a reaction to the Fukushima nuclear disaster. USA is now also one of the global leaders in terms of new installation. Even though historically USA have been a laggard on solar power generation, this indicates an intention to move towards solar PV. Till 2012, renewable energy (hydroelectric, biomass, wind, geothermal and solar) accounted for 11.2% of total electricity generation of which only 2.7% came from solar.

Overheated Solar PV Market: The reason behind 'unfair' prices?

Solar PV market grew at an astounding 70% per year between 2007-2011 ("Solar Markets Around The World," n.d.). This growth was fueled mostly by China. In 2009, China announced two major supportive programs named Golden Sun and Solar Rooftop which provided the Chinese solar industry an effective protection from global recession. Also goals like installation of 35 GW of solar electricity by 2015 and 10 GW by 2013 stimulated the industry. As we can see in figure 3, Chinese production soared exactly in the year 2009. This means, the programs announced by the Chinese government did not only abated the demand depression related to global recession, it provided so much incentive that 2009 can easily be marked as the 'breakthrough year' for Chinese solar PV production.

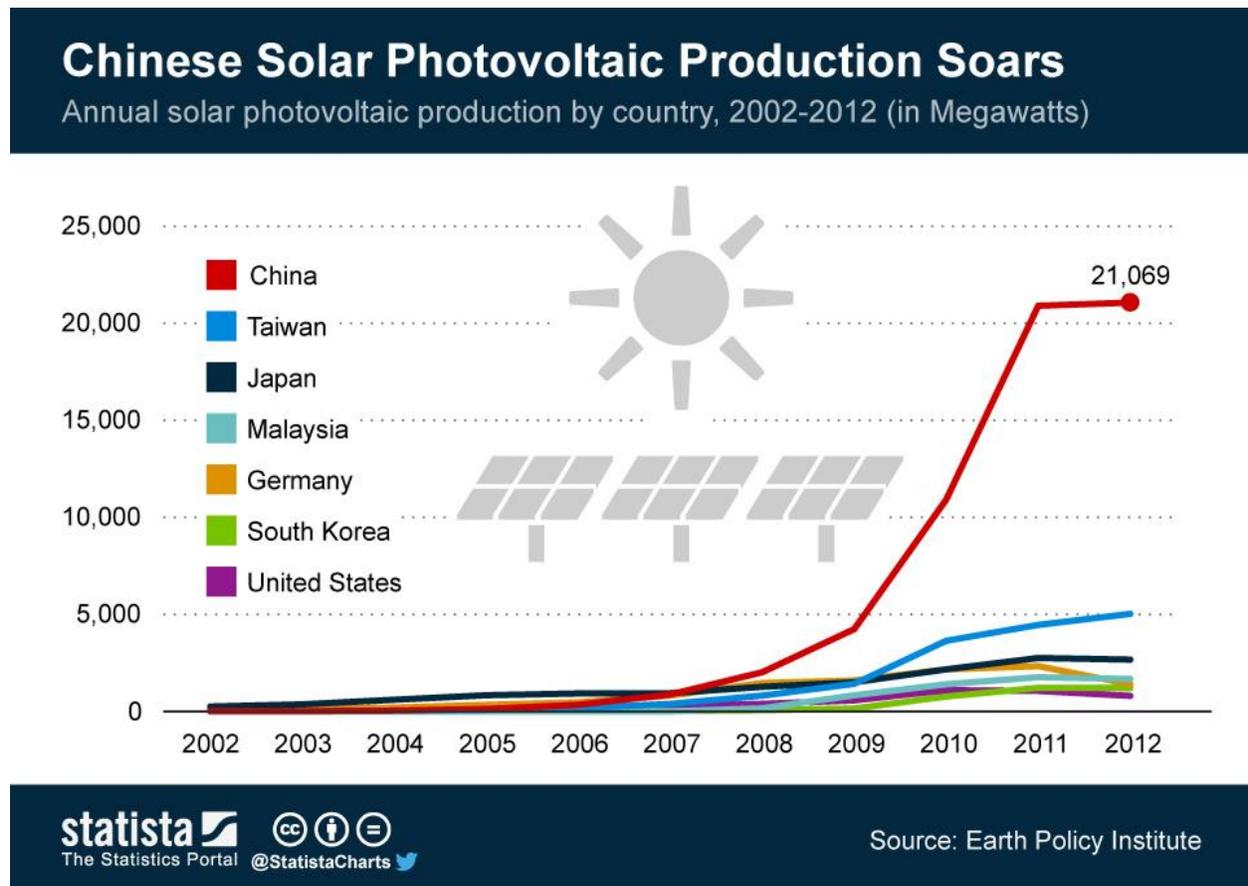


Figure 3 Solar PV manufacture by region (taken directly from Earth Policy Institute)

Analysts predict that such incentives and an over expectation of sales in the global market drove hosts of Chinese company into the business. Such capacity additions started to show their downside as by as early as 2011 as approximately 6 GW of crystalline inventory went unsold. There was obviously a rise in demand for solar PV throughout the globe but the entrepreneurs responded by adding much more than it was healthy for the market. This created panic around the global solar market as Q-Cells, a major German manufacturer had to leave the market. Anti-Chinese solar PV quarters may reasonably assume that Chinese firms started selling solar PV modules at very low prices in order to clear the glut in their inventory.

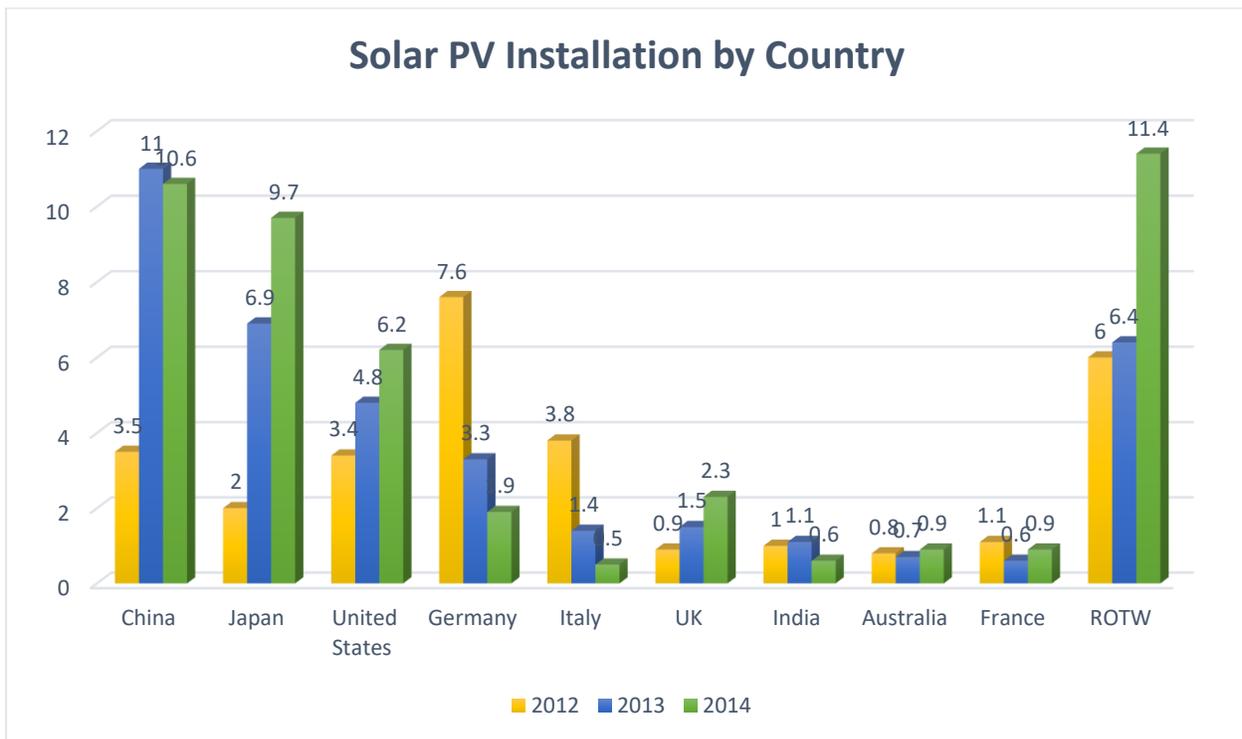


Figure 4 Breakdown of global new solar PV installation (2012-2014)(“Solar Markets Around The World,” n.d.)

Stakeholder Analysis

Solar Industry Value Chain

The solar industry can be divided into two broad categories: upstream and downstream. We can also take into consideration companies who supply the basic material polysilicon. Upstream activities involve manufacturing the solar cell parts: wafers, PV cells and modules. For example: SolarWorld produces all the components of solar panels and finished product. The downstream solar segment includes installation and distribution of solar cells and financing. For example: SolarCity, a downstream solar energy company, designs, finances and installs solar power systems.

Divergence of Interest

A divergence of interest stems from this distinction of upstream and downstream companies. As we can see, the purpose of upstream companies is to sell solar PV to either end users directly or through downstream companies. Largest of US upstream companies like SolarWorld do have upstream operations as well. But we can reasonably assume that downstream operations of these firms will always want to buy products from their own upstream productions. For example: SolarWorld Systems Solutions is a part of SolarWorld Americas. They provide designing and installing services. Importantly, their service is limited to design and install for only those who buy SolarWorld solar PVs. So we can infer that the main operation of these upstream companies is to produce and sell solar PVs.

On the other hand there are downstream companies who are not involved in any production at all. Their job is to design, install and/or finance solar power system.

