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China's Solar Industry and the U.S. Anti-Dumping/Anti-Subsidy Trade Case

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We also interviewed the Business Development Coordinator at a Chinese solar module manufacturer who asked to remain anonymous.

We also consulted more than one hundred print and online sources of expertise in preparation of this report; these are cited throughout the report in footnotes.

Executive Summary

The anti-dumping and anti-subsidy trade case filed in October 2011 by SolarWorld Industries America and six other U.S.-based solar manufacturers followed close on the heels of a very rough two years for U.S. solar manufacturers. After spiking in 2006, prices of crystalline silicon photovoltaic (CSPV) solar cells and modules plummeted in 2008, falling about 70 percent through 2011.

Gordon Brinser, President of SolarWorld Industries America, says China is to blame. China, he said, has targeted the solar industry for global production and dominance. "Since 2010, employees of at least 12 U.S. solar manufacturing companies – in Arizona, California, Florida, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Texas and Wisconsin – have become road kill along China's five-year planning superhighway."

Indeed, China's development in solar manufacturing has been big and fast. In 2001 China produced 1 percent of the world's solar cells and modules. By 2010 it produced nearly half. Today, four of the top 5 solar cell producers are Chinese; three of the five module producers are.

But that meteoric rise to the top does not necessarily mean that the Chinese government has been illegally subsidizing its solar manufacturers. Chinese manufacturers' super-low prices don't necessarily mean they're dumping product below the cost of production. In this report, we aim to sort out facts and well-founded opinions from unfounded opinions and half truths, to discern the role that subsidies have played, and to explore the other factors that might give China's producers a legitimate competitive advantage.

The stakes are high. For one thing, countervailing (anti-subsidy) duties, if high enough, could dramatically affect the solar industry in the U.S. and around the world, as could anti-dumping tariffs. There are potentially severe unintended consequences of any policy action in this case – or inaction, for that matter.

And for another, this case is well-representative of a phenomenon that is happening in many industries: China-based manufacturers are rising at the cost of U.S-based manufacturers. Enforcing World Trade Organization (WTO) regulations, as well as domestic trade laws, is a vital way to ensure that the playing field is level and producers in the U.S., Germany, Japan, and elsewhere are given a fair chance to compete with Chinese producers. But perhaps there are other actions that U.S. policymakers must consider, as well, to ensure that U.S. firms remain productive and innovative through the next century as well.

In the pages that follow you'll find a balanced, fact-based discussion of the trade case; an exploration of how China's solar industry has grown so big so fast; and a thorough analysis of what might be the consequences – many of them likely unintended – of likely outcomes of this trade case. We trust you will come away with a new sense of how the industry got to where it is and where we should go from here – a path that mutually benefits us all.

Highlights from the report

Section 1 – The facts

The trade case – On October 19, 2011, a group of seven U.S. solar manufacturers, founding members of the Coalition for American Solar Manufacturing (CASM), filed petitions with the U.S. International Trade Commission and Department of Commerce International Trade Administration seeking relief for the U.S. domestic producers injured by Chinese imports of crystalline silicon photovoltaic (CSPV) products.

On March 20, 2012 the Department of Commerce announced its affirmative preliminary determination in the countervailing duty (anti-subsidy) investigation. Suntech Power received a preliminary countervailing duty of 2.90 percent; Trina Solar 4.73 percent; and all other Chinese producers 3.61 percent. Commerce is currently scheduled to make its final determination in June 2012.

The Department of Commerce preliminary anti-dumping duty determination has been postponed to the latest possible date, May 16, 2012. The decision will be announced on May 17.

Section 1.2 – Data on the global solar PV market

Demand – Demand for solar photovoltaic systems is driven largely by the relative price of the electricity produced by those systems compared to electricity generated by other means. Since the early 2000s, on-grid installation of PV systems has grown exponentially (45 percent per year on average between 2003 and 2009), driven almost exclusively by government policies in Germany, Spain, Italy, Japan, and the U.S. These policies are designed, in one way or another, to subsidize the cost of solar power so that it is competitive with other on-grid electricity sources.

Through 2010 Germany had 43 percent of the world's cumulative (total) installed solar PV capacity. The United States had 6 percent of the world's total installed capacity and China had just 2 percent. But Germany and Italy's shares of PV installations are shrinking, while China's is growing. Germany's annual demand for solar modules will be just 15 percent of the world's total by 2015, and China's will be 19 percent. Like Germany's, Italy's share of annual installations is expected to fall, while the United States and Japan's will rise.

Supply – Global production of solar photovoltaics has risen dramatically in the last decade – from 371 megawatts in 2001 to more than 24 gigawatts in 2010, an increase of 6,376 percent. In 2001, Japan was the single largest producer of photovoltaics, supplying 46 percent of the world production. By 2010, China was the single largest producer, with 45 percent of the world market. The United States' share fell from 27 percent to 5 percent over the same period. By 2006, China was producing more photovoltaics than the U.S.

Price – The overall global trend in the price of solar cells and modules has historically been downward. Price declines accelerated beginning in 2008. Estimates are that global CSPV module prices declined from about $3.30 per watt in 2008 to about $1.80 per watt at the beginning of 2011 and $1.00 per watt at the end of 2011. The price is projected to fall to $0.74 per watt by 2014.

Five factors determine the price of solar cells and modules, and have driven the general downward trend (save the spike between 2004 and 2008) in prices. Those factors include: 1) Declining prices for inputs, most importantly polysilicon; 2) competition from lower-priced thin film products; 3) waning government incentives and demand subsidies; 4) increasing economies of scale and efficiency improvements (driven by learning and innovation); and 5) oversupply.

Section 1.3 – Who has received subsidies, and how much?

As Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, points out, subsidy programs are "not necessarily anticompetitive." In fact, "policy assistance is often required to help new technologies compete with existing market alternatives – especially when the existing alternatives such as coal already receive explicit and implicit public subsidies. We have similar green energy programs here in the United States."[1]

U.S. subsidies – The United States offers subsidies that both aim to nurture green energy technologies and to strengthen America's exports. The U.S. Department of Energy's SUNPATH initiative is designed not only to help domestic PV manufacturers commercialize solar technology, but to "restore the United States' position at the forefront of solar manufacturing."[2] And in his 2012 State of the Union address, U.S. President Obama said "I will not cede the wind or solar or battery industry to China or Germany because we refuse to make the same commitment here."

The federal policies that currently support (or have recently supported) the solar industry in the U.S. include the Investment Tax Credit (ITC), 1603 Treasury Program, Advanced Energy Manufacturing Tax Credit (MTC), Temporary Loan Guarantee Program for Deployment of Renewable Energy, and Department of Energy SunShot. Many U.S. states offer additional support. (See *Section 1.3.1* for details.)

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[1] Melanie Hart. *Shining a Light on U.S.-China Clean Energy Cooperation*. Center for American Progress, Feb. 2011: Print.

[2] SEMI North American PV Advisory Committee, *Manufacturing Solar Photovoltaic Products in the United States* (Washington: SEMI North American PV Advisory Committee, 2012)

China subsidies – Many of the U.S. credits, guarantees, subsidies, and grants to solar manufacturers (as well as consumers and producers of solar power) look quite similar, in fact, to those that China offers. But one tool that the U.S. doesn't employ to promote solar manufacturing, which China does very well, is industrial policy – a very clear and specific strategic national policy that directs (and then promotes) the development of a specific industry. The pinnacle of industrial policy in China is the Five Year Plan. This plan, according to Gordon Brinser, President of SolarWorld Industries America, is one of the key reasons why China's solar manufacturers have grown so big so fast.

It is clear that a number of China's provinces offer support for solar manufacturers above and beyond what is offered at the national level. It's not clear, however, exactly how this support is doled out – and to what extent. Determining the specific mechanisms that the provincial governments use to build the solar industry is "extremely difficult."[3]

Section 1.4 – Who are the players and what are they doing, where?

Of the top fifteen solar cell manufacturers in 2010, six were Chinese companies. Two were American. Of the fifteen solar module manufacturers in 2010, eight were Chinese. One was American.

Solar manufacturing is currently experiencing a global "shakeout" due to difficult global business conditions, stiff competition particularly from Chinese manufacturers, and slowing demand for solar panels.[4] While lower-cost Chinese producers play a significant role in this "shakeout" they are themselves not immune to the other global pressures – notably reduced subsidies in Europe that will likely lead to a reduction in demand (or, at least, demand growth) there.

[3] Melanie Hart. Shining a Light on U.S.-China Clean Energy Cooperation. Center for American Progress, Feb. 2011: Print.

[4] Michaela D. Platzer. Congressional Research Service. *U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support*. Washington: Congressional Research Service, 2012. Print.

Section 2 – Why has China's solar industry grown so big so fast?

Section 2.1 – How much has government support fueled industry development?

While it is difficult to parse exactly which companies are receiving what kinds of subsidies from whom in China, it is clear that the Chinese government strongly supports the development of a world-leading solar manufacturing industry there – not least of all by direction in the Five Year Plan. (See Section 2.1 for details.)

Section 2.2 – Do Chinese manufacturers have a cost advantage?

18-30 percent cost advantage – Estimates of the cost advantage of top tier Chinese cell and module manufacturers compared to their U.S. counterparts range from about 18 percent to 30 percent. According to GTM Research analyst Shyam Mehta, the cost differential between U.S. and Chinese manufacturers is about 25 to 30 percent in 2012. Rob Wanless, Director of Business Development at SOLON Corporation, said that the cost of solar panels from Chinese manufacturers is about $1 per watt, and $1.20-1.30 per watt from U.S. manufacturers. One executive at a Chinese module manufacturer suggested similarly, that China has about a cost advantage of about $0.20 per watt on modules and about $0.10 per watt on cells. (See *Section 2.2* for details.)

NREL study grossly misrepresented – In a study that was publicized by many solar-related media outlets, analysts at the National Renewable Energy Laboratory (NREL) conducted an analysis of cost of solar cell and module production in China and in the U.S. All of the popular reports on the study argued that it demonstrates that Chinese solar manufacturers have a 5 percent cost disadvantage compared to U.S. manufacturers when the cost of shipping from China to the U.S. is included.[5] *But that was, in fact, not the conclusion of the study at all.*

According to NREL, China's core cost advantage of 18-20 percent in cell manufacturing comes largely

[5] See, for example, CleanTechnica and the Coalition for American Solar Manufacturing

from manufacturer scale and vertical integration; the analysts compare a 60 MW plant in the U.S. to a 2,000 MW plant in China. That scale and integration gives China's manufacturers a 10 percent discount on all materials ("due to supplier leverage and captive production strategies") and a 50 percent discount on equipment from Chinese equipment vendors. Labor costs are certainly much lower in China, but labor only makes up about 5-10 percent of the cost of a module, and U.S.-based manufacturers make up for higher labor costs with more highly automated plants.

Section 2.3 – What has been the role of foreign direct investment (FDI) and technology transfer?

The development of some industries in China – integrated circuits and automotives, for example – has been fueled at least in part by foreign invested enterprises. The presence of foreign invested enterprises (FIEs) fuels development of China's own industry in a couple of ways, including through technology transfer and the rapid diffusion of know-how.

Foreign invested enterprises have not played that kind of role in the development of China's solar industry, which has largely been homegrown. That's not to say, however, that the transfer of technology and know-how into China has not been a factor; indeed, it has been a critical element in the growth of China's solar manufacturing industry.

Technology transfer from equipment manufacturers and through licensing and research collaboration, and know-how from the Chinese diaspora – In particular, technology transfer from American, German, and Swiss equipment makers has allowed Chinese manufacturers to nearly plug-and-play solar production lines into their factories. Technology transfer through licensing and research collaboration continues to play an important role in innovation within Chinese solar firms. And know-how from the Chinese diaspora has been invaluable as well; many of the top companies' founders and executives first worked at solar firms in other countries and/or studied at solar research facilities outside China.

Section 2.4 – The role of trade credits

Another advantage that China's manufacturers have is the ability to provide what Jigar Shah, President of the Coalition for Affordable Solar Energy, calls "trade credits" – more often referred to as vendor financing. Instead of requiring payment from customers before shipping the solar cells or modules, a number of top tier Chinese manufacturers offer 60-day payment windows.