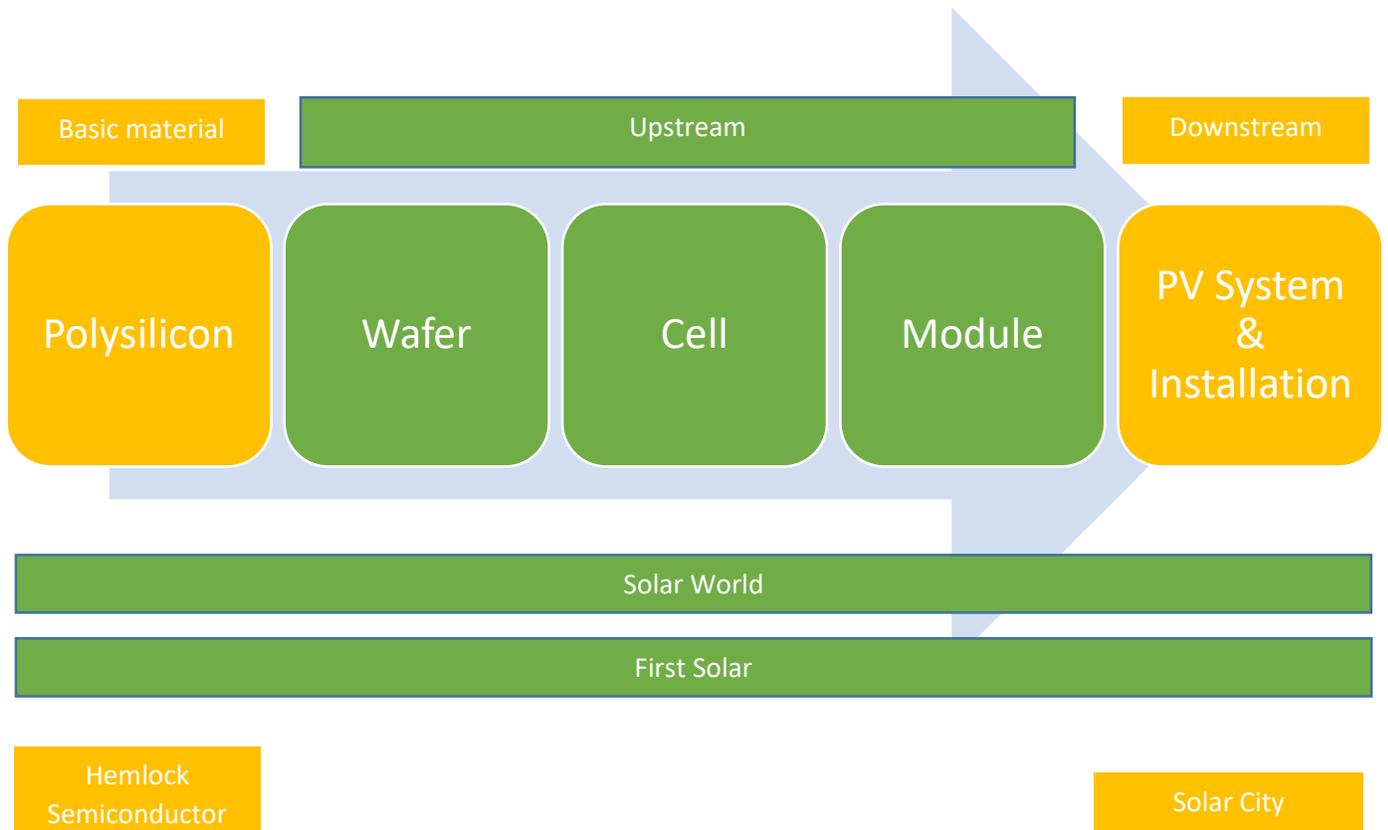


Figure 5 US solar PV industry value chain. Portions in blue are supposed to be benefitted from the anti dumping (AD) and countervailing duties (CVD). Portions in yellow are harmed by these duties.

The price of solar PVs impact these two groups differently. Upstream companies need the price of solar PVs to cover at least their marginal cost³ of production. Also importantly, they need to invest a lot in R&D as it is heavily suggested that future cost reductions in solar PV industry will come mainly from technological improvements(Lacey, 2013). On the other hand, it is always advantageous for downstream firms to have cheaper solar PVs. Cheap solar panels let them offer lower price and thus attract more customers and profit.

This divergence of interest has led to bitter rivalry between these two groups represented by CASM and CASE. CASM, and its leader SolarWorld expects US Department of Commerce (USDoC) and US International Trade Commerce will impose punitive tariffs on Chinese manufacturers on the grounds of

³ Marginal cost here refers to cost of production and economic profit.

illegal subsidies and dumping. On the other hand CASE suggests that such action will violate the principle of free trade and deprive US consumers of affordable solar power. We will discuss more on CASM and CASE in the next section.

Stakeholders

Coalition for American Solar Manufacturing (CASM)

CASM is the association involving US based solar PV manufacturers (upstream companies). Currently it involves 256 corporations which includes solar installers, developers, manufacturers, shippers and suppliers (“American Solar Manufacturing,” n.d.). However, just like their name, their activities suggest that this consortium is primarily an organization of crystalline silicon solar producers. The purpose of this organization is, as described in their website, ‘...uphold fair U.S. international trade by opposing illegal trade practices in the solar industry such as improper and artificial underselling and illegal, export oriented governmental subsidies.’ In effect, this means the coalition opposes the cheap solar panel imports from China on the ground that Chinese manufacturers receive subsidies from the government and then sell at unfairly low prices to remove competition.

CASM is led by SolarWorld which is a large US solar manufacturing company (more on SolarWorld in the next section). As the lead organization, Solar World does most of the media communication and represents CASM interests in the court.

Importantly, some US upstream solar companies including First Solar is not a member of CASM. Given that First Solar is a significant player in the industry with a global capacity of 2700 MW (“FIRST SOLAR, INC. (Form: 10-K, Received: 02/25/2015 06:16:43),” n.d.) and the only US company listed in the top ten global solar module producer (“Solar Markets Around The World,” n.d.), their non-participation hurts CASM’s claim of representing US solar upstream producers. The issue is explored in more detail in the section ‘Impact on US Solar Industry.’

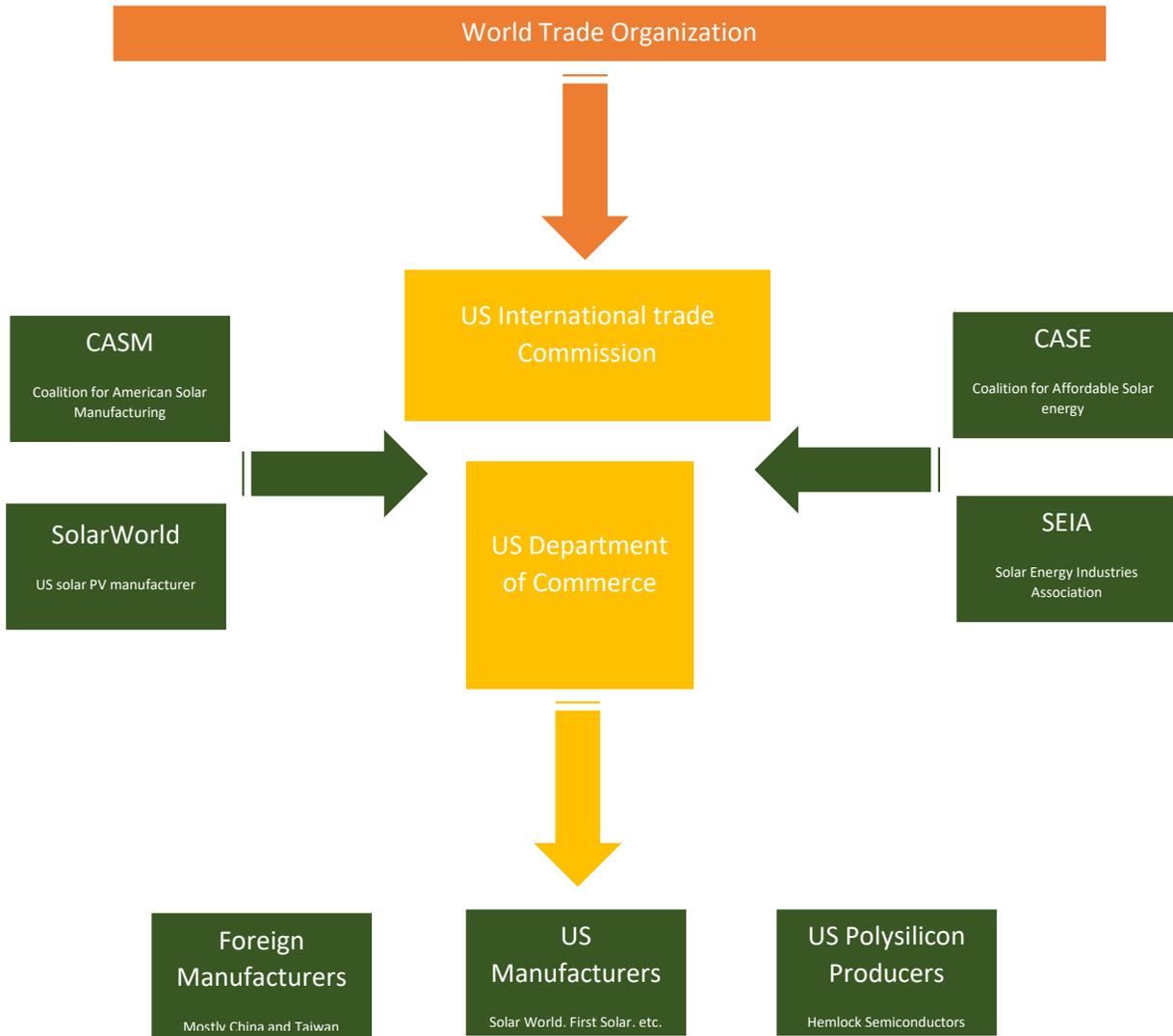
SolarWorld Industries America Inc.

SolarWorld is the protagonist of the movement against cheap Chinese solar panels. Originated and headquartered in Germany, SolarWorld claims to be the largest producer of solar goods in USA. The US headquarters and facility of SolarWorld is located in Hillsboro, Oregon. The company is involved in all levels of solar value chain from raw materials to end-use promotion. On October 19, 2011 SolarWorld filed petition with United States Department of Commerce (USDOC) And International Trade Commission (ITC) against imports of cheap Chinese solar PV. The petition asserted that the Chinese manufacturers are receiving massive illegal subsidies from the Chinese government including contract awards, trade barriers, financing breaks and supply-chain subsidies. The petition also asserted that Chinese firms are dumping crystalline silicon solar cells in US markets (Wesoff, 2011).