Section 2.5 – The role of Chinese domestic demand

China has not to date been a very large market for solar power installations. But that is clearly changing. In 2010 China's annual installations of CSPV solar was just 3 percent of the world total. But by the end of 2013 analysts expect China's share to have grown to 21 percent. The two most significant drivers of domestic demand for solar power in China are feed-in-tariffs, at both the regional and the national levels, and the national Golden Sun program.

Are Chinese manufacturers gearing up to meet domestic demand? – To put China's installed capacity targets in perspective, consider that total installed capacity for the whole world was just under 40 GW in 2010. China is planning to have that much capacity on its own within the decade. Even given current oversupply of cells and modules, Chinese manufacturers will have to continue producing at very high levels to meet targeted domestic demand there.

Section 3 – What might be the consequences – for all the stakeholders – if the Department of Commerce imposes significant tariffs on Chinese solar PV cells and modules?

Section 3.1 – How might China react?

China could stop its dumping and illegal subsidies – If Chinese manufacturers are found to have dumped their products on global markets, one potential outcome of the trade case is that China could remove its (relatively modest) subsidies and stop dumping. And there is precedent for that kind of outcome.

Chinese manufacturers could retaliate – The U.S. is still an important supplier of polysilicon, as well as CSPV manufacturing equipment. But Chinese manufacturers could ramp up their own production of polysilicon (which they have already begun doing) and turn to Germany and Switzerland to fill the equipment gap – effectively cutting out the U.S. firms that are still competitive in the solar supply chain.

Chinese solar manufacturers could ramp up production in the U.S. – There is a case to be made for locating solar module assembly facilities in the end market. But to avoid the tariffs, Chinese manufacturers would have to locate their cell production facilities in the United States as well. To achieve the kind of scale and vertical integration that allow them to keep costs low, Chinese manufacturers would have to invest huge sums of money in the United States – to essentially recreate the Chinese solar supply chain here. It's not clear that the United States is a large enough market – not yet at least – to warrant that kind of capital investment.

Chinese firms could move manufacturing to Taiwan – A far more likely response to significant (punitive) tariffs would be for Chinese firms to move cell production to Taiwan. In fact, if manufacturing cells in Taiwan would allow Chinese manufacturers to keep their upstream supply chains intact, that could be their best solution. They could then assemble the modules anywhere in the world – in Taiwan, in China, in Mexico, in the end-use country.

Chinese manufacturers could do nothing – Shyam Mehta, Senior Analyst at GTM Research, said that even if the U.S. imposed tariffs as high as 15 percent, if the Chinese cost advantage is 30 percent, then it may still be to Chinese manufacturers' advantage to keep doing business as usual – manufacture in China and simply take the tariff hit on U.S. imports.

Section 3.2 – The net economic effects of tariffs

Effect on sellers, distributors, and installers of solar PV in the U.S. – Punitive tariffs against Chinese cell imports could affect solar PV sellers, distributors, and installers in the U.S. – and the 76,000 Americans they employ – in a number of ways.[6] Most significantly, low-cost cell and module imports from China have dramatically reduced total PV system cost. And low total system cost is critical to the growth of the solar industry given that solar power is still not, in many cases, cost competitive with traditional power sources. So if the imposition of tariffs causes costs to increase, that could cause demand for solar products to decline – and an associated reduction in American jobs in areas like marketing, sales, installation, construction, engineering, and distribution.

In addition to employing more people, those activities outside of cell and module manufacturing create more value for the U.S. economy as well. According to GTM Research, 71 percent of total CSPV system value in 2010 was created domestically.[7] Domestic value creation is particularly high in mounting structures, site preparation, labor, soft costs, and value chain markup for the module distributor and system installer. It is these activities that stand to lose the most if tariffs raise the price of solar panels in the U.S.

Effect on U.S.-based polysilicon producers – The U.S. produces about 25 percent of the world's polysilicon – a key photovoltaic material and the first step in the CSPV value chain.[8] In 2010, U.S. net exports (exports less imports) of polysilicon to the world was almost $2.4 billion, up 125 percent from 2009, and $869 million to China alone. In 2011, net exports of polysilicon to the world was just under $2.3 billion, $673 million to China alone. That's why Rob Wanless, Director of Business Development at SOLON Corporation, said that he's particularly nervous about China retaliating and imposing tariffs on polysilicon imports from the U.S.

Effect on U.S.-based solar equipment manufacturers – The story is essentially the same for U.S. manufacturers of PV capital equipment as

[6] National Solar Jobs Census 2011
[7] GTM. U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States. Washington: GTM, 2011. Web. 2012.
[8] GTM. *U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States.* Washington: GTM, 2011. Web. 2012.

for polysilicon producers. In 2010, U.S. net exports (exports less imports) of PV capital equipment to the world was just over $975 million, up 137 percent from 2009, and $761 million to China alone. In 2011, net exports of capital equipment to China was $602 million.[9]

Yet there are some who argue that refraining from assessing tariffs on subsidized and (allegedly) dumped Chinese imports just because China might retaliate and cause losses in the U.S. polysilicon and PV capital equipment industries would be short-sighted. They argue that China will seek to dominate the polysilicon and capital equipment industries just as they have cell and module manufacturing.

There are, broadly, two problems with China's rise in the polysilicon industry. For one, if China's rise takes away production from the U.S. (which is not inevitable) that would represent a further deterioration of the solar manufacturing industry in the U.S. And that would send ripple effects across the economy. Secondly, China's leading solar cell and module manufacturers are equally as innovative as U.S. manufacturers today. But if China develops a monopoly across the solar supply chain, that could drive out innovation – which is still critical to reach grid parity (where the unsubsidized price of solar power equals the price of power generated by coal or natural gas).

Effect on the growth of solar power as an alternative energy source – Adam Hersh, Economist at the Center for American Progress, argued that if Chinese producers have an unfair advantage it will undermine the world's transition to renewable energy as a source of power. Others argue that imposing tariffs on China's low-cost solar products will raise the price of solar systems dramatically enough to curb demand for them. Low total system cost is critical to the growth of the solar industry given that solar power is still not, in many cases, cost competitive with traditional power sources. So if the imposition of tariffs causes costs to increase, that could cause demand for solar products to decline – and slow the transition to solar energy as an alternative power source.

Section 4 – Moving forward

If we assume, for the sake of argument, that the Department of Commerce does not find evidence of dumping, or finds relatively low dumping margins and, thus, tariffs against Chinese manufacturer remain relatively small and not particularly punitive, then we still likely have a problem. U.S. solar manufacturers will still struggle with the difficulties that have plagued them the past several years. Chinese manufacturers will still have the scale, the vertical integration, the discounted materials and equipment, and the low labor costs that allow them to sell cells for 20 percent less than their American competitors. And they will still have the significant support of the Chinese government's industrial policy.

According to Shyam Mehta, Senior Analyst at GTM Research, Western and Japanese crystalline silicon manufacturers will never beat China at the CSPV game because China has such lower costs. For non-Chinese companies, he said, the future lies in either differentiated technology or a new business model. Others suggest that the U.S. develop an industrial policy. "U.S. incentives can level the playing field. The scale of Chinese incentives dwarf U.S. efforts. Access to capital is a critical compliment to the United States' capacity to innovate."[10] Speaking at the Conference on the Renaissance of American Manufacturing, Gordon Brinser, President of SolarWorld Industries America, said that the U.S. must respond more quickly when there is evidence that China is violating international or domestic trade laws.

These are all steps that could help – the U.S. *should* help its manufacturers and enforce international and domestic trade laws. But it's important to realize, as this report and the preliminary countervailing duty from the Department of Commerce have made clear, that China's top tier solar cell and module manufacturers are highly competitive for many

[9] GTM. *U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States.* Washington: GTM, 2011. Web. 2012.

[10] Alan Goodrich, Ted James and Michael Woodhouse. *Solar PV Manufacturing Cost Analysis: U.S. Competitiveness in a Global Industry*, Power Point Presentation, Stanford University: Precourt Institute for Energy, 10 Oct. 2011.

more reasons than having received subsidies on the order of 3-5 percent.

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Introduction

This ChinaGlobalTrade.com Content Package provides new perspective on the topic of global solar manufacturing and the anti-dumping and countervailing (anti-subsidy) petitions currently before the U.S. International Trade Commission and Department of Commerce. We address two key underlying questions: 1) Why has China's solar industry grown so big so fast? and; 2) What might be the consequences – for all the stakeholders – if the Department of Commerce imposes significant tariffs on Chinese solar PV cells and modules?

In **Section 1** we'll explore the facts: first, an overview of the *Countervailing Duty Investigation of Crystalline Silicon Photovoltaic Cells, Whether or Not Assembled into Modules, From the People's Republic of China* (the trade case), then a review of the CSPV supply chain. Then we'll talk about global demand for solar photovoltaic products and the factors that influence that demand. Next we'll analyze global supply of CSPV products by country.

Then we'll look at the price of CSPV products – a critical component of this trade case – and analyze the five factors that have driven price reductions in the solar industry (declining input prices, competition from thin film products, government regulations, increasing economies of scale and efficiency improvements, and oversupply).

In *Section 1.3* we look at national and local subsidy programs in China and the United States, to get a sense of the degree to which producers in each country gain competitive advantage through government support. Finally, in *Section 1.4* we get to know the world's six largest solar cell and module manufacturers – Suntech Power, First Solar, Yingli Green Energy, Trina Solar, Sharp, and JA Solar – and explore how those companies have succeeded. We also get an overview of CSPV product manufacturing in Mexico, Japan, Taiwan, Malaysia, Germany, and the Philippines.

Knowing the facts, in **Section 2** we dive into the question of how China's solar manufacturers got so big so fast. We explore the role of government support in fueling industry development. Then in *Section 2.2* we analyze the extent to which China-based manufacturers have a legitimate cost advantage over U.S.-based producers. We consider the role of scale, vertical integration, discounted equipment, discounted materials, and low cost labor as factors that allow Chinese manufacturers to sell cells and modules for 20-30 percent less than their U.S.-based competitors.

In *Section 2.3* we consider the role of foreign direct investment into China in the development of the solar industry there. It has been the case in a number of Chinese industries – integrated circuits and automotives, for example – that foreign invested enterprises like Intel and GM have played a significant role in the development of China's domestic semiconductor and auto industries. Has the same been true for China's solar industry? We explore the role that traditional foreign direct investment has had, and then consider other forms of technology transfer that have helped fuel the development of China's solar industry, including technology transfer from equipment manufacturers and through licensing and research collaboration, as well as know-how from the Chinese diaspora.

In *Section 2.4* we consider the role trade credits, or vendor financing, might have in the success of China's manufacturers. Finally, in *Section 2.5* we look at China's domestic demand for solar PV products. It has to date been puny, but has begun and should continue to increase quite dramatically, potentially eating up a lot of the production capacity in China.

In **Section 3** we explore what might be the consequences, many of them likely unintended, of this trade case. In *Section 3.1* we explore the question: if the Department of Commerce imposes significant – punitive – tariffs on Chinese-made solar cells and modules, how might China's producers react? Would

China respond by putting an end to its illegal subsidies for solar manufacturers? Would those firms stop dumping their product? There is precedent for such an outcome.

Or might Chinese manufacturers retaliate? They could turn to Germany or Switzerland for the $602 million worth of PV equipment they buy from the U.S. annually. They could ramp up their own production of polysilicon, eschewing the $673 million worth of polysilicon they currently buy from U.S. producers each year.

Or, Chinese manufacturers could do what the Japanese automakers did in the 70s and 80s – move production to the U.S. Until the U.S. is a more significant end market, however, that is not a very likely outcome. Far more likely would be for Chinese manufacturers to move production to Taiwan or Malaysia or Mexico – which would raise their costs but wouldn't bring back any of those lost American jobs. An equally likely outcome is that the anti-dumping duty will be relatively small, as the preliminary countervailing duty was, and Chinese manufacturers will simply pass on the 5 percent cost increases to their end customers and go on about their business as usual.

Then in *Section 3.2* we explore what the net economic effect would be of any of those outcomes. If China retaliated, what would that mean? What if China does nothing? We explore the likely net economic effects on the sellers, distributors, and installers of solar PV in the U.S. – the "other" part of the solar industry whose interests are not in direct alignment with the interests of the U.S.-based solar manufacturers. We explore potential net economic effects on U.S.-based polysilicon producers and equipment manufacturers. And we explore whether tariffs would result in a significant cost increase in the solar market, and, if so, how that would affect the growth of solar power as an alternative energy source.

We conclude the report in **Section 4** with some paths forward that could yield mutually beneficial gains across the global solar industry.

1 The facts

1.1 The trade case

On October 19, 2011, a group of seven U.S. solar manufacturers, founding members of the Coalition for American Solar Manufacturing (CASM), filed petitions with the U.S. International Trade Commission and Department of Commerce International Trade Administration seeking relief for the U.S. domestic producers injured by Chinese imports of crystalline silicon photovoltaic (CSPV) products.

The group of petitioners is led by SolarWorld Industries America, the U.S. division of German manufacturer SolarWorld AG. The other six petitioners filed anonymously; recently two have come forward – MX Solar US and Helios Solar Works[11] – the other four remain unnamed, possibly fearing retaliation by the Chinese government, "which could come in the form of denying them access to the Chinese market or denying them visas."[12] SolarWorld AG, along with fellow German solar company Coenergy filed a similar complaint in August 2009 with the German government and the European Union (EU); the EU has not initiated an investigation.

There are actually two petitions at issue. The antidumping petition seeks duties to offset Chinese dumping alleged to exceed 100 percent (alleged dumping margins are 49.88 to 249.96 percent). Dumping is defined as a foreign company selling a product in the United States at less than fair value.[13] Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, explains that dumping "is the practice of selling goods in the United States at less than home market price or cost of production. Dumping is prohibited by the WTO agreements and by U.S. law, if it results in material injury to a competing U.S. industry."[14]

The countervailing duty petition alleges that China illegally subsidizes its solar industry by providing cash grants; discounted polysilicon and aluminum necessary for production of solar panels; heavily discounted land, power and water; multi-billion dollar preferential loans and directed credit; tax exemptions, incentives and rebates; export grants and insurance; and by holding its currency under value. Subsidies are defined as financial assistance from foreign governments that benefit the production, manufacture, or exportation of goods.[15]

The case will proceed before two federal agencies. The U.S. International Trade Commission (ITC) will rule on whether Chinese imports of crystalline silicon photovoltaic (PV) products have indeed "injured" U.S. producers. The Department of Commerce International Trade Administration (ITA) will determine the amount of any subsidy or dumping margin. Some preliminary findings to note:

- On December 5, 2011, the ITC publicly announced its affirmative preliminary "injury" finding in both the anti-dumping and countervailing duty investigations. The ITC is scheduled to make its final injury determination by July 19, 2012.

[11] On March 8, Helios Solar Works, a Wisconsin founding partner of the Coalition for American Solar Manufacturing (CASM) today publicly declared its participation in CASM and its strong support for the trade cases. On March 14 MX Solar USA also publicly announced its founding role in the Coalition for American Solar Manufacturing (CASM).
[12] Keith Bradsher, "Trade War in Solar Takes Shape," *New York Times* 11 Nov. 2011: B1.
[13] United States, Department of Commerce, International Trade Administration. *Fact Sheet*: Washington: GPO, 2012. Print.
[14] Melanie Hart. *Shining a Light on U.S.-China Clean Energy Cooperation*. Center for American Progress, Feb. 2011: Print.
[15] United States, Department of Commerce, International Trade Administration. *Fact Sheet*: Washington: GPO, 2012. Print.

- On January 27, 2012, the Department of Commerce issued a preliminary "critical circumstances" determination, which means that if Commerce imposes countervailing and/or anti-dumping duties, those duties will be retroactive to 90 days before the determination.[16]
- On March 20, 2012, the Department of Commerce announce a clarification of the scope of the case, finding that the scope covers not only imports of solar cells produced in China and solar modules (panels) produced in China from Chinese-made cells, but also imports of solar modules produced outside of China from solar cells produced in China.[17] The scope does not cover imports of modules produced in China from solar cells produced in a third country. *In other words, all Chinese-made cells are subject to the rulings, as are all modules composed of Chinese-made cells.*[18]
- On March 20, 2012 the Department of Commerce announced its affirmative preliminary determination in the countervailing duty (anti-subsidy) investigation. Suntech Power received a preliminary countervailing duty of 2.90 percent; Trina Solar 4.73 percent; and all other Chinese producers 3.61 percent. Commerce is currently scheduled to make its final determination in June 2012.
- The Department of Commerce preliminary anti-dumping duty determination has been postponed to the latest possible date, May 16, 2012. The decision will be announced on May 17.

If the Department of Commerce makes affirmative final determinations in the countervailing and anti-dumping case, and the U.S. International Trade Commission (ITC) makes an affirmative final determination that imports of solar cells and modules from China materially inure the domestic industry, Commerce will issue a countervailing/anti-dumping duty order.[19]

To note, Chinese industries have lost almost all of the anti-dumping and countervailing case against them in the U.S. because the U.S. categorizes China as a nonmarket economy, which means that special rules – which tend to favor American industry – are used in these cases.[20]

Yet the countervailing duties of 2.90-4.73 percent were lower than what many observers had expected. Gordon Brinser, President of SolarWorld Industries America, said "We can fairly state that in no way represents the amount of harm that has been done to the solar industry."

One executive at a Chinese solar module manufacturer agreed that the countervailing duties were lower than expected. "It's a price disadvantage to Chinese companies. But it wasn't as bad as we thought because it was supposed to be 7 or 8 percent. So we will still have a price advantage compared to U.S. companies. So it was good news for us."

Fourteen Chinese PV companies, including Suntech Power and Yingli Green Energy, objected to the U.S. solar trade case and rejected allegations that they have been receiving illegal government subsidies. And other U.S. companies in the solar industry have spoken out against the trade case as well. The Coalition for Affordable Solar Energy (CASE), led by solar electricity company SunEdison, has said that many

[16] United States, Department of Commerce, International Trade Administration, *Countervailing Duty Investigation of Crystalline Silicon Photovoltaic Cells, Whether or Not Assembled into Modules, From the People's Republic of China: Preliminary Determination of Critical Circumstances*. Washington: Department of Commerce, 2012. Print.
[17] The technically correct term is module, but "panel" is often used interchangeably – both words refer to the same thing: a packaged interconnected assembly of solar cells.
[18] United States, Department of Commerce, International Trade Administration. *Fact Sheet*: Washington: GPO, 2012. Print.
[19] *ibid*
[20] Keith Bradsher, "Trade War in Solar Takes Shape," *New York Times* 11 Nov. 2011: B1.

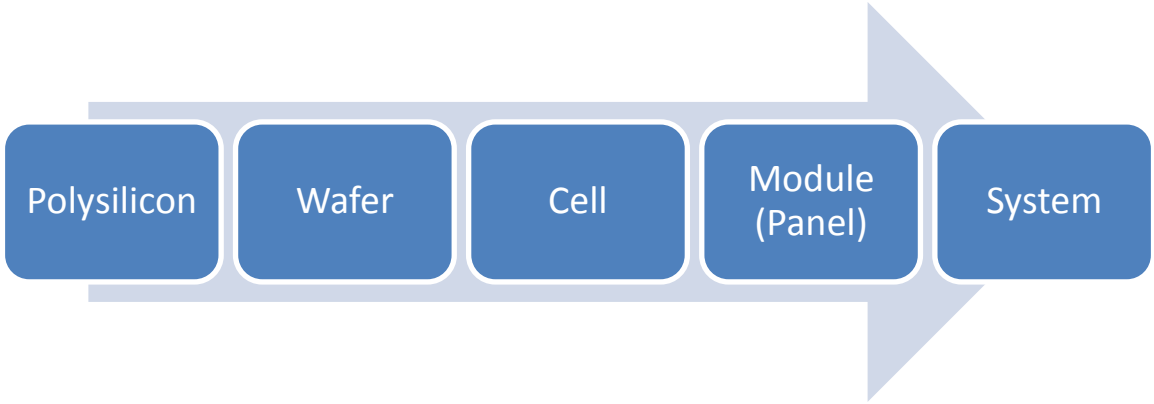
more companies (employing many more American workers) are in the business of installing, selling, and distributing solar PV panels, and they benefit from low-cost imports from China.[21]

This is not the first instance of trade disputes around renewable energy. In October 2010, in response to a petition from the United Steelworkers, the U.S. launched an investigation into whether China's practices of special funds for manufacturing, export product funds, and financing through export credits by China's Export-Import Bank were consistent with World Trade Organization policies. The United States Trade Representative (USTR) decided in December 2010 not to take action of the solar components of the petition, citing a lack of evidence.[22]

1.2 Data on the global solar PV market

1.2.1 PV supply chain

Figure 1: Crystalline Silicon Photovoltaic (CSPV) Supply Chain



Polysilicon manufacturing. "Polysilicon, based on sand, is the material used to make the semiconductors that convert sunlight into electricity. Its production requires large processing plants, with the construction of a polysilicon plant taking about two years and costing between $500 million and $1 billion. Polysilicon comprises about a quarter of the cost of a finished solar panel. Historically, polysilicon prices have been volatile, because the construction of a new plant can add a large amount of supply to the market. High polysilicon prices can adversely affect the profitability of manufacturers further down the supply chain. A handful of manufacturers from the United States, Europe, and Japan currently dominate polysilicon production, with much of it now located in Europe and the United States, but increasingly manufacturers like GLC Solar from China and OCI from South Korea have expanded their production levels."[23]

Wafer manufacturing. "Using traditional semiconductor manufacturing equipment, wafer manufacturers, including companies such as Sumco, Siltronic, Nexolon, and MEMC, shape polysilicon

[21] Michele Nash-Hoff, "Viewpoint: What's Really Happening to America's Solar Industry?" *Industry Week*, 22 Feb. 2012. Web. Apr. 2012.
[22] People's Republic of China, *12th Five-Year Plan for the Solar Photovoltaic Industry*, trans. Wiley Rein (Washington: Wiley Rein, 2011).
[23] Michaela D. Platzer. Congressional Research Service. *U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support*. Washington: Congressional Research Service, 2012. Print.

into ingots and then slice the ingots into thin wafers. The wafers are then cut, cleaned, and coated according to the specifications of the system manufacturers."[24]

Cell manufacturing. "Solar cells are the basic building blocks of a PV system. They are made by cutting wafers into desired dimensions (typically 5 x 5 or 6 x 6 inches) and shapes (round, square, or long and narrow). The manufacturer then attaches copper leads so the cell can be linked to other cells. Minimizing the area covered by these leads is a key issue in cell design, as the lead blocks sunlight from reaching parts of the cell surface and thus reduces potential energy output. The U.S. Department of Energy estimates that a manufacturing plant to produce 120 MW of cells per year would require an investment of around $40 million."[25]

Module manufacturing. "Modules, which normally weigh 34 to 62 pounds, are created by mounting 60 to 72 cells on a plastic backing within a frame, usually made of aluminum. The module is covered by solar glass to protect against the elements and to maximize the efficiency with which the unit coverts sunlight into power. Production of solar glass is highly capital intensive, and approximately 60 percent of the global market is controlled by four global manufacturers: Ashai [Japan], NSG Group/Pilkington [Japan], Saint Gobain [France], and Guardian [U.S.]. The glass is expensive to ship, so glass producers tend to locate near module manufacturers. In some countries, module manufacturing is highly automated; in others, more labor-intensive processes are used."[26]

Chinese producers have to date concentrated in the mid-stream wafer and cell segments of the supply chain. Chinese producers account for about 60 percent of total global market volume in the wafer segment, 50 percent in the cells segment, and 48 percent in module assembly.[27] Chinese producers have a smaller but still sizable presence at the beginning of the supply chain, accounting for 17 percent of total global market volume in polysilicon processing.[28]

1.2.2 Demand

Demand for solar photovoltaic systems is driven largely by the relative price of the electricity produced by those systems compared to electricity generated by other means. Until the late 1990s, PV systems were installed almost exclusively off the grid for uses such as powering communications devices, satellites, and remote habitations, where solar PV was cost-competitive compared to other off-grid electricity sources.[29]