Coalition for Affordable Solar Energy (CASE)

CASE claims to represent US based solar downstream companies. CASE vehemently opposes CASM claiming CASM’s interest is depriving US consumers from low cost solar energy. They refer to SolarWorld

as a ‘foreign manufacturing company’ and refers to the litigation as having harmful impact on US domestic solar industry and its employees(“Coalition for Affordable Solar Energy | Strata Solar,” n.d.). CASE is heavily represented in the media by Jigar Shah, a solar entrepreneur much known for founding solar giant Sun Edison(“This Entrepreneur Plans to Save the World, \$1 Trillion at a Time,” n.d.).



The figure above explains the various roles of the stakeholders in US solar PV market. Parties on the left are pursuing USDOC and USITC to impose tariffs on Chinese solar PV. Parties on the right are pursuing otherwise. Parties at the bottom are the victims of the decision by USDOC/USITC. At the top is World Trade Organization who has a mandate to oversee the any tariff related activities in the national sphere from an international point of view.

Solar Energy Industries Association (SEIA)

SEIA is an advocacy and education platform which works for the expansion of solar energy in US. Launched in 1974, it now boasts more than a thousand members.

SEIA expresses a point of view that the dispute between Chinese and US manufacturers should be resolved in an amicable manner outside the court. Even though they maintained a neutral stance at the beginning of this case, with time they have expressed annoyance at CASE and SolarWorld as SEIA believes their insistence on the issue is harming the US solar market.

United States Department of Commerce (USDOC)

USDOC is the department of US government which has a mission to “promote job creation and improved living standards for all Americans by creating an infrastructure that promotes economic growth, technological competitiveness and sustainable development (“Department of Commerce,” n.d.).

If any US firm thinks that it is being subjected to unfair business practices like illegal subsidy or dumping by rival from another country then it can file a petition with USDOC. USDOC then investigates the issue and provides a determination under Anti-Dumping (AD) and Countervailing Duty (CVD) law. USDOC publishes two reports- preliminary and final determination. If the final determination is affirmative to the complaint then the verdict depends on whether USITC also provides an affirmative determination to the complaint or not.

USDOC define dumping to occur when a foreign company sells a product in the United States at less than its fair value. Countervailing subsidies are defined to be financial assistance from foreign governments to specific companies or industries and are contingent upon either export performance or use of domestic goods over imported goods. USDOC’s role is to strictly determine whether or not dumping and countervailing subsidies exist and if so then what are the margin of these.

United States International Trade Commission (USITC)

USITC is a quasi-judicial federal agency of the United States. The agency holds the right to determine the impact of imports on US industries. Pertinently to this case, they hold the verdict on whether or not unfair trade practices such as subsidies, dumping, patent, trademark and/or copyright infringement have harmed US industries. The website(“About the USITC | USITC,” n.d.) of USITC lists the following operations:

- Import Injury Investigations
- Intellectual Property Based Import Investigations
- Industry and Economic Analysis
- Tariff and Trade Information Services
- Trade Policy Support

The case in point is relevant to the import injury investigations portion of USITC. Like USDOC, USITC also investigates the issue of countervailing duties (subsidies) and dumping. However, USITC investigates a separate issue from USDOC. USITC's role is to find if the imports of the goods have caused any material injury or have threatened to cause a material injury to the US industries.

If both USDOC and USITC provides affirmative determination then and only then USDOC is mandated to issue countervailing duties (CVD) and antidumping (AD) rates in order to offset the impact of illegal subsidy and dumping.

Anti Dumping vs Countervailing Duties

Anti Dumping (AD) rates are issued to offset the impact of dumping done by the foreign company. Countervailing Duties (CVD) are issued to offset the impact of illegal subsidies that the foreign company received from its government.

Both AD and CVD are subject to a review after every five years.

World Trade Organization (WTO)

WTO is the global organization which governs the rules of international trade. Large majority of the nations are member of WTO. WTO's purpose is to let the multilateral trading system work smoothly in the spirit of free trade and significantly lower trade barriers("WTO | The WTO in brief," n.d.).

Few of the agreement under WTO are General Agreement on Trade and Tariff (GATT), General Agreement of Trade and Services (GATS), Agreement on Trade Related Intellectual Property Rights (TRIPS) and, very relevantly, WTO Agreements on Subsidies and Countervailing Measures (SCM Agreement). These agreements are based on principles of Most Favored Nations Treatment and National Treatment. These principles state that no country can provide favorable treatment of good, services or corporations of one country over other("ipcc_wg3_ar5_chapter13.pdf," n.d.). As a signatory of these agreements, USA is bound by international law to follow these principles.

If any country thinks it is receiving unfavorable treatment for its good, services or corporations then it can file complaint in WTO dispute settlement. Verdicts by WTO are binding on member nations. China filed a complaint in WTO dispute settlement regarding US tariffs on Chinese Solar Panels. We will discuss this broadly in the next section.

Litigation, Conflicts and Results

First Petition

On October 19, 2011, SolarWorld filed a petition with USDOC and USITC against Chinese solar PV manufacturers alleging government subsidies and unfair prices are enabling Chinese manufacturers to outcompete Us firms in crystalline silicon solar cells. In the original petition SolarWorld alleged that the dumping margins can be as high as 100% and multiple US companies have been driven out of business because of such practices("American Solar Manufacturing," n.d.).

The case soon captured national attention. On November 2, 2011, President Barack Obama questioned the competitiveness of Chinese firms. Replying to a journalist, the President told "We have seen a lot of questionable competitive practices coming out of China when it comes to the clean energy space, and I

have been more aggressive than previous administrations in enforcing our trade laws. We have filed actions against them when we see these kinds of dumping activities, and we're going to look very carefully at this stuff and potentially bring actions if we find that the basic rules of the road have been violated."

On December 2, 2011 59 house representatives sent a letter to President Barack Obama expressing support for CASM's petition. In fact, the letter advocated for taking action against China through WTO. It stated "The enforcement of US trade remedy laws is necessary, but not sufficient, to ensure equal footing for US industry. We must also devote more resources and attention to the enforcement of China's obligation under WTO and other international agreements."

On 27th January 2012, USDOC issued its preliminary ruling affirming most of the claims of the petition("FR-Notice-1.pdf," n.d.). The determination stated that the subsidy allegations filed by the petition are inconsistent with SCM Agreement (Agreement on Subsidies and Countervailing- a WTO enforced agreement). However, USDOC published final preliminary determination on May 27th 2012("Department of Commerce," n.d.). The final rates were divided into two parts- Anti-Dumping Rate and Countervailing Duty rate. USDOC set different AD rates on a case by case basis for two companies. Suntech received a rate of 31.73%, Trina solar received 31.22%. Other companies who requested for a case by case judgement received a flat rate of 31.18%. Companies who did not hand over any such request were handed a flat rate of 249.96%. CVD duties were set at 14.78% for Suntech, 15.97% for Trina Solar and 15.24% for all other Chinese manufacturers.

After a revision of the rates, in October 12, 2012 Suntech received a rate of 14.78%, Trina solar received 15.97%. Other companies who requested for a case by case judgement received a flat rate of 25.96%. Rates did not change for other companies.

Very importantly, USDOC decided that the product scope will not include panels which uses solar cells produced in a third country. The original petition filed by SolarWorld included such third party production into product scope. As we will discuss shortly, this decision had a huge impact on Chinese solar PV import. On November 7, 2012, USITC issued its final determination which was in line with the findings of USDOC.

Appeals after the First Petition

Chinese manufacturers responded to this new hindrance quite quickly. They started outsourcing solar cells to companies from Taiwan and then used them in solar panels otherwise produced in China. As a result, the solar panels from China fell outside the scope of the USDOC and ITC determination("US to slap new tariffs on Chinese PV panels," n.d.). In such a process Chinese manufacturers can produce silicon crystals and then slice them into solar wafers. The next step in the production process is to convert the wafers into solar cells. Chinese manufacturers outsourced this portion of the production to Taiwan before assembling and finishing the products back in China. On February 1, 2013, CASM announced that they were appealing against this possible loophole in law. On April 9, 2013, USDOC issued a letter to US Customs and Border Protection ("solar-cells-referral-cbp.pdf," n.d.). The letter mentioned 'The Anti-Dumping Duty (AD) and Countervailing Duty (CVD) orders on solar cells also cover modules consisting of solar cells.....the data suggests that some importers may either be improperly

declaring merchandise as not subject to AD/CVD orders....' While it is unclear if this indicated that USDOC was concerned with the evasion of duties through using the loophole that did exist in the determination, subsequent events proved that the rulings from USDOC and USITC did not have the intended effect because of this loophole.

USDOC announced its preliminary determination on the appeal on June 3, 2014 (DATE, 2015) where it indicated that solar PVs which had parts manufactured in Taiwan (any foreign country, for that matter) will not be exempted from the duties. On December 16, 2014, USDOC announced its final determination in this regard which was pretty much in line with preliminary determination (USDOC, n.d.). The antidumping rates found by the USDOC ranged from 26.71% to 165.04% for Chinese producers while it ranged from 11.45% to 27.55% for Taiwanese producers. The rate of countervailing subsidies ranging from 27.64% to 49.79%. Importantly, USDOC thought that the Government of China failed to respond to certain questions completely and so they decided to use the 'adverse facts available.'

It is very important to note that even though the tariff rates seem to be extremely high, the range of the tariffs is very broad. Some of the biggest Chinese manufacturers received tariff rates which are pretty modest. Trina solar, possibly the largest Chinese solar manufacturer received a CVD rate of 26.71%, lowest among all the companies (Author, n.d.). On July 9, 2015, Yingli Green Energy received a combined tariff rate of 21.73% ("Yingli Green Energy Comments on U.S. Department of Commerce's Solar PV Tariff Rulings Following Administrative Reviews of Imported Panels Using Chinese Cells," n.d.). It is needless to state that these rates will not be able to hamper the exportability of Chinese solar PV panels.

Retaliation against US Basic Material Manufacturers

On July 24, 2013, China enacted new tariffs on US Polysilicon producers Hemlock Semiconductors and REC silicon imposing tariffs of 53 and 57 percent respectively. Chinese official statement mentioned that the reason behind the tariffs is that products from these manufacturers were dumped in China.