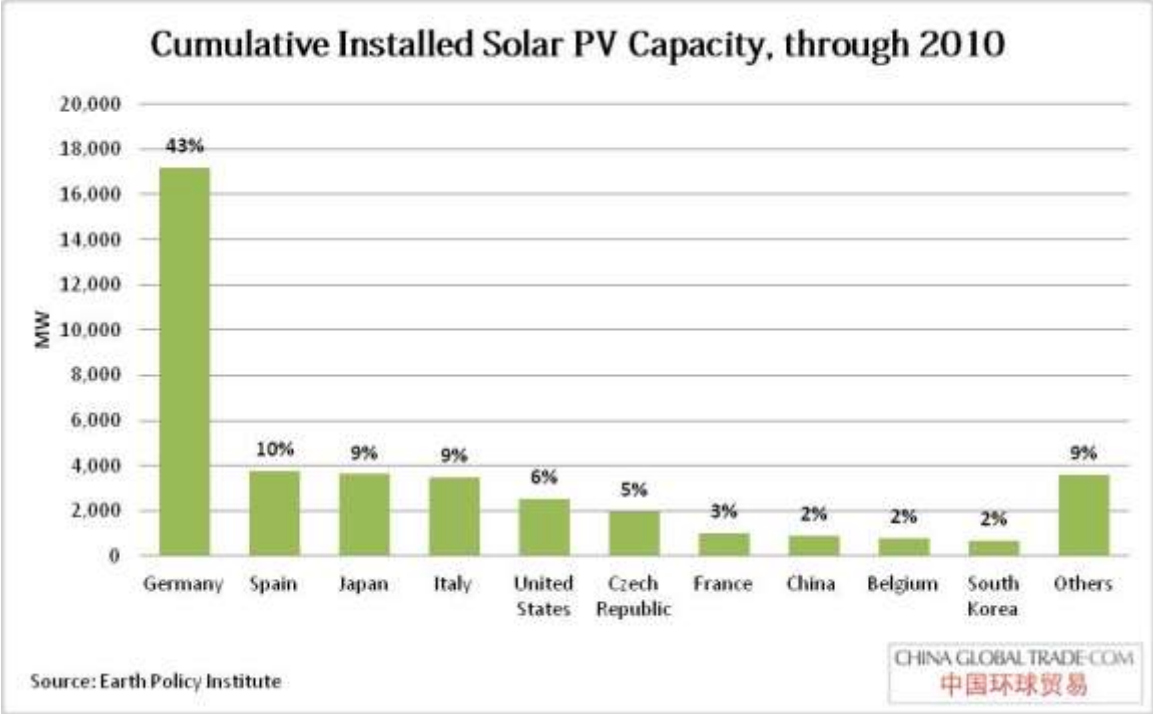
But since the early 2000s, on-grid installation of PV systems has grown exponentially (45 percent per year on average between 2003 and 2009). This growth has been driven almost exclusively by government policies in Germany, Spain, Italy, Japan, and the U.S. These policies are designed, in one way or another, to subsidize the cost of solar power so that it is competitive with other on-grid electricity sources.

One of the most significant forms of subsidy for on-grid PV is the Feed-in-Tariff (FIT), which is a fixed guaranteed price at which electricity suppliers must purchase renewable electricity from producers. FITs have been used since 1994 in Japan, 2000 in Germany, and 2006 in Spain. Today, most developed countries have implemented FITs, except the United States, where 29 states have instead implemented

[24] Michaela D. Platzer. Congressional Research Service. *U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support*. Washington: Congressional Research Service, 2012. Print.
[25] *ibid*
[26] *ibid*
[27] Goldman Sachs Research, July 2011
[28] Jacob Funk Kirkegaard, et al., ―Toward a Sunny Future? Global Integration in the Solar PV Industry,‖ *Working Paper*, May 2010. p. 21. *http://pdf.wri.org/working_papers/toward_a_sunny_future.pdf.*
[29] Arnaud de la Tour, Matthieu Glachant and Yann Ménière, "Innovation and International Technology Transfer: The Case of the Chinese Photovoltaic Industry," *Energy Policy* 39 (2011) 761-770.

Renewable Portfolio Standards (RPS), which are mandates requiring utilities to produce a minimum percentage of their power from renewable energy sources.[30]

Figure 2: Cumulative Installed Solar PV Capacity (MW), through 2010



Germany has to date been the world's leader in solar installations, by far. Through 2010, Germany had 43 percent of the world's cumulative (total) installed solar PV capacity. The United States had 6 percent of the world's total installed capacity and China had just 2 percent. This data make clear a fact highlighted by Alan King, Vice President of Sales at Canadian Solar (USA), in his presentation to the USITC, "[S]olar module manufacturers have tended to focus on customers outside of the U.S. This has been the case even for U.S. producers that have historically exported much of their production primarily to Europe. Thus, demand outside of the United States is a critical driver of success in the industry."[31]

But Germany and Italy's shares of PV installations are shrinking, while China's is growing. According to Goldman Sachs forecasts, Germany's annual demand for solar modules will be just 15 percent of the world's total by 2015, and China's will be 19 percent. Like Germany's, Italy's share of annual installations is expected to fall, while the United States and Japan's will rise.

Germany's Environment Minister Norbert Roettgen announced in March that the country would cut federal subsidies by as much as 29 percent on March 29 and continue scaling back subsidies each month beginning in May. Those cuts are the most severe since Germany began supporting the solar industry with a feed-in tariff in 2004. The United Kingdom, Italy, and France have also accelerated subsidy curbs for solar energy, in part to adapt to lower solar panel prices and in part because of fiscal constraints.[32]

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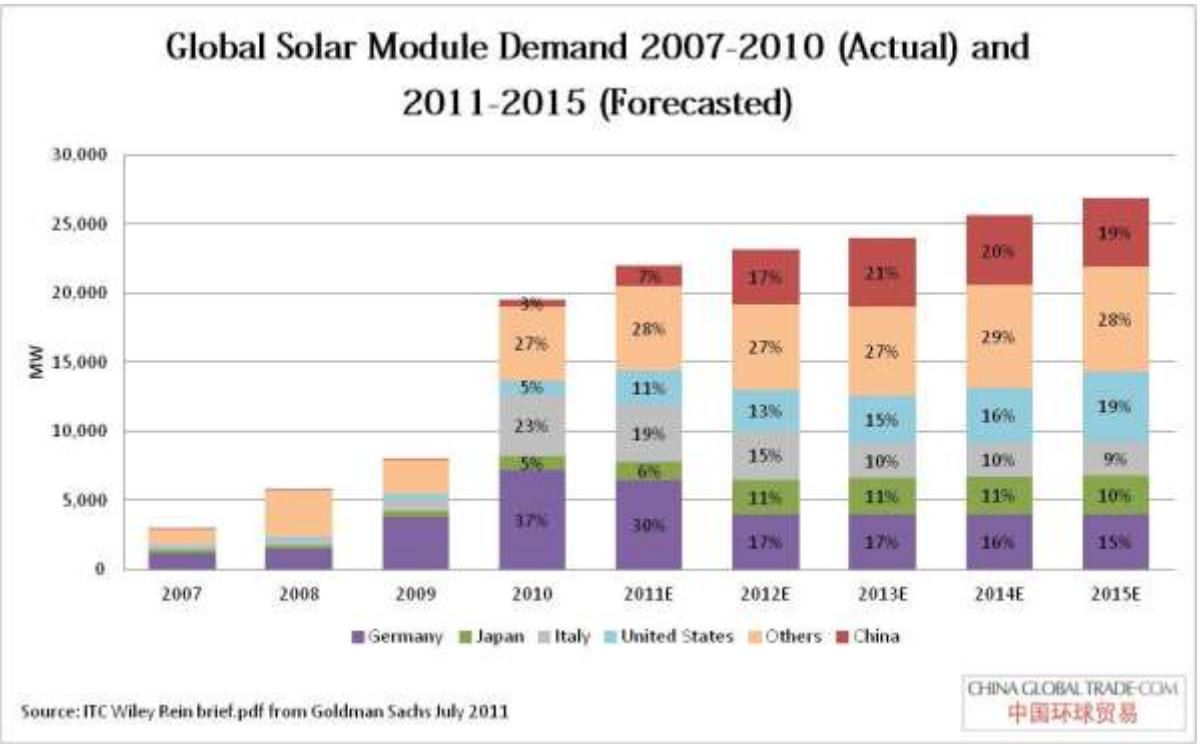
[30] Arnaud de la Tour, Matthieu Glachant and Yann Ménière, "Innovation and International Technology Transfer: The Case of the Chinese Photovoltaic Industry," *Energy Policy* 39 (2011) 761-770.
[31] Alan King, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.
[32] Belinda Cao, "Trina Leads Solar Slump on German Tariff Cut: China Overnight," *Bloomberg Businessweek*, 24 Feb 2012.

Figure 3: Global Solar Module Demand 2007-2010 (Actual) and 2011-2015 (Forecasted)

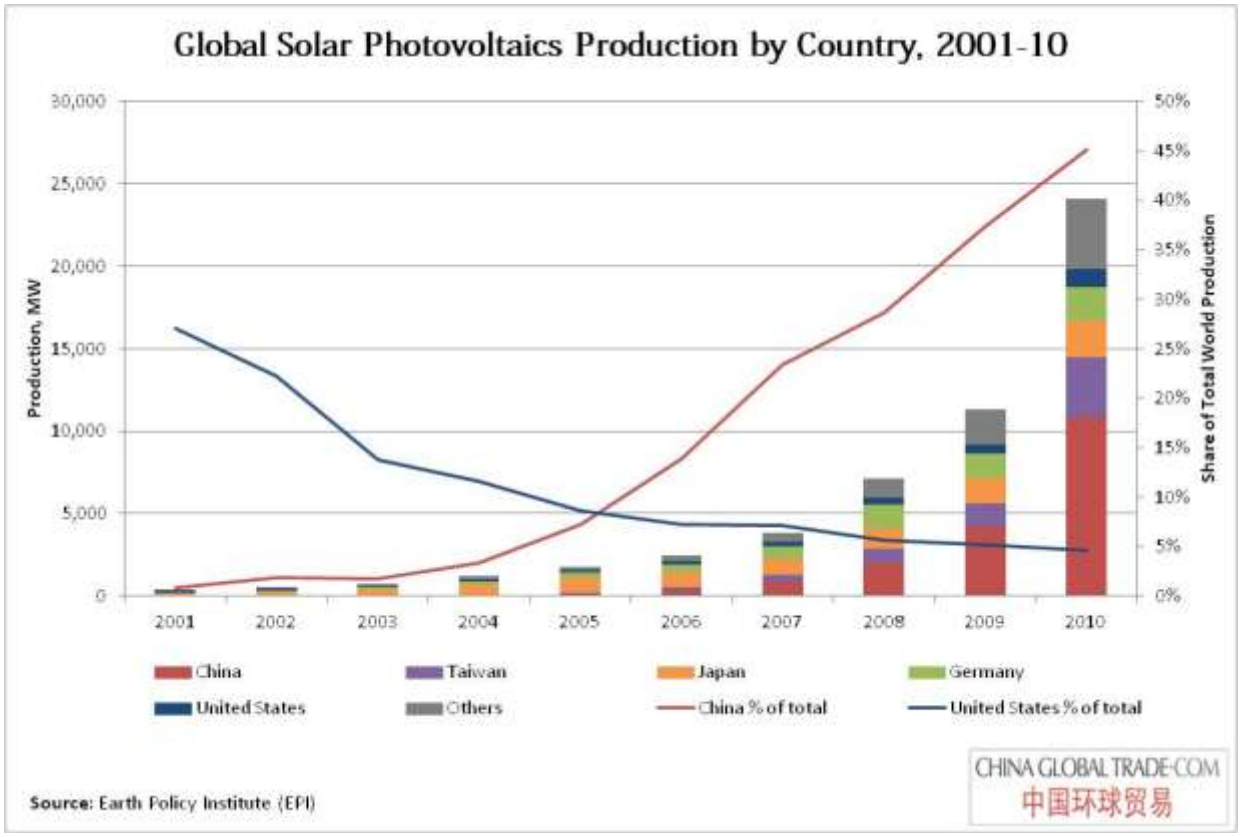


We will discuss the role of domestic demand on China's solar manufacturing industry in *Section 2.5*.

1.2.3 Supply

Global production of solar photovoltaics has risen dramatically in the last decade – from 371 megawatts in 2001 to more than 24 gigawatts in 2010, an increase of 6,376 percent. In 2001, Japan was the single largest producer of photovoltaics, supplying 46 percent of the world production. By 2010, China was the single largest producer, with 45 percent of the world market. The United States' share fell from 27 percent to 5 percent over the same period. By 2006, China was producing more photovoltaics than the U.S.

Figure 4: Global Solar Photovoltaic Production by Country, 2001-10



This increase in supply coincides, not surprisingly, with an increase in demand that also began in the early 2000's. Yet by 2004, as global demand increased very rapidly – particularly in Europe – manufacturers in China and elsewhere saw an enticing opportunity, and quickly began to ramp up production of solar cells and modules. In fact, many of the Chinese manufacturers entered the global market in 2004 and 2005. (For a more detailed discussion, see *Section 1.2.4.5*.)

While China has dominated world production of solar cells and wafers, it is also rapidly increasing its foothold in polysilicon production as well, a segment of the supply chain once dominated by the United States, Germany, and Japan. With government support (see *Section 1.3.3*), China now produces about 17 percent of the world's polysilicon.

1.2.4 Price

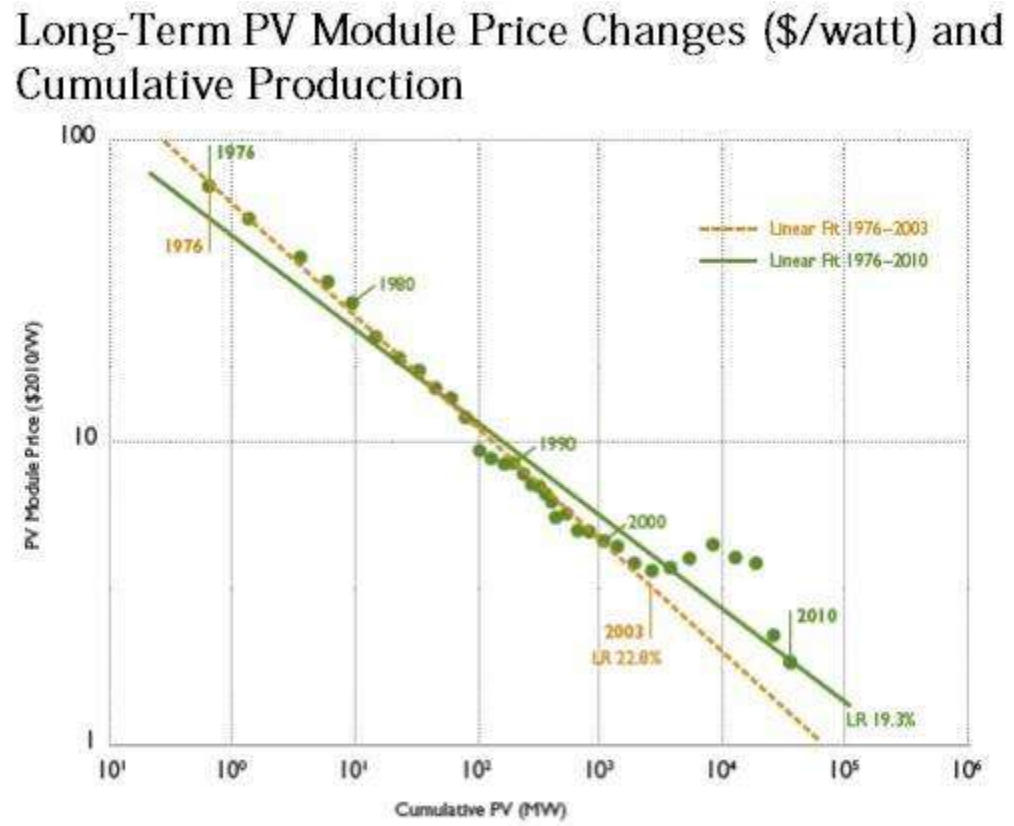
The overall global trend in the price of solar cells and modules has been downward. Since 1976, the long-term trend has been that when volume doubles, price declines by 20 percent. There have been short-term increases in price, as between 2004 and 2008 when there was a polysilicon shortage and prices for that input rose. But overall, as economist Kenneth Button noted, "Consistent with the history of a wide range of semiconductor type products, the price of PV modules has been declining progressively for many years, long before Chinese producers entered the PV market."[33]

Those price declines accelerated beginning in 2008. Estimates are that global CSPV module prices declined from about $3.30 per watt in 2008 to about $1.80 per watt at the beginning of 2011 and $1.00

[33] Kenneth Button, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.

per watt at the end of 2011. The price is projected to fall to $0.74 per watt by 2014.[34] Shyam Mehta, Senior Analyst at GTM Research, forecasts that the price for solar modules will be $0.60 per watt by 2015. "And if anything that's a conservative forecast," he said, meaning that the price could well be even lower. Solarbuzz, a market research firm, forecasts that over the next five years module prices will drop another 43-53 percent from 2011 levels.[35]

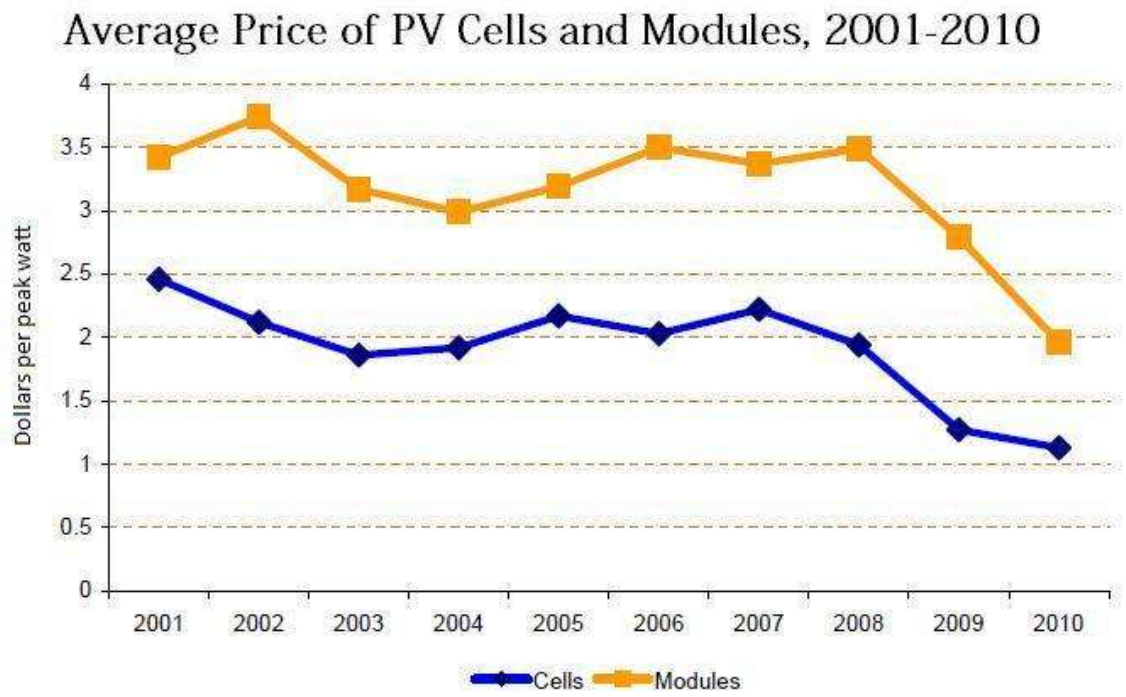
Figure 5: Long-Term PV Module Price Changes ($/watt) and Cumulative Production



Source: SEMI North American PV Advisory Committee, Manufacturing Solar Photovoltaic Products in the United States (Washington: SEMI North American PV Advisory Committee, 2012)

[34] Mark Berkman, Lisa Cameron and Judy Chang. *The Employment Impacts of Proposed Tariffs on Chinese Manufactured Photovoltaic Cells and Modules* (Washington: The Brattle Group, 2012) 1-26.
[35] "World Solar Photovoltaic Market Grew to 27.4 Gigawatts in 2011, Up 405 Y/Y," *SolarBuzz*. Press Release, 19 March 2012.

Figure 6: Average Price of PV Cells and Modules, 2001-2010

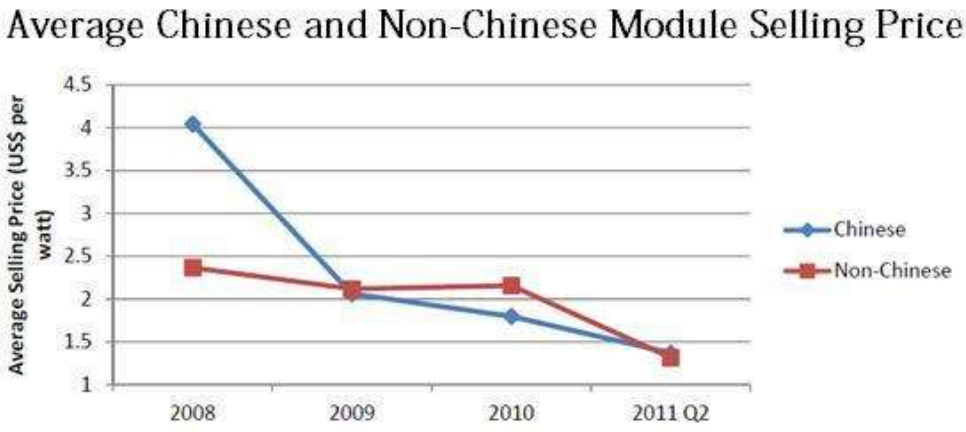


Source: Michaela D. Platzer. U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support. Washington: Congressional Research Service, 2012.

One linchpin in the petitioners' argument is that Chinese manufacturers "could not possibly have production costs low enough to be selling modules and cells at their current prices in the U.S."[36] In 2011, Chinese solar manufacturers were selling CSPV modules at about the same price as non-Chinese firms, according to research commissioned by the George Washington University Solar Institute.

[36] Alim Bayaliyev, et al. "China's Solar Policy: Subsidies, Manufacturing Overcapacity & Opportunities" Capstone Project, George Washington University, 2011.

Figure 7: Average Chinese and Non-Chinese Module Selling Price



Source: Alim Bayaliyev, et al. "China's Solar Policy: Subsidies, Manufacturing Overcapacity & Opportunities" Capstone Project, George Washington University, 2011.

That would suggest that market forces, not Chinese dumping, have driven down the price of PV modules. But, note that in 2010 the non-Chinese average selling price was above the Chinese selling price; some analysts suggest that undercutting by Chinese manufacturers in 2010 drove prices down for all manufacturers in 2011. But there are other factors that determine the price of solar cells and modules, and have driven the general downward trend (save the spike between 2004 and 2008) in prices. Those factors include:

1) Declining prices for inputs, most importantly polysilicon;
2) competition from lower-priced thin film products;
3) waning government incentives and demand subsidies;
4) increasing economies of scale and efficiency improvements (driven by learning and innovation); and
5) oversupply.

According to the petitioners in the solar trade case, "Average module prices in the U.S. are largely determined by Chinese imports. A major industry report predicted that 41 percent of all PV installations in the U.S. used panels subject to a tariff in the third quarter of 2011." That's not surprising, given that China produces about half of the world's cells and modules now. But, *that* doesn't mean that China's cells and modules are illegally subsidized or that China's producers are dumping them below cost. See *Section 2.2*.

1.2.4.1 Declining input prices

The cost of polysilicon, as one of the key material inputs for CSPV cells, is what Neil Ellis called a "critical condition of competition" in the solar power industry.[37] Polysilicon contributes about 35 percent to the total cost of a CSPV cell and about a quarter of a module's cost, so it is indeed one important determine of a cell's and module's price.

[37] Neil R. Ellis, et al. "Investigation Nos, 701-TA-481 and 731-TA-1190", Post-conference brief. Washington: 15 Nov. 2011.