This was a heavy blow to the US polysilicon industry. Hemlock Semiconductor closed one of its facilities in Clarksville, Tennessee. The plant initiated in 2008 with an estimated expense of US\$1.2 billion ("Hemlock closing Clarksville plant permanently," n.d.). REC Solar also reported that it feared of losing its entire revenue of US\$600 million annually.

Interestingly, this seems like a *déjà vu*. In 2012, EU initiated an investigation similar to China. Within a few months after the investigation suggested imposition of tariffs on Chinese solar PVs, China started investigating US solar polysilicon makers. EU and China eventually reached an 'amicable solution'. EU started investigating the case after an association of EU solar named EU ProSun manufacturers filed a complaint. EU ProSun, like CASM, is headed by SolarWorld.

China's Request to WTO

On May 25th, 2012, China requested consultations with the US through WTO on the issue of countervailing duties (CVD) issued by USDOC and USITC ("WTO | dispute settlement - the disputes - DS437," n.d.) on many⁴ products including the solar panels. China claimed that the US is violating Article

⁴ solar panels; wind towers; thermal paper; coated paper; tow behind lawn groomers; kitchen shelving; steel sinks; citric acid; magnesia carbon bricks; pressure pipe; line pipe; seamless pipe; steel cylinders; drill pipe; oil country tubular goods; wire strand; and aluminum extrusions.

VI of General Agreement on Tariffs and Trade (GATT), articles 1.1, 1.2, 11.1, 11.2, 11.3, 12.7 and 14.(d) of the Subsidies and Countervailing Measures (SCM) Agreement and Protocol of Accession of China. The following section briefly describes what these treaties mean and what WTO's verdict on these issues was. One important aspect regarding WTO rules is that when one country agrees to open their markets for goods or services, they bind their commitments to it meaning they agree to a ceiling on custom tariff rates and cannot exceed it without following adequate WTO procedure("WTO | Understanding the WTO - principles of the trading system," n.d.).

A panel to investigate the issue was formed on 28th September 2012 and the panel provided its final report on July 2014. Australia, Brazil, Canada, The EU, India, Japan, Korea, Norway, the Russian Federation, Turkey and Viet Nam reserved the panel's third party rights.

Relevant Laws, Chinese Complaints and WTO verdict on the Issue DS437

Relevant Laws

Article VI GATT: GATT is a multilateral agreement preceding the establishment of WTO. It now is effective under the WTO umbrella. Article VI of GATT is about the evidence that a country requires against another country to impose customs tariffs above the agreed on limit("19-adp.wpf - 19-adp.pdf," n.d.). It also states how all relevant parties must be involved and how each party will have a right to defend themselves.

The SCM Agreement: The Subsidies and Countervailing Agreement governs the determination and action against subsidies by a WTO member country against another. The articles cited by China (articles 1.1, 1.2, 11.1, 11.2, 11.3, 12.7 and 14.(d)) are concerned with the definition of subsidies, initiation of investigation, the procedure to be followed during investigation and conditions when government procurement can be determined as conferring a benefit. These articles also deal with the issue of the 'adverse facts available' issue which USA used while ruling in favor of SolarWorld (mentioned in the previous sections)("24-scm.wpf - 24-scm.pdf," n.d.).

Protocol of Accession of China: Protocol of Accession are documents which determine the conditions which are applicable to China when they are a member of WTO.

Complaints from China

1. USDOC was wrong in identifying subsidies as they did not follow the definitions provided in article 1.1 of the SCM agreement.
2. USDOC initiated and conducted the investigations in respect of allegations that state owned enterprises in China receive illegal subsidies suffered from a lack of evidence or proper review of evidence.
3. USDOC incorrectly determined that the Chinese firms were illegally benefitted by selling to Chinese government. In order to establish this claim, USDOC needed to have evidence that the government bought the products for more (or less) than usual prices (article 14.d of SCM agreement). No such evidence was presented.
4. USDOC failed to provide any evidence that there was any specific preferential treatment to any one of the industries in terms of input material price which they needed to prove according to article 2.1 and 2.4 of SCM agreement.

5. USDOC's determination that China failed to respond to their questions were wrong and thus the use of 'adverse facts available' is unacceptable. The responses from China did not enable article 12.7 of the SCM agreement which allows a party to use 'adverse facts available'.
6. USDOC's determination that Chinese firms were using lands for less than adequate remuneration is inconsistent with rules set in article 2.2 and 2.4 of the SCM agreement.

WTO Verdict

The verdict from WTO was overwhelmingly on China's favor. WTO ruled that

- i. Chinese state owned enterprises were public bodies and thus legally capable of receiving subsidies
- ii. Alleged subsidies were regionally specific
- iii. USDOC is partially right in determining that there were market distortions in China and thus they were right to use benchmark prices from another country.
- iv. USA was right to use 'adverse facts available' meaning China did not respond adequately to USDOC's questions

Importantly, this verdict meant that USDOC's actions violate article 10 and 32.1 of the SCM Agreement. Article 10 is about the application of using GATT article VI while article 32.1 states that no nation can take action against another nation if it is not in accordance with provisions of the GATT 1994.

Appeals and Cross Appeals

China appealed against almost everything that went against them in the preliminary verdict. On August 27th, USA cross-appealed on a few issues importantly leaving out the verdict that USDOC was wrong in determination of certain entities as public bodies. The appellate body reversed certain decisions from the preliminary findings and stated:

- i. USDOC's use of benchmark prices from another country is not appropriate
- ii. USDOC has not been able to prove the existence of a subsidy program
- iii. USDOC's use of 'adverse facts available' is inappropriate under WTO rules

Enforcing the verdict of WTO

United States have accepted the verdicts from WTO but asked for a 'reasonable amount of time' to implement the decisions. However, China requested to WTO that 'reasonable amount of time should be specific and legally binding. Responding to this request the WTO set a time limit of 14 months which is set to expire on April 1, 2016.

Evaluating the Scenario

In the following section we aim to evaluate this whole fiasco from different perspectives. We will try to evaluate how the industry players, US government, Chinese manufacturers and international climate regime see this case.

US solar market

US solar market today is now a 15 billion US\$ industry. US solar production capacity now stands at an impressive 26 GW. In the year 2015, US is supposed to install a total of 7.7 GW of solar energy ("Executive Briefing: The Future of U.S. Solar," n.d.). Much of this is due favorable policies towards solar power. Solar power now represents 1% of all US electricity generation. While this is still a tiny dot in the energy industry, falling prices, rising efficiency, climate change

Cost of solar in US

The most obvious impact is on price of solar PV modules. In the fourth quarter of 2014, made in China tier-1 solar PV price in USA was 72 cents per watt which was higher than any other major global market ("BUSINESS_ U.S.-China solar war spiking PV prices for Americans -- Tuesday, March 3, 2015 -- www.eenews.pdf," n.d.). In contrast Chile had the lowest price for these kinds of panels at 56 cents. However, if we take a look at the following figure we will see that the cost of solar PV has only went downwards since 2012 and projected to go further downwards.

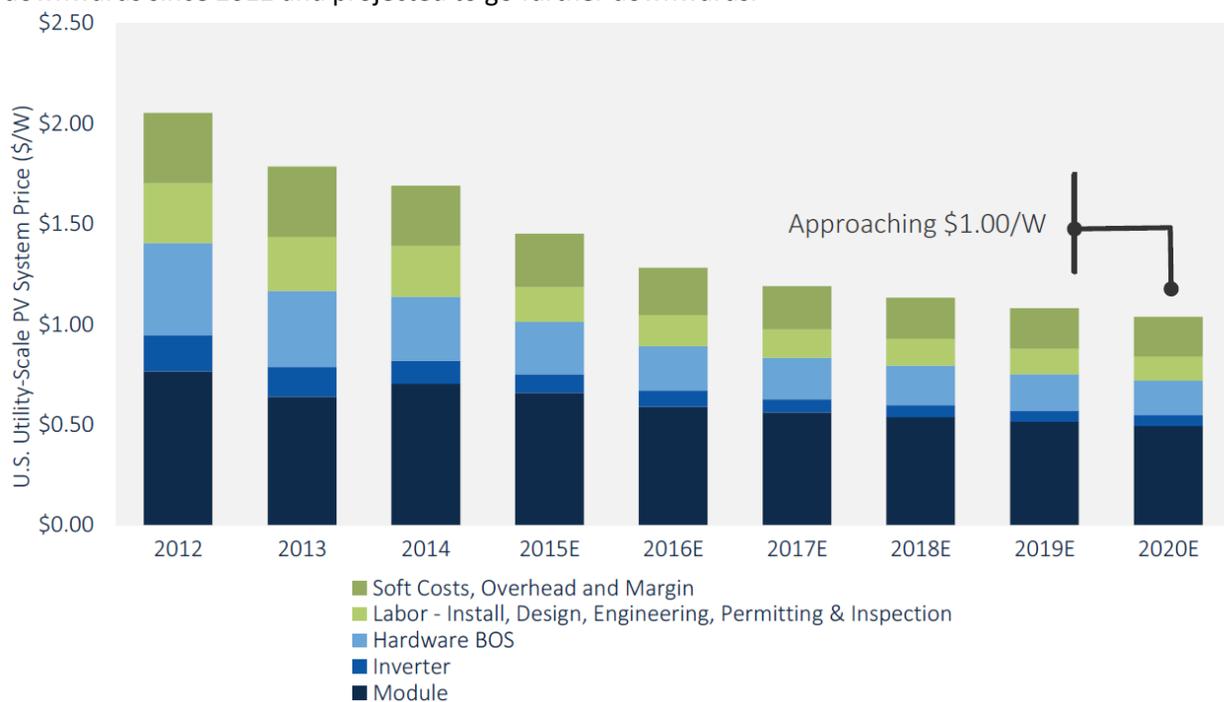


Figure 6 US utility-scale solar PV price 2012-2020 (estimated). Residential and commercial purpose PVs are usually a bit more expensive. source: Green Tech Media Research

Solar Installations

As we can see in figure 7, US solar installation has been growing at a frantic pace from 2010 onwards. The growth rate from 2011-2015 was 125%, 75%, 41%, 30% and 14% respectively. In absolute terms, USA has been adding more than a gigawatt of solar power to its national electricity supply each year from 2011-2014. It must be noted that even though most of the solar panels have been imported, the huge amount of new installations each year has contributed to sharp rises in downstream jobs (installations, financing, etc.) in USA.