Figure 8: Polysilicon Wafer, Cell, and Module Cost and Gross Margin 2011 and 2012

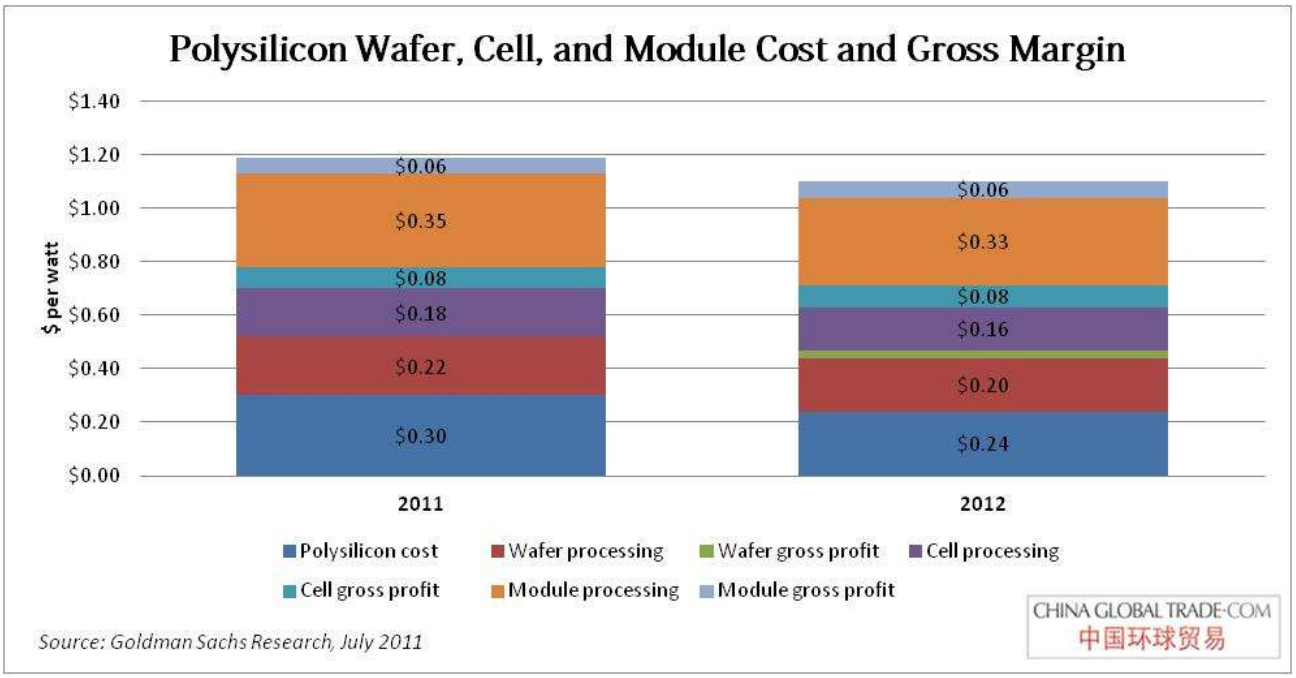
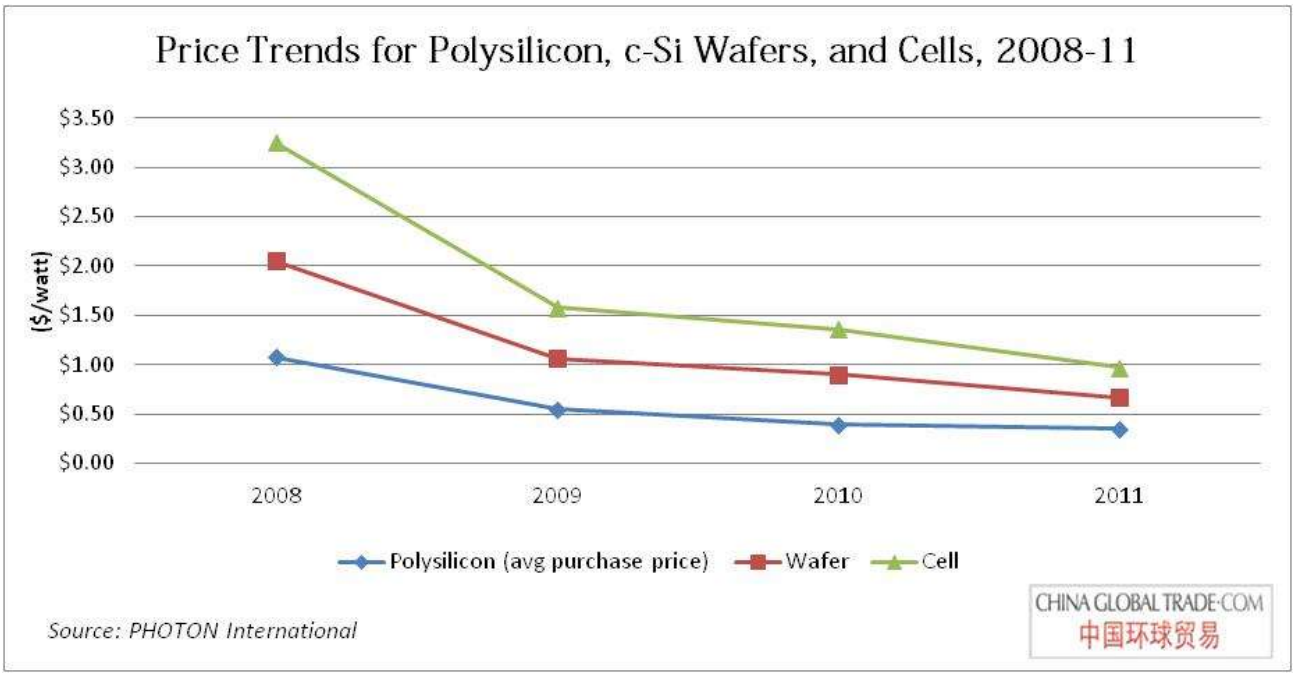
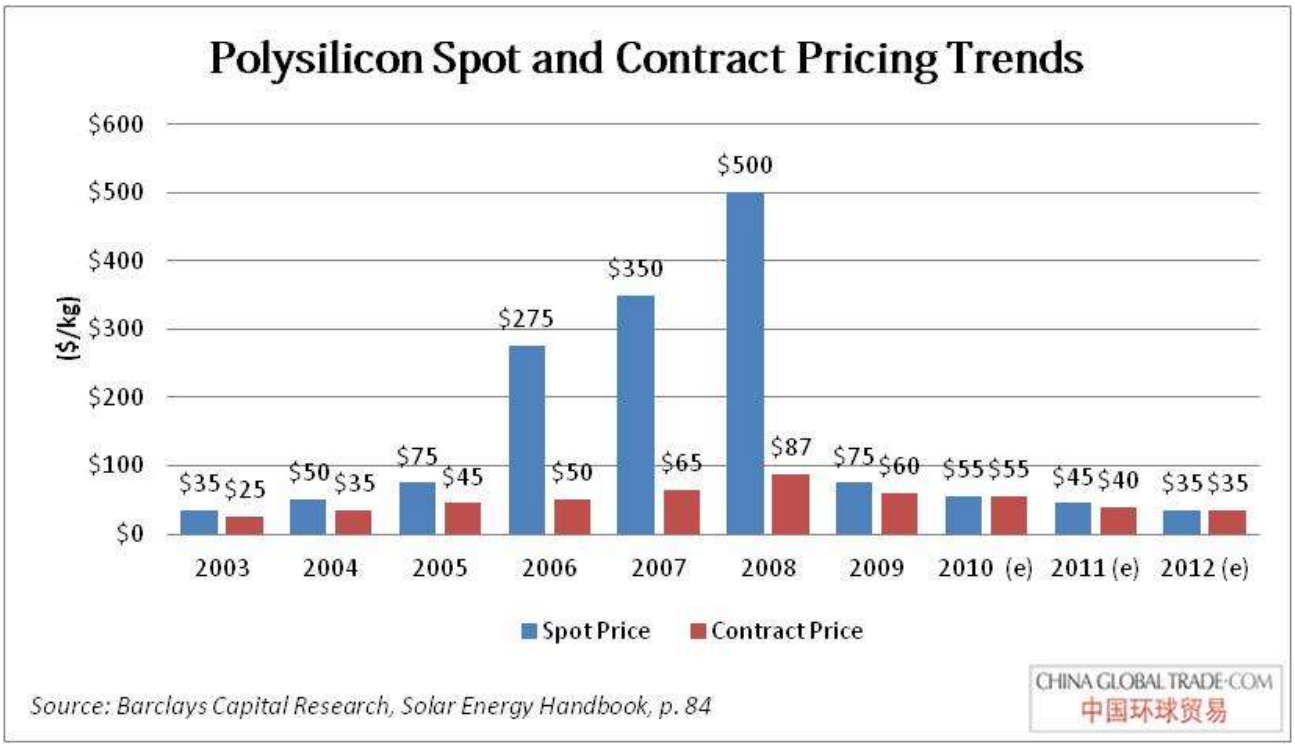


Figure 9: Price Trends for Polysilicon, c-Si Wafers, and Cells, 2008-11



But the price of polysilicon itself has been very volatile over the last decade. It increased dramatically between 2004 and 2008 – from $35 to $87 per kilogram in contract prices (a 149 percent increase) and $50 to $500 per kilogram in spot prices (a 900 percent increase) – due to a shortage of polysilicon. At the same time, the price of CSPV cells increased over the same period, to their highest level since 1998.

Figure 10: Polysilicon Spot and Contract Pricing Trends



In response to the high demand for polysilicon, new producers (including Chinese companies) entered the market, and existing producers scaled up.[38] But they overshot, and the shortage became an oversupply – resulting in a 91 percent price decline in spot prices and 54 percent decline in contract prices from 2009 to 2011.[39] Over the same period, CSPV cell prices fell 70 percent.

1.2.4.2 Competition from thin film products

Polysilicon prices are not the only determinant of CSPV cell and module prices. Another factor is competition from other solar power technologies, including thin film products. The respondents in the trade case, in fact, argued that thin film products should be included as domestic like products in the trade case because they can be substitutes for CSPV products. The International Trade Commission determined that CSPV and thin film are not domestic like products, but called that determination "close." As far as the competition question goes, the ITC said "The evidence is mixed as to whether the established PV technology and newer thin film product technology are perceived by producers and customers to compete with each other."[40]

According to the respondents in the trade case, "Another key condition of competition in the solar power industry is the market presence of products based on thin-film technology. Even if the Commission finds

[38] "Historically much of the global production of polysilicon resided in the United States and Europe. China's production of polysilicon is, however, increasing. A 2011 report estimated that in 2010, China represented more than 30 percent of global polysilicon production." See United States, U.S. International Trade Commission, *Crystalline Silicon Photovoltaic Cells and Modules from China* (Washington: GPO, 2011).
[39] Neil R. Ellis, et al. "Investigation Nos, 701-TA-481 and 731-TA-1190", Post-conference brief. Washington: 15 Nov. 2011.
[40] United States, U.S. International Trade Commission, *Crystalline Silicon Photovoltaic Cells and Modules from China* (Washington: GPO, 2011).

that thin-film products are not part of the domestic like product, these products undeniably compete with CSPV cells. Competition from thin-film products is important because these products have lower costs of production than comparable CSPV products. In turn, thin-film producers, like First Solar and Uni-Solar, are able to offer their products at lower per unit prices than CSPV producers. This per-module price advantage is tempered by other costs associated with a thin-film solar project, making the prices of thin-film and CSPV quite competitive when the entire value proposition is considered. As a result, CSPV producers must justify to potential end-users the higher prices associated with their products or, if they cannot do so, lower those prices to meet the competition offered by producers of thin-film solar products."[41]

1.2.4.3 Government regulations (incentives and demand subsidies)

Another factor affecting the price of solar cells and modules is government regulation. Governments in Europe, the United States, and now China as well, implemented incentives and other programs designed to put solar power on an even playing field with fossil fuels. In Europe especially, many of those programs are now being rolled back, in part to account for the lower cost of solar modules, and in part because of fiscal constraints. Yet only in some cases is solar power able to stand on its own, without government programs, as cost competitive with fossil fuels.

For the producers of solar power products like cells and modules, the installers of those systems, and the financiers who have backed utility-scale solar projects not yet completed, there is "tremendous pressure" to see that solar power projects continue to be economically viable. That means reducing total cost levels. About a third of the total cost of a solar power project is attributable to the cost of solar modules, so the pressure on solar module producers to continue reducing costs is very high.[42]

As Robert Petrina, Managing Director at Yingli Green Energy Americas, Inc., explained at the ITC conference, "Government incentives for [solar] projects have been very important in lowering net costs so that the projects can achieve these goals and are implemented. However, with incentive levels declining on an unpredictable basis, there has been tremendous pressure to maintain the all-in total cost for the projects at levels that continue to be economically viable and drive adoption, preferably and ultimately without incentive support."[43]

1.2.4.4 Increasing economies of scale and efficiency improvements

As we'll discuss later (see *Section 2.2.1*), China's solar cell and module manufacturers have been particularly adept at scaling up their factories very quickly. And here, as in many commodity manufacturing cases, greater scale drives lower costs. Now that three of the world's five biggest producers of modules are Chinese companies, there is far more scale in the production system overall, which has helped to push the price of cells and modules down. At the same time, as manufacturers have become more experienced making solar cells and modules, they have learned and innovated more efficient modes of production.