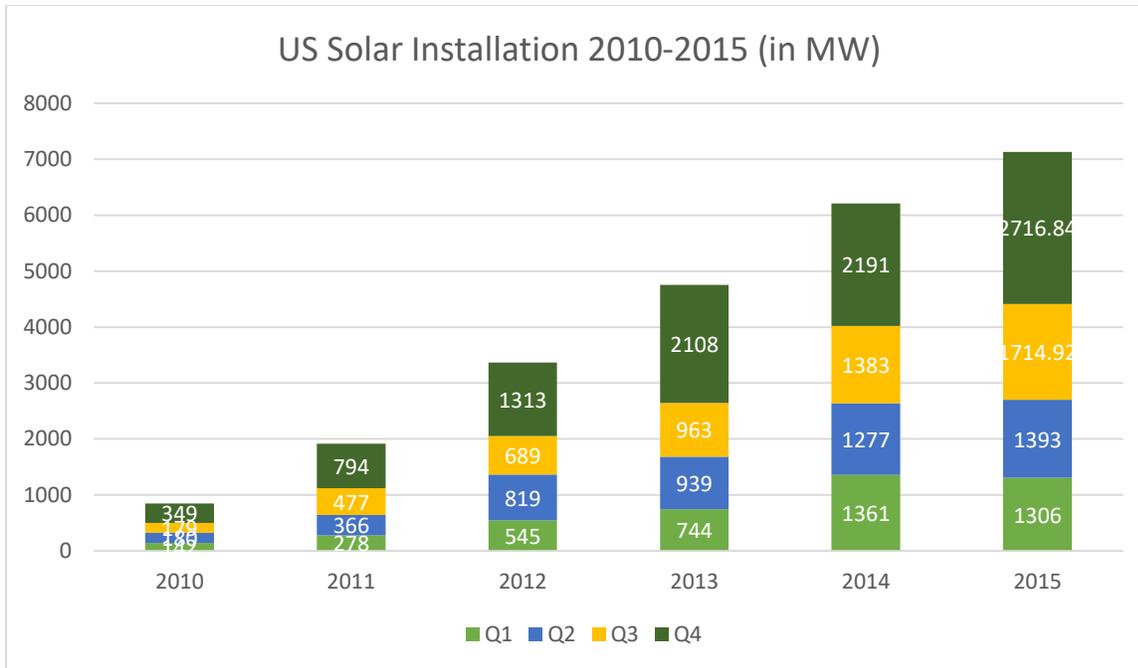


Figure 7 US Solar Installation. Data for 2015 Q3 and Q4 are estimates. Source: SEIA.

US Government

US government is indeed extremely relevant here. From 2009 to 2014, US government has invested US\$150 billion in renewable energy (“Layout 1 - 0418_clean_investments_final paper_PDF.PDF,” n.d.). It is fair to say that without so many policies like solar ITC and SunShot, US solar market would have been lagging much farther behind. Democratic Presidential nominee Hillary Clinton recently mentioned if elected her administration will ensure 140 GW of solar energy by 2020 which is even more ambitious than anything the current administration is aiming for.

Policies toward solar

Solar ITC

A very prominent example of such policies is the solar Investment Tax Credit (ITC). ITC is a 30 percent tax credit for solar systems on both residential and commercial properties. Solar ITC was first implemented in 2006 and it was extended up to year 2016. Since 2006, the US solar industry has seen a growth by over 1600% (“Solar Investment Tax Credit (ITC),” n.d.). From 2009 to 2011, this policy offered 30% grant instead of tax credit which was much effective during the time of financial crisis.

SunShot Initiative

USDOC has invested 20 million US\$ in four projects under this initiative. The goals of this initiative are reducing the cost of solar power by 75% from 2010 to 2020. This includes lowering the price of residential system prices to \$1.5 per watt, commercial system prices to \$1.25 per watt and utility scale system prices to \$1 per watt (“SunShot Initiative | Department of Energy,” n.d.).

Net Metering

Net metering is a policy which allows solar users to feed the solar power they do not use into the electric grid. 43 states have already adopted a net metering policy. This policy encourages people to use more solar power("Net Metering," n.d.).

Loan Guarantee Program

US Department of Energy (DOE) initiated the loan guarantee program for solar energy projects back in 2005. So far, DOE has provided loan guarantee for 28 projects resulting in private investments of more than US\$25 billion. This program target to save projects from 'valley of death' by guaranteeing privately held debt by energy manufacturers("Loan Guarantee Program," n.d.).

There are other policies favoring solar power in areas as distributed solar, power plant development, international trade, environment, finance and tax etc.

The compelling question here is that why does the US government provide such generous support to solar? The answer to this is twofold. First is the uncertainty regarding fossil fuels. The impending threat of climate change and unstable, unreliable or hostile governments in major oil exporting nations all are reasons behind this uncertainty. On the other hand is the issue of jobs. It is not easy to get bipartisan support for the issue of climate change in the government(Herszenhorn, 2015). So the government tried to connect this with the issue of unemployment and aimed at creating green jobs("Green-jobs evangelist sells Obama’s ambitious plans | Renewable Energy Jobs," n.d.).

We proceed further on this issue by using two avenue. First we try to understand if the tariffs imposed by USDOC and USITC has any impact on jobs. Second, we try to understand if these tariffs will help US fight climate change in the future.

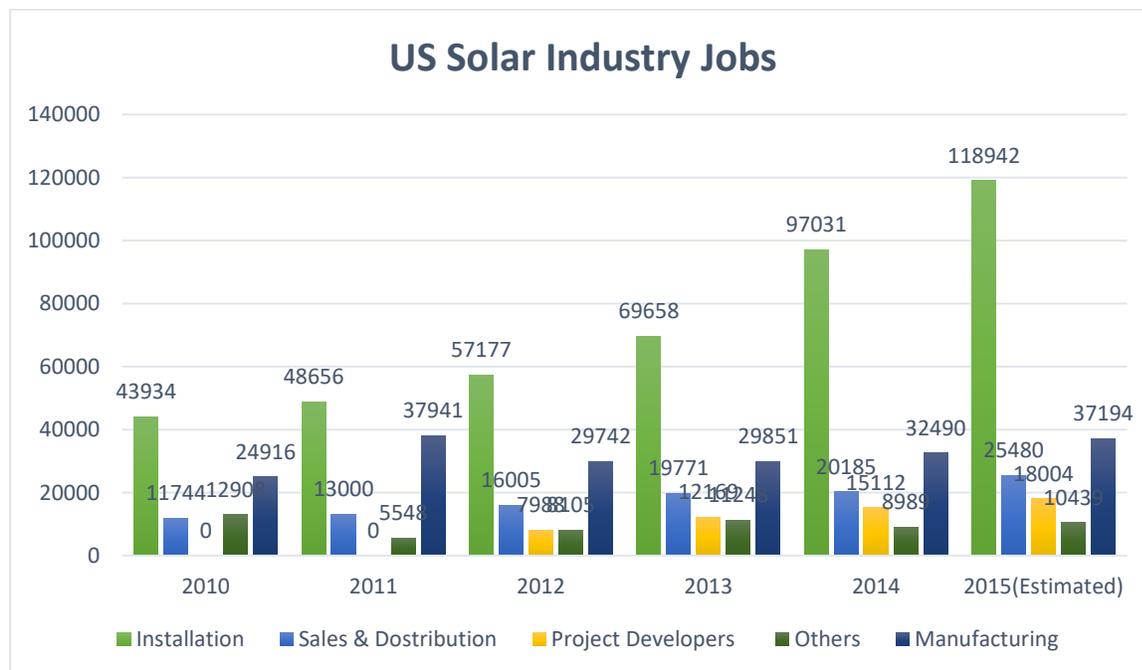


Figure 8 US Solar Industry Jobs (2010-2015) divided into sub-sectors("National Solar Jobs Census 2014 | The Solar Foundation," n.d.)

Solar Jobs

If we look at figure 8 we can see that number of solar jobs in USA has been constantly increasing since 2010.

It is interesting to see if the USDOC tariffs had any impact on solar jobs. First preliminary verdict against Chinese manufacturers came out on January 2012 and the final verdict came out on October of the same year. One can reasonably expect that it will have impact on solar manufacturing jobs. But the data doesn't say so. In 2013, solar manufacturing jobs saw a growth rate of 0.37%. However, if we assume that the verdict took some time to cast an impact and look at manufacturing jobs growth from 2012 to 2014, the growth rate is 10.8%. In contrast, the growth rate in 2011 from the year 2010 was -21.6%. So we can assume that the verdict had some effect on solar manufacturing jobs. So we can say there is at least a correlation between the verdict and manufacturing jobs. The second verdict was finalized on December 2014 and so we will not do any analysis because a timeframe of 12 months is not enough for having an impact.

We should be very careful in interpreting these results. The uncertainty regarding future grid electricity price, increasingly vocal climate change regime, pro solar policies by US government and falling price of solar (as we can see in figure 6) even after the tariffs all probably had a contribution in the increase in jobs.

Other solar jobs (installation, sales & distribution, project development) also increased during this time. From 2011 to 2013, solar installation jobs increased by 43%. Considering that the tariffs made the solar panels more expensive than they could have been without tariffs, solar installers should have faced a depression. But as solar installation increased every year in USA, solar installation jobs followed suit.

US solar downstream companies (installers, inverter manufacturers and financiers) claim that these tariffs have depressed jobs growth in solar industry. We have stated earlier that US solar PV price is among the highest in the world at 72 cents per watt. US solar downstream companies claim that if the prices were not so high then US solar installation would have grown by much further ("Jigar Shah: Trade duties already harming US solar companies | PV-Tech," n.d.).

So we have two opposing claims here. US solar manufacturers claim that they were closing down factories and laying off workers in the face of Chinese unfairly traded, cheap solar panels. On the other hand, US solar downstream companies claim that the higher price of solar panels due to the tariffs have depressed US solar market which could have grown much further and created a lot more jobs. We need to look at the numbers again in order to assign weights to their claims.

In 2015, the number of solar jobs in USA is roughly 200000. Only 37000 of these jobs are from manufacturing. To be conservative let us forget about all other jobs and compare between the installation and manufacturing jobs only. Even then, the number of jobs in manufacturing is only 37000 while against 118000 manufacturing jobs.

On the other hand, solar manufacturing jobs have another advantage. According to experts ("TRADE_ Light at the end of a solar trade war_ Experts see alternative to U.S. vs. China -- Friday, August 2, 2013 -- www.eenews.pdf," n.d.) one solar manufacturing jobs give rise to 3.8 supporting jobs while the same ratio is 0.8 for solar installation jobs.

Comparing all these issues we can say that the impact of these tariffs on solar jobs is unclear and there is no clear winner on this issue. More importantly from US government point of view is that US solar installation can provide the jobs which is so important to maintain political support for solar power.

Maintaining R&D Advantage to fight Climate Change

Given climate change scenario and the enormous potential of solar power to fight it, USA needs to maintain technological advantage in solar panels. Very importantly, In case of solar panels, it has been indicated that future reduction in price and increases in efficiency will come through research as the potential for price reductions through cheap raw materials is already extinguished(Lacey, 2013). So it is time to look forward to technological breakthroughs to make this technology affordable. As we know, Germany has done the major share of technological improvements in solar so far. USA have also chipped in. However, China is mostly about manufacturing. It seems the future of solar leadership depends on which country can cut down cost by technological innovations. A frequently cited argument from the side petitioning against solar firms is that if USA loses manufacturing facility entirely to China then in the long run it is bound to lose the technological edge following from research & development on this sector too(Haley and Haley, 2013). In the following paragraphs we try to evaluate this claim by using scholarly research on two theories- technology life cycle theory and lead market.

Technology life cycle theory assumes that a technology starts its life cycle usually from a developed economy where it goes through initial research and development phase. Initially, the product is manufactured at the original region. With time, however, production center starts to shift to peripheral, lower factor price regions as the market expands to mass levels(Klepper and Graddy, 1990).

The relevant question to this paper is that if the R&D capacity is also lost with manufacturing centers. Studies suggest that the West still possess the knowledge base in solar PV industry(De La Tour et al., 2011). However, proponents of CASM and SolarWorld may express fear that this will not last for much longer. Life-cycle theory literature have some interesting clues about this. It has been suggested that peripheral countries need more than traditional conventional technology transfer mechanism (like FDI and licensing) to become leaders in innovation(Lema and Lema, 2012). The authors mention that initiatives like international collaboration and local innovation can play that role.

Let us examine both these issues of local innovation and international collaboration. First, local innovation. Since mid 1980s, multi national corporations have been conducting some R&D activities in developing countries to exploit the cost differentials and Science and Technology resources(Reddy, 1997). This has significant impact in knowledge diffusion and improvement in absorptive capacity of the host country. A factor contributing to this is the emergence of world class universities in developing countries like China and India. Given that China and India both are the production destinations of the whole world, the presence of such universities guarantees efficient R&D workforce. Such a scenario should spur research through both multi national and local companies.

The second issue is the growth of international collaboration in research activities in recent years. Very pertinent to this discussion are two bilateral research center in China and India, both partnered with USA. These are named US-China Clean Energy Research Center (CERC) and Indo-US joint Clean Energy Research and Development Center (JCERDC).

CERC was established in 2009 on a basis of cost and task share. It had three research thrusts at that time: Advanced Coal Technology, Building Energy Efficiency and Clean Vehicles. The project was

extended up to 2020 with expanded funding and a new research thrust named Water-Energy Nexus. So far, more than 25 patents have been published and a few products have already reached markets (“BEE_June_1_2015_English.pdf,” n.d.)

Indo-US JCERDC is a project similar to CERC in terms of cost and task sharing structure. This platform focuses on building energy as well as solar energy and second generation bio fuels (“jcerdc-status-report-2015.pdf,” n.d.). The intellectual property management structure for both these organizations are pretty much the same too. They both refer to non-exclusive license to the partner’s territory through IP (“CERC-BEE_TMP_22_Sep_2011.pdf,” n.d.). This means, US firms will not get market access in these countries in case of products developed in these centers. Given the huge market size of both these countries this is a serious problem in the long run.

The motivating factor behind establishing these two centers is the same: to build effective partnership to prepare for climate change. From the point of view of an environmentalist, the existence of these centers are positive, at least symbolically. However, wearing a SolarWorld lens in the eyes will totally change the perspective and show how USA is losing out territory to the pressure of once peripheral countries.

Lead Market Literature

Lead market literature assumes that the first mover in a field will always retain a significant advantage over the competitors. Marian Beise and Klaus Rennings (Beise and Rennings, 2003) showed that when other countries accept the standards and practices of the lead market, the lead market ultimately becomes a large exporter of the technology. However, this is not the case for solar panels as we have already seen that the lag market of China has already surpassed the lead market of USA and Europe. However, as previously mentioned, the knowledge base is still in the west so it is perhaps possible to retain advantage in the long run.

In light of these theories we can say that SolarWorld’s and its supporters’ claim is not completely unfounded. Solar PV market was once dominated by EU and Japan but now the dominant player is China. Once a player become dominant in a certain industry and captures majority of global shares it has every incentive to invest the profit from this sales in R&D activities to maintain their advantage in the industry. For the US government then it is important to ensure that USA can do high-end R&D on solar panels.

From US government perspective, it is indeed a matter of concern that shifting production away from China may impede further technological development of solar power in USA.

Winners and Losers from the Case

US Basic Manufacturers

We have mentioned earlier that China retaliated against USDOC tariffs by imposing tariffs of over 50% to US polysilicon producers like Hemlock Semiconductors and REC silicon. Also, Figure 5 showed that US basic manufacturers are on the losing side of this dispute.

US Solar Manufacturers

US Solar manufacturers are supposed to be the principal beneficiary of these tariffs. It is expected that such tariffs will create a level playing field for US firms and they will be able to compete with Chinese

manufacturers. However, the issue is clearly not that simple. First is the issue that major US producers are not a part of CASM who claims to represent entire US solar manufacturing industry. Why is this so? It is because these two firms are already producing most of their solar panels outside America.

First Solar’s production facility is located in USA, Germany and Malaysia. In 2012, their capacity was 280 MW in USA, 220 MW in Germany and 1400 MW in Malaysia (“FIRST SOLAR, INC. (Form: 10-K, Received: 02/25/2015 06:16:43),” n.d.). SunPower also makes most of their panels in Philippines and Malaysia.

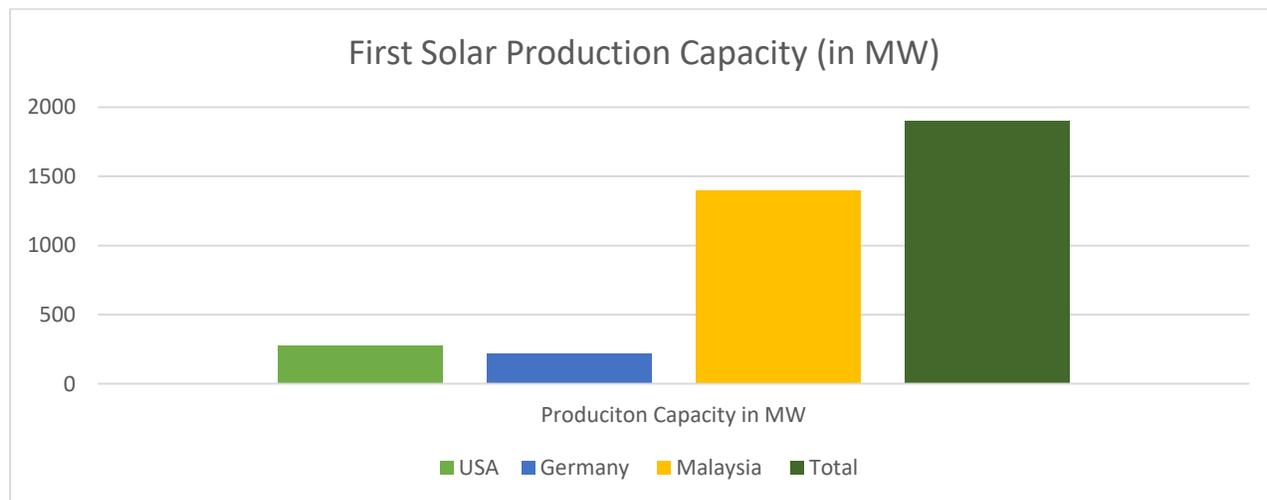


Figure 9 First Solar’s production facilities are mostly on foreign soils indicating protecting US solar manufacturers may not lead to US production

Why do these companies do so? The answer is simple- cost. Regardless of what SolarWorld or CASM claims, USA is simply too costly to produce solar panels. GTM research recently ranked USA 37th in the world in terms of cost competitiveness. Compared to that, Malaysia is 6th, South Korea is 12th and Germany is 32nd (“pv-map-100623748-orig.png (PNG Image, 958 × 555 pixels) - Scaled (63%),” n.d.). So even if the verdict helps US solar manufacturers, this will not bring jobs to USA as much as expected as major players are already producing outside the country. Industry experts have also voiced opinions that even if China loses market share in the USA, that share will go to other South East Asian manufacturers rather than US firms (“Solar margins improving, but a long way to go: pv-magazine,” n.d.).

Uncertainty of the regulation

As we have noted in this paper, the tariffs imposed by USDOC and USITC on the Chinese manufacturers face an uncertain fate. According to WTO verdict, USA must reverse these decisions by April 1, 2016. Will USA actually implement WTO verdict is an issue of speculation. However, what is relevant for this industry is that firms cannot invest based on a regulation which is so shaky. SolarWorld and a few other companies have added some manufacturing capacity around 450 MW after the verdict employing around 550 people. However, such additions are too little to have any big impact in the market.

Lower Margins in Solar Manufacturing

Margins in solar manufacturing is uncertain and very low. Given the host of low cost manufacturers other than China and Taiwan (Singapore, South Korea, Philippines, Malaysia, etc.) available in the market it is unlikely that the scenario will improve for US manufacturers. However, downstream

operations in solar are much more profitable and certain. That is the reason why companies like FirstSolar have invested so much in vertical integration. Downstream operation gives US firms kind of certainty which is unavailable in upstream activities.