1.2.4.5 Oversupply

Between 2004 and 2008, the combination of record-high solar module prices and high demand for solar systems led many manufacturers to believe that solar was a "golden opportunity." New entrants – many

[41] Neil R. Ellis, et al. "Investigation Nos, 701-TA-481 and 731-TA-1190", Post-conference brief. Washington: 15 Nov. 2011.
[42] GTM. *U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States.* Washington: GTM, 2011. Web. 2012.
[43] Robert Petrina, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.

of them Chinese manufacturers – flooded the market. Capacity increased far more rapidly than demand did. Year-over-year growth in demand peaked in 2010, at 122 percent, but was just 1 percent in 2011. In 2011, total global PV capacity was just over 30 MW; demand was just over half that, at 17 MW.

Figure 11: Global PV Supply and Demand 2005-09 (Actual) and 2010-12 (Forecasted)

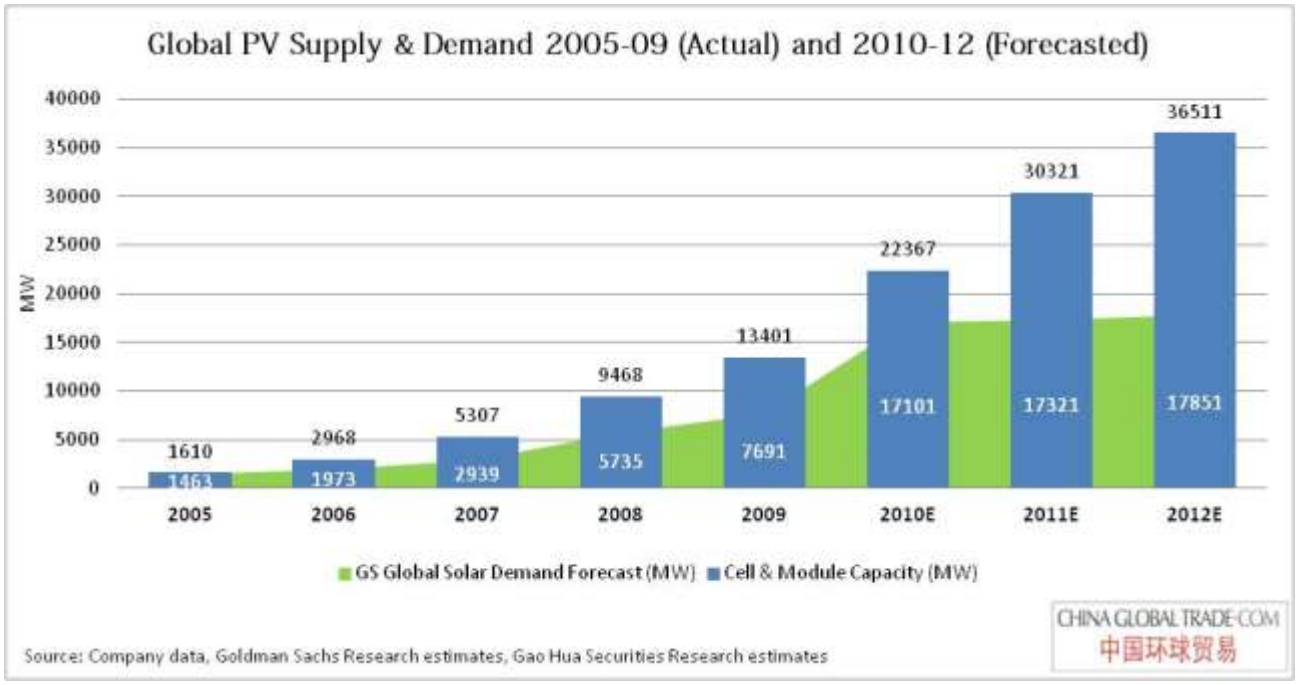
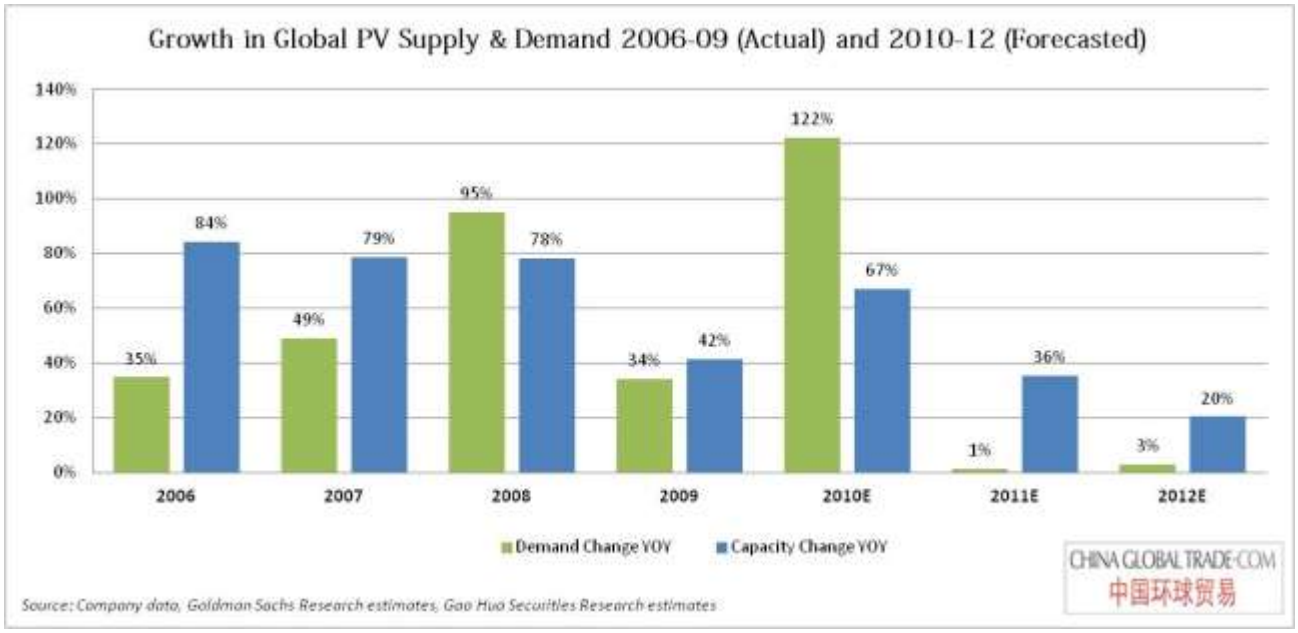


Figure 12: Growth in Global PV Supply and Demand 2006-09 (Actual) and 2010-12 (Forecasted)



This oversupply has made life difficult for CSPV cell and module manufacturers all over the world. A number of analysts and industry insiders (including one at a Chinese manufacturer and one at a U.S. manufacturer) report that they had to sell their cells and modules below cost in order to move inventory. The steep price drop damaged profits for manufacturers around the world.

There is a difference, according to Jigar Shah, President of the Coalition for Affordable Solar Energy (CASE), between that – holding a fire sale to move inventory in an oversupplied market – and dumping. "Companies who had extra inventory, like the Chinese, said 'I need to get that cash back. I need to lower my prices to get more market share to sell product.' That's not dumping. That's just selling at a lower margin just like you do if you have extra furniture in your furniture store, you say 'Everything is 70% off' to sell out inventory and get new stuff in. So China's basically in a situation where they have no pricing power right now. Demand has all the power; supply has no power right now."

When Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, interviewed solar analysts in China for her recent report, they all told her that China's low solar PV prices are indeed due (at least in part) to "excess capacity and market-induced inventory clearing."[44]

But, according to Shah, the solar industry has always been characterized by swings in price and, consequently, periods of over- or undersupply. "We're probably in this glut for about three years and then three years from now we'll be in a shortage because nobody invested in new manufacturing facilities."

In addition to lowering prices, companies have taken other measures in response to overcapacity. "First Solar delayed the launch of a facility in Vietnam. SolarWorld, REC, SOLON, and PV Crystalox have all announced shutdowns, and other companies (e.g., Solyndra and SOLON) have declared bankruptcy. Suntech, the second largest Chinese manufacturer and world's largest solar module manufacturer, announced it will put capacity expansions on hold in 2012."[45]

Yet while prices for solar cells and modules have fallen globally, it does seem clear that the leading Chinese manufacturers generally price their cells and modules lower than manufacturers in other countries. But why is that? Is it because they're receiving illegal subsidies from the Chinese government that allow them to operate at a loss? Or is it because they can produce solar cells and modules at a lower cost than other manufacturers can? To answer that question, we must first consider who has received government subsidies, and how much.

1.3 Who has received subsidies, and how much?

Solar World, MX Solar US, Helios Solar Works, and the four anonymous petitioners in the solar trade case contend that, in addition to dumping solar cells and modules on the U.S. market, Chinese producers have received illegal subsidies from the Chinese government, including:

- Cash grants
- Discounted polysilicon and aluminum necessary for production of solar panels
- Heavily discounted land, power, and water
- Multi-billion dollar preferential loans, and directed credit
- Tax exemptions, incentives, and rebates

[44] Melanie Hart. *Shining a Light on U.S.-China Clean Energy Cooperation*. Center for American Progress, Feb. 2011: Print.
[45] Alim Bayaliyev, et al. "China's Solar Policy: Subsidies, Manufacturing Overcapacity & Opportunities" Capstone Project, George Washington University, 2011.

- Export grants and insurance
- An undervalued currency

While the Department of Commerce is not schedule to rule on the dumping case until the end of May 2012, it has already issued a preliminary ruling on the subsidies case. Commerce found that Chinese producers/exporters have received countervailable subsidies ranging from 2.90 to 4.73 percent. As such, Commerce assessed countervailing duties of 2.90 percent on Suntech, 4.73 percent on Trina Solar, and 3.61 percent on all other Chinese producers/exporters.

Gordon Brinser, President of SolarWorld Industries America, said that he thinks Commerce will impose additional tariffs in its final subsidy determination. "The amount that did come out, we can fairly state that in no way represents the amount of harm that has been done to the solar industry." But, Brinser added, "[the Department of Commerce] also stated in their release that they still had some additional subsidies that had not been fully analyzed, so they're still in the middle of their process. So we want to really say that it is a process that will continue until the final determination."

It's important to note, here, as Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, points out, that subsidy programs are "not necessarily anticompetitive." In fact, "policy assistance is often required to help new technologies compete with existing market alternatives – especially when the existing alternatives such as coal already receive explicit and implicit public subsidies. We have similar green energy programs here in the United States."[46]

In fact, "The demand for PV solar cells and modules is driven by the demand for solar panel installations. Solar technology has expanded rapidly in recent years due to the increasing interest in low-emissions technology and the declining costs of solar cells. Since it is a newer technology, however, it is still generally more expensive to deploy than natural gas or coal, at least in the short term. Most countries already have extensive infrastructure to support coal, but solar infrastructure is still underdeveloped so solar prices have to include infrastructure development and capital costs. Due to those additional costs, the price differential for solar panels over the past decade has been driven primarily by government subsidies to boost deployment of solar energy."[47]

The problem, Hart says, is policies designed "not just to support infant industries but also to undercut competitors so that China's domestic enterprises can take over a larger share of the global market." If China's policies are designed to do that, she says, they violate a "host" of trade rules.[48]

It's important to point out that the United States offers subsidies that both aim to nurture green energy technologies, but also to strengthen America's exports. The U.S. Department of Energy's SUNPATH initiative is designed not only to help domestic PV manufacturers commercialize solar technology, but to "restore the United States' position at the forefront of solar manufacturing."[49] And in his 2012 State of the Union address, U.S. President Obama said "I will not cede the wind or solar or battery industry to China or Germany because we refuse to make the same commitment here."

The following table highlights the credits, guarantees, subsidies, and grants given out by the United States federal and state governments and by the Chinese national and provincial governments.