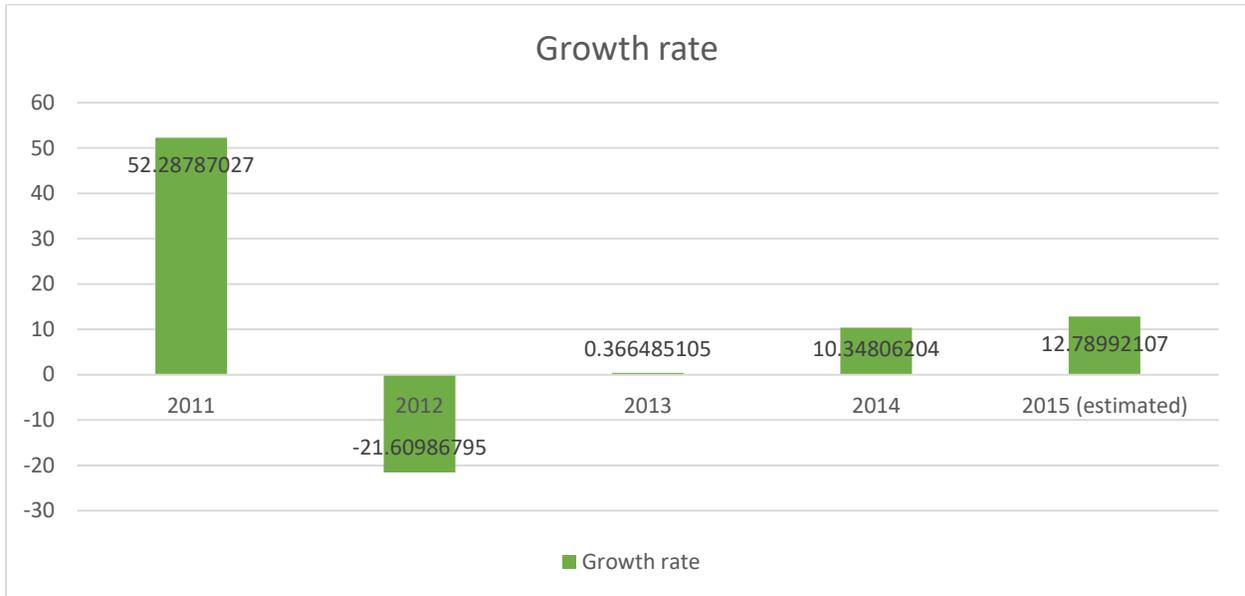


Figure 10 Growth rate of US solar manufacturing jobs

Considering all these issues, we can clearly see that US manufacturers are not clearly winners from this issue. Figure 10 suggests that the industry has reversed the negative growth but as shown in figure 8, the industry is yet to recover to the level of 2011 despite so much installation over the years.

US Solar Installers

We have seen in figure 8 that US solar installers have been the biggest source of jobs in this industry. Importantly, they have kept growing within a period when the process of solar power have raised because of tariff barriers. However, even though prices in US are high compared to other countries, prices have come down in absolute terms (Figure 6). So even though US solar installers are not winners from this case, they have been doing well over the years.

Chinese Manufacturers

We have seen that the tariffs imposed by USA on Chinese solar manufacturers are unsustainable in the long run. However, even if these tariffs could be retained, the impact of these tariffs are much smaller than first thought. We mentioned previously that the tariffs imposed by USDOC ranges from 20%-250%. Importantly, largest Chinese firms like Yingli Green Energy and Trina Solar received the lowest of these tariffs (around 20% for Yingli). These tariffs are most likely inadequate given the huge cost difference between USA and China and China's ability to scale production to monumental level.

Global Climate Change Regime

All major climate change players were excited with the falling prices of solar production. As we mentioned in the beginning of this paper, organizations like IEA bets on solar energy to stop fossil fuel based electricity production.

Climate change is a global problem and it is placed above the national trade interests. Increasing cost of solar for any reason is harmful to climate change. International climate change regime stands with China while it comes to the issue of green energy (Bastasch, 2015) and thinks USA is lagging behind on this issue.

The fight against climate change is getting more expensive with every minute of inaction. The climate change activists do not care who is making fight cheap as long as it is helping the world's GHG emission go low. Given USA's role of global hegemon and the expectation on them to lead the way, the global climate change regime loses a lot from these tariff barriers.

Inferences from Evaluation

1. Once peripheral countries like China and India are getting increasingly equipped with knowledge centers and skilled labors and posing a threat to build self-sufficient research and manufacturing base.
2. The tariffs are unsustainable in the long run
3. USA is not cost competitive in the global market
4. USA needs to retain production in order to retain R&D advantage
5. Chinese manufacturers still hold advantage over US ones

Future Actions

USA faces two contrasting goals for the future. First, it needs to continue to create jobs for the US population. As we have seen in our analysis, jobs are primarily added by solar installation firms who are firmly against these tariffs. Second, USA needs to keep investing in solar R&D in order to hold technological advantage in an industry whose importance in future climate regime is unparalleled.

We look to global semiconductor industry to give us an insight. We picked this industry because this industry is seeming to do exactly what solar industry is supposed to do by our analysis. Semiconductor production is increasingly shifting to Asia while the R&D advantage still lies with Western nations.

Fabless-Foundry Model of Global Semiconductor Industry

Semiconductors are part of almost every electronic equipment that we use. The global industry sales revenue stands today at around US\$333.2 billion. There are two steps in semiconductor manufacturing: design and manufacturing. Circuit manufacturing facilities are very costly to build and maintain. As a result it is an absolute necessity that these facilities are always maintained at full optimization. This was found to be very difficult for semiconductor manufacturers due to business cycles, new product launching and fading out.

This difficulty has divided the semiconductor industry in two parts. On one hand there are Integrated Design and Manufacturing (IDM) companies who still design and manufacture semiconductors in their own facility. Intel Corporation is an example of IDM. On the other hand are fabless manufacturers and foundries. Fabless manufacturers only design semiconductors but do not produce them in their own facilities. Foundries take orders from different fabless manufacturers and produce them. They take orders and schedule them in a way so that their facilities always remain at full optimization level. Some IDM companies also take outside orders to achieve full optimization. Foundries who only take part in production and no design are called pure-play foundries.

The growing fabless and foundry model shows that it is possible to manufacture products outside USA but still hold advantage in terms of design and R&D.

Fabless Manufacturer Sales Ranking		Foundry Sales Ranking	
Company	Country of Origin	Company	Country of Origin
Qualcomm	USA	TSMC	Taiwan
Broadcomm	USA	Globalfoundries	USA
AMD	USA	UMC	Taiwan
MediaTek	USA	SMIC	China
Nvidia	USA	Powerchip	Taiwan

Table: This table incorporates global fabless(Manners, n.d.) and foundry(“Spreadtrum, Dialog, MegaChips shine in fabless rankings | EE Times,” n.d.) sales ranking from the year 2013 and 2011 respectively. We have included only the companies who are purely foundries and excluded the ones who take orders from outside.

The table shows us that all top five global fabless manufacturers are from USA while four of top five global pure-play foundries are from Asia. Globalfoundries, the only US corporation in the list produces semiconductors outside USA as well(“Manufacturing Overview,” n.d.).

Lessons for Solar Industry

Solar industry, albeit its differences with semiconductor industry, can learn a lot from here. Semiconductor industry shows an effective route which quashes the fear that USA will lose all its technological advantage by losing manufacturing facilities. We have already seen that we do not need solar manufacturing for the purpose of jobs. This model shows us here that the purpose of maintaining technological and R&D advantage can be maintained through effective cooperation with Chinese or Asian manufacturers.

Challenge

The obvious concern in utilizing such a model is the issue of technology theft. Skeptics may argue that manufacturing panels with advanced technology in a competitor country will inevitably lead to technology drain to that country. This can mean that the competitor countries will get the fruit of R&D activities in USA.

The issue of technology theft is not specific to any industry, however. Every industry who outsources production faces this issue. The only way to face this issue is constant innovation. Specifically, semiconductor industry follows a pattern of constant innovation called Moore’s law(“Moore’s Law,” n.d.). Foundries cannot involve in technology theft due to this constantly arriving waves of newer and better technology.

While semiconductor industry provides example to an extreme, solar industry can also build a sustainable model by adopting a constant innovation policy. Building solar manufacturing facility is costly and so has a large breakeven period. So even a moderate pace of technological shift will impede parties to engage in technology theft. We are already observing that some US companies are slashing down costs by using newer technologies(“Solar startup to build big factory in upstate New York - Fortune,” n.d.).

Policy To-dos

Below we provide a list of actions to be taken based on our analysis of the scenario.

1. Stop pursuing tariff barriers

The tariff barriers lead to bitter relations with a very important trade partner. More importantly, these barriers create a protection which is not going to last after 2016 which makes any sustainable return from these barriers unlikely. In such a scenario US government should talk with its Chinese counterpart and reach an amicable solution on the issue.

2. Expand solar installation

Solar installation is the major source of job growth in this industry. More installation also means moving forward to effective climate change mitigation. US government should pursue Solar ITC, net metering and other policies mentioned in previous sections in order to increase solar installation as much as possible.

3. Invest in solar R&D

R&D is the only way to minimize costs and be a step ahead than competitors. US government can introduce tax credits for investment in solar R&D while funding universities to carry out basic research in the field of solar and renewable energy in general.

4. Collaborative research with other technology leaders

Countries like Germany and Japan, historical leaders in solar technology are also suffering from the same issue. USA should look to build technological cooperation so that these countries can learn from each other and build an effective solar technology system in the process which will lead to faster technological growth in the sector.

Conclusion

Climate change is probably the most significant challenge awaiting the world. While issues like lower solar costs can take us in the right direction, misunderstood national interests can harm our capability to do so by artificially increasing the cost of an already costly endeavor. On the other hand, technology transfer is beneficial but not when this harms inventors of those very technologies. Solar industry stands at the crossroads of these issues and it is no wonder that it has led to so much of rivalry and retaliations. The only way to solve this problem is to innovate constantly and engage collaboratively.

References

- 19-adp.wpf - 19-adp.pdf, n.d.
- 24-scm.wpf - 24-scm.pdf, n.d.
- About the USITC | USITC [WWW Document], n.d. URL http://www.usitc.gov/press_room/about_usitc.htm (accessed 11.20.15).
- American Solar Manufacturing [WWW Document], n.d. URL <http://www.americansolarmanufacturing.org/about/> (accessed 11.20.15).
- Author, n.d. U.S. Department of Commerce issues final duties against solar PV products from China and Taiwan [WWW Document]. URL <http://www.solarserver.com/solar-magazine/solar-news/archive-2014/2014/kw51/us-department-of-commerce-issues-final-duties-against-solar-pv-products-from-china-and-taiwan.html> (accessed 12.7.15).
- Bastasch, M., 2015. UN Climate Chief Praises China For Fighting Global Warming [WWW Document]. Dly. Caller. URL <http://dailycaller.com/2015/07/22/un-climate-chief-praises-china-for-fighting-global-warming/> (accessed 12.14.15).
- BEE_June_1_2015_English.pdf, n.d.
- Beise, M., Rennings, K., 2003. Lead markets of environmental innovations: a framework for innovation and environmental economics.
- BUSINESS_ U.S.-China solar war spiking PV prices for Americans -- Tuesday, March 3, 2015 -- www.eenews.pdf [WWW Document], n.d. . Dropbox. URL https://www.dropbox.com/s/qduwvkeusr02mfn/BUSINESS_%20U.S.-China%20solar%20war%20spiking%20PV%20prices%20for%20Americans%20--%20Tuesday%2C%20March%203%2C%202015%20--%20www.eenews.pdf?dl=0 (accessed 12.7.15).
- CERC-BEE_TMP_22_Sep_2011.pdf, n.d.
- Coalition for Affordable Solar Energy | Strata Solar, n.d.
- DATE, F.C., 2015. ORD-Order. Order 2, 10.
- De La Tour, A., Glachant, M., Ménière, Y., 2011. Innovation and international technology transfer: The case of the Chinese photovoltaic industry. *Energy Policy* 39, 761–770.
- Department of Commerce [WWW Document], n.d. . Dep. Commer. URL <https://www.commerce.gov/> (accessed 11.20.15).
- Executive Briefing: The Future of U.S. Solar [WWW Document], n.d. URL <https://forms.greentechmedia.com/Extranet/95679/forms.aspx?msgid=3fd52c44-1bb7-4194-85bc-7ca0a4ce2175&LinkID=CH00095679eR00000379AD> (accessed 12.7.15).
- FIRST SOLAR, INC. (Form: 10-K, Received: 02/25/2015 06:16:43) [WWW Document], n.d. URL http://secfilings.nasdaq.com/edgar_conv_html%2f2015%2f02%2f25%2f0001274494-15-000006.html#FIS_BUSINESS (accessed 11.20.15).
- FR-Notice-1.pdf, n.d.
- Green-jobs evangelist sells Obama’s ambitious plans | Renewable Energy Jobs [WWW Document], n.d. URL <https://www.renewableenergyjobs.com/content/green-jobs-evangelist-sells-obamas-ambitious-plans> (accessed 12.8.15).
- GSR2014_full report_low res.pdf, n.d.
- Haley, U.C.V., Haley, G.T., 2013. *Subsidies to Chinese Industry: State Capitalism, Business Strategy, and Trade Policy*. Oxford University Press.
- Hemlock closing Clarksville plant permanently [WWW Document], n.d. URL <http://www.theleafchronicle.com/story/news/local/clarksville/2014/12/17/hemlock-closing-clarksville-plant-permanently/20536529/> (accessed 11.21.15).
- Herszenhorn, D.M., 2015. Votes in Congress Move to Undercut Climate Pledge. *N. Y. Times*.

iea-pvps.org - Statistic Reports [WWW Document], n.d. URL <http://www.iea-pvps.org/index.php?id=32> (accessed 11.21.15).

ipcc_wg3_ar5_chapter13.pdf, n.d.

jcerdc-status-report-2015.pdf, n.d.

Jigar Shah: Trade duties already harming US solar companies | PV-Tech [WWW Document], n.d. URL http://www.pv-tech.org/news/jigar_shah_trade_duties_already_harming_us_solar_companies (accessed 12.8.15).

Klepper, S., Graddy, E., 1990. The Evolution of New Industries and the Determinants of Market Structure. *RAND J. Econ.* 21, 27. doi:10.2307/2555491

Lacey, S., 2013. Here's How Chinese Firms Will Produce Solar for 36 Cents per Watt [WWW Document]. URL <http://www.greentechmedia.com/articles/read/solar-cost-reduction-drivers-in-2017> (accessed 11.20.15).

Layout 1 - 0418_clean_investments_final paper_PDF.PDF, n.d.

Lema, R., Lema, A., 2012. Technology transfer? The rise of China and India in green technology sectors. *Innov. Dev.* 2, 23–44. doi:10.1080/2157930X.2012.667206

Loan Guarantee Program [WWW Document], n.d. . SEIA. URL <http://www.seia.org/policy/finance-tax/loan-guarantee-program> (accessed 12.7.15).

Manners, D., n.d. Fabless companies grew 8% in 2013, says IC Insights | Electronics Weekly. *ElectronicsWeekly*.

Manufacturing Overview [WWW Document], n.d. URL <http://globalfoundries.com/manufacturing/manufacturing-overview> (accessed 12.14.15).

Moore's Law, n.d.

National Solar Jobs Census 2014 | The Solar Foundation [WWW Document], n.d. URL <http://www.thesolarfoundation.org/national-solar-jobs-census-2014/> (accessed 12.7.15).

Net Metering [WWW Document], n.d. . SEIA. URL <http://www.seia.org/policy/distributed-solar/net-metering> (accessed 12.7.15).

pv-map-100623748-orig.png (PNG Image, 958 × 555 pixels) - Scaled (63%) [WWW Document], n.d. URL <http://core0.staticworld.net/images/article/2015/10/pv-map-100623748-orig.png> (accessed 12.8.15).

Reddy, P., 1997. New trends in globalization of corporate R&D and implications for innovation capability in host countries: A survey from India. *World Dev.* 25, 1821–1837. doi:10.1016/S0305-750X(97)00079-X

Renewable Energy [WWW Document], n.d. . Young Peoples Trust Environ. URL <https://ypte.org.uk/factsheets/renewable-energy/fossil-fuels-non-renewable> (accessed 11.20.15).

solar-cells-referral-cbp.pdf, n.d.

Solar Investment Tax Credit (ITC) [WWW Document], n.d. . SEIA. URL <http://www.seia.org/policy/finance-tax/solar-investment-tax-credit> (accessed 12.7.15).

Solar margins improving, but a long way to go: pv-magazine [WWW Document], n.d. URL http://www.pv-magazine.com/news/details/beitrag/solar-margins-improving--but-a-long-way-to-go_100012984/#axzz3thScY820 (accessed 12.8.15).

Solar Markets Around The World [WWW Document], n.d. URL http://solarcellcentral.com/markets_page.html (accessed 11.20.15).

Solar startup to build big factory in upstate New York - Fortune [WWW Document], n.d. URL <http://fortune.com/2015/10/07/solar-factory-upstate-new-york/> (accessed 12.14.15).

Spreadtrum, Dialog, MegaChips shine in fabless rankings | EE Times [WWW Document], n.d. URL http://www.eetimes.com/document.asp?doc_id=1261538 (accessed 12.14.15).

SunShot Initiative | Department of Energy [WWW Document], n.d. URL <http://energy.gov/eere/sunshot/sunshot-initiative> (accessed 12.7.15).

Technology Roadmap Solar Photovoltaic Energy - 2014 edition - TechnologyRoadmapSolarPhotovoltaicEnergy_2014edition.pdf, n.d.

This Entrepreneur Plans to Save the World, \$1 Trillion at a Time [WWW Document], n.d. . Entrepreneur. URL <http://www.entrepreneur.com/article/242438> (accessed 11.20.15).

TRADE_ Light at the end of a solar trade war_ Experts see alternative to U.S. vs. China -- Friday, August 2, 2013 -- www.eenews.pdf [WWW Document], n.d. . Dropbox. URL https://www.dropbox.com/s/6jw9h61hvbaw4gr/TRADE_%20Light%20at%20the%20end%20of%20a%20solar%20trade%20war_%20Experts%20see%20alternative%20to%20U.S.%20vs.%20China%20--%20Friday%2C%20August%202%2C%202013%20--%20www.eenews.pdf?dl=0 (accessed 12.8.15).

USDOC, n.d. FACT SHEET Commerce Finds Dumping of Imports of Certain Crystalline Silicon Photovoltaic Products from China and Taiwan and Countervailable Subsidization of Imports of Certain Crystalline Silicon Photovoltaic Products from China.

US to slap new tariffs on Chinese PV panels [WWW Document], n.d. . Pv Mag. URL http://www.pv-magazine.com/news/details/beitrag/us-to-slap-new-tariffs-on-chinese-pv-panels_100015321/ (accessed 12.4.15).

Wesoff, E., 2011. Solar Trade War Officially Starts Today [WWW Document]. URL <http://www.greentechmedia.com/articles/read/solar-trade-war-officially-starts-today> (accessed 11.20.15).

WTO | dispute settlement - the disputes - DS437 [WWW Document], n.d. URL https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds437_e.htm (accessed 12.4.15).

WTO | The WTO in brief [WWW Document], n.d. URL https://www.wto.org/english/thewto_e/whatis_e/inbrief_e/inbr00_e.htm (accessed 11.20.15).

WTO | Understanding the WTO - principles of the trading system [WWW Document], n.d. URL https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact2_e.htm (accessed 12.4.15).

Yingli Green Energy Comments on U.S. Department of Commerce's Solar PV Tariff Rulings Following Administrative Reviews of Imported Panels Using Chinese Cells [WWW Document], n.d. URL <http://www.prnewswire.com/news-releases/yingli-green-energy-comments-on-us-department-of-commerces-solar-pv-tariff-rulings-following-administrative-reviews-of-imported-panels-using-chinese-cells-300110923.html> (accessed 12.7.15).