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[46] Melanie Hart. *Shining a Light on U.S.-China Clean Energy Cooperation*. Center for American Progress, Feb. 2011: Print.
[47] *ibid*
[48] *ibid*
[49] SEMI North American PV Advisory Committee, *Manufacturing Solar Photovoltaic Products in the United States* (Washington: SEMI North American PV Advisory Committee, 2012)

Table 1: Credits, Guarantees, Subsidies, and Grants for Solar Manufacturers in the U.S. and China

	UNITED STATES		CHINA
	Federal	**State**	**National, Provincial & Local**
Domestic proprietorship required	Yes ("Buy American")		Yes
Sales/value added tax waiver	Yes	Yes	Yes
Property tax credits	100%	100%	N/A
Subsidized cost of debt	4.00%	3.00%	3.0-4.5%
Subsidized debt limit (D/D+E)	60%	60%	80%
Delay in processing subsidized debt	2 years	<1 year	<1 year
Facilities grant		100%	100%
Land grant			Discount purchase (land use rights)
Training grant (millions USD)	$0.5-4.5	$0.5-4.5	Yes
Effective corporate income tax rate	28%	28%	21%
Income tax credits	30% ITC *or* cash grant in lieu (see here) MTC ($811 million total, see here)	Yes; varied (up to 15-year holiday)	20 year holiday
Loans/ loan guarantees	Temporary Loan Guarantee Program ($1.3 billion, see here)		$30 billion total credit line from China Development Bank (see here)

Source: Alan Goodrich, Ted James and Michael Woodhouse. Solar PV Manufacturing Cost Analysis: U.S. Competitiveness in a Global Industry, Power Point Presentation, Stanford University: Precourt Institute for Energy, 10 Oct. 2011.

1.3.1 U.S. federal subsidy programs

Direct federal support for solar manufacturing has existed in the U.S. since the Carter Administration; the Energy Tax Act of 1978 provided tax credits for homeowners who invested in solar, and the Public Utility Regulatory Policies Act required utilities to purchase power from qualified renewable power facilities. Still, production of solar PV power in the U.S. remained small.[50]

[50] Michaela D. Platzer. Congressional Research Service. *U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support*. Washington: Congressional Research Service, 2012. Print.

By the mid-1980s, domestic PV manufacturers were selling products at a loss. When President Reagan's Tax Reform Act of 1986 reduced the Investment Tax Credit (ITC) to 10 percent in 1988, solar manufacturing in the U.S. slumped further. Then in 2005 President Bush signed the Energy Policy Act which included a 30 percent Investment Tax Credit (ITC) for property owners who installed commercial and residential solar energy systems.[51]

The federal policies that currently support (or have recently supported) the solar industry in the U.S. include:

- **Investment Tax Credit (ITC)** – The ITC functions as a 30 percent uncapped income tax credit for residential solar systems under Section 25D and commercial solar systems under Section 48 of the Internal Revenue Code. The Investment Tax Credit is in effect through December 31, 2016.
- **1603 Treasury Program** – The Section 1603 Treasury Program, created in 2009, allowed solar and other renewable energy developers to receive a direct federal grant in lieu of the Section 48 Investment Tax Credit (ITC). The program, originally approved through the end of 2010, was extended for an additional year, and expired on December 31, 2011.
- **Advanced Energy Manufacturing Tax Credit (MTC)** – The 2009 American Recovery and Reinvestment Act (ARRA) included a competitive 30 percent tax credit capped at $2.3 billion in total tax expenditures for advanced energy manufacturing projects (new code Section 48C). "Over 500 applications were submitted, totaling over $8 billion and oversubscribing the program by a ratio of more than 3 to 1. Credits were awarded to 183 separate renewable energy projects across the United States. More than fifty solar facilities received awards, or 27% of the total number of facilities selected and 50% of the $2.3 billion made available."[52] The MTC program reached its cap in 2010, though a $5 billion extension of the MTC has been proposed through the Security in Energy and Manufacturing Act of 2011. That bill would give higher priority to facilities that manufacture – rather than assemble – goods in the United States.[53]

Table 2: Selections for Section 48C Advanced Energy Manufacturing Tax Credit (MTC)

Applicant Name	Tax Credit Requested (millions)	Technology Area	Facility State
Abound Solar, Inc.	$12.60	Solar PV	CO
Advanced Energy Industries, Inc.	$1.23	Solar Components and Materials	CO
Amonix, Inc	$3.63	Solar PV	AZ
Amonix, Inc	$5.89	Solar PV	NV
Applied Photovoltaics, LLC	$1.07	Solar PV	NJ
CaliSolar, Inc.	$51.56	Solar CSI	CA
Centrosolar Oregon LLC	$4.74	Solar CSI	OR
Dow Corning - Solar Silane	$27.30	Solar PV	MI
E.I. du Pont de Nemours and Co.	$50.73	Solar PV	OH
First Solar, Inc.	$16.32	Solar PV	OH
GreenRay, Inc.	$0.18	Solar Components and Materials	MA
Hemlock Semiconductor Corp.	$141.87	Solar Components and Materials	MI

[51] Michaela D. Platzer. Congressional Research Service. *U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support*. Washington: Congressional Research Service, 2012. Print.
[52] "Solar Manufacturing Tax Credit" *Solar Energy Industries Association*, 2012.
[53] Michaela D. Platzer. Congressional Research Service. *U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support*. Washington: Congressional Research Service, 2012. Print.

Jabil Circuit Inc.	$20.40	Solar CSI	FL
Miasole	$10.45	Solar PV	CA
Miasole	$91.35	Solar PV	CA
Nanosolar	$43.45	Solar PV	CA
PPG Industries, Inc.	$0.27	Solar PV	PA
PPG Industries, Inc.	$0.15	Solar PV	PA
Sharp Electronics Corp	$1.65	Solar CSI	TN
Solar Power Industries, Inc	$1.61	Solar CSI	PA
Solar Power Industries, Inc.	$3.76	Solar CSI	PA
SolarWorld Industries America Inc.	$82.20	Solar Components and Materials	OR
Spire Semiconductor, LLC	$2.04	Solar PV	NH
Stion Corporation	$37.50	Solar PV	CA
STR, Inc.	$0.83	Solar PV	CT
Sumco Phoenix	$0.73	Solar Components and Materials	AZ
Sumco Phoenix	$2.67	Solar Components and Materials	NM
Suniva, Inc.	$5.70	Solar CSI	GA
Suntech	$2.11	Solar CSI	AZ
The Dow Chemical Company	$2.22	Solar PV	OH
The Dow Chemical Company	$17.81	Solar PV	MI
Wacker Polysilicon North America LLC	$128.48	Solar Components and Materials	TN
Xunlight Corporation	$34.50	Solar PV	OH
Yingli Green Energy Americas	$4.53	Solar CSI	AZ
Total	**$811.55**		

Source: White House Press Release, "President Obama Awards $2.3 Billion for New Clean-Tech Manufacturing Jobs," 8 Jan 2010.

- **Temporary Loan Guarantee Program for Deployment of Renewable Energy** – This Department of Energy (DOE) program provided almost $13.3 billion in loan guarantees for solar energy projects. Of that, almost $1.3 billion went to solar manufacturers, including the now infamous Solyndra. The remaining $12 billion went to solar generation projects.[54] The program, which expired on September 30, 2011 "was designed to provide support to these cutting edge industries, which have great potential to create jobs in whatever country wins the clean energy race, but also involve technology and market risks that private sector lenders often cannot or will not underwrite," according to Jonathan Silver, Executive Director of the Loan Programs Office at the DOE.

Table 3: Solar Manufacturing Projects Supported by DOE's 1705 Loan Guarantee Program

Project	Loan Guarantee Amount (millions)	Technology
1366 Technologies	$150	Silicon solar wafer manufacturing process that may reduce silicon waste by as much as 50% compared with current processes.
Abound Solar	$400	Proprietary manufacturing process for thin-film cadmium telluride (CdTe) photovoltaic modules.

[54] Phillip Brown. Congressional Research Service. *Solar Projects: DOE Section 1705 Loans Guarantees*. Washington: Congressional Research Service, 2012. Web. 2012.

SoloPower	$197	Copper indium gallium selenide (CIGS) photovoltaic cell and module manufacturing using a proprietary electrochemical fabrication process.
Solyndra Inc.	$535	Cylindrical CIGS photovoltaic cell and module manufacturing for commercial rooftop applications.
Total	**$1,282**	

Source: Phillip Brown, "Solar Projects: DOE Section 1705 Loan Guarantees," Congressional Research Service, 25 Oct 2011.

- **Department of Energy SunShot –** The DOE SunShot Initiative "aims to dramatically decrease the total costs of solar energy systems by 75% by 2020, bringing it down to a goal of $1 per watt" – in order to make solar energy price-competitive with conventional forms of electricity without subsidies. The SUNPATH initiative is designed to "support companies with pilot level commercial production facilities to scale up their manufacturing capabilities so that they can fast track the ramp up to full production capacity." [55] One SunShot program is the Photovoltaic Manufacturing Initiative (PVMI), which has as an explicit goal "help the United States regain the lead in the global market for solar technologies." The first PVMI awarded a total of $110 million to three groups – the Bay Area PV Consortium, SVTC Solar, and the U.S. Photovoltaic Manufacturing Consortium – to develop advanced manufacturing techniques that will lower the cost of producing PV panels.[56]

1.3.2 U.S. state subsidy programs

The following descriptions of U.S. state programs designed to bolster demand for solar power, or help solar manufacturers grow, is not designed to be all-inclusive; there are many other state programs not listed here. Rather, it is designed to offer a sense of the kinds of state programs offered in the U.S., as a means of comparison to China's provincial and local programs.

- **Oregon** offers solar manufacturers: [57]
  - Business Energy Tax Credit (BETC) equal to 50 percent of the incurred capital investment costs for eligible activities
  - Property tax abatements
  - Certified 'shovel-ready' sites
  - Other financial incentives

  These policies have attracted a number of solar PV manufacturers to Oregon. The largest project was the conversion of a former semiconductor manufacturing plant to a 500 MW solar PV plant for SolarWorld.
- **Michigan** provides solar manufacturers: [58]
  - Tax credits and general property tax exemptions through the NextEnergy program
  - 21st Century Investment Fund to leverage on private sector investments

[55] SEMI North American PV Advisory Committee, Manufacturing Solar Photovoltaic Products in the United States (Washington: SEMI North American PV Advisory Committee, 2012)
[56] "SunShot Photovoltaic Manufacturing Initiative." *SunShot Initiative*. 19 Mar. 2012. Web. 8 May 2012.
[57] SEMI North American PV Advisory Committee, *Manufacturing Solar Photovoltaic Products in the United States* (Washington: SEMI North American PV Advisory Committee, 2012)
[58] SEMI North American PV Advisory Committee, *Manufacturing Solar Photovoltaic Products in the United States* (Washington: SEMI North American PV Advisory Committee, 2012)

- State tax credits for "anchor" technology companies that assist in attracting a supply chain facility within 10 miles of the "anchor" facility
- Tax credit – equal to 25 percent of capital investments in a new facility in a given year, up to $15 million – for manufacturing activities or development of PV energy, systems, or technology
- Exemption from state business, education, personal and real property, and local income taxes for businesses located within Renewable Energy Renaissance Zones. Tax abatements are available for up to 15 years, with a 25 percent incremental phase-out over the last 3 years.

- **Colorado** gives solar manufacturers: [59]
  - Tax credits, grants, and loans from a strategic fund
  - Job training tax credits – available to small innovative companies
  - Investment tax credits – available to small innovative companies

  Abound Solar, Ascent Solar, SMA Solar, and PrimeStar Solar are among the solar manufacturers that have taken advantage of Colorado's incentives and located facilities there.

1.3.3 Chinese national subsidy programs

Clearly, the United States offers significant credits, guarantees, subsidies, and grants to solar manufacturers (as well as consumers and producers of solar power). Many of them look quite similar to the incentives that China offers (and remember, as Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, points out, subsidies are not necessarily anti-competitive). Some are even expressly designed to position the U.S. as the global leader in solar manufacturing.

One tool that the U.S. doesn't employ to promote solar manufacturing, which China does very well, is national industrial policy – a very clear and specific strategic *national* policy that directs (and then promotes) the development of a specific industry. The pinnacle of industrial policy in China is the Five Year Plan.

While it doesn't outline specific subsidies for China's solar manufacturers, China's 12th Five Year Plan does very clearly articulate China's goals for the industry. Most generally, the Five Year Plan (FYP), identifies seven new strategic industries for development (strategic emerging industries, or SEIs), including alternative energy (nuclear power, solar power, wind power, biomass power, and smart power grids). And the government "appears set to take measures to bolster demand for its SEI products."[60] For example, China plans to invest $100 million to build power projects using Chinese solar panels in 40 African nations.[61]

And China's Five Year Plans have traditionally proven quite successful. The 11th Five Year Plan, for example, designated clean energy technology (solar, wind, bio, and nuclear energy) for government support. China spent approximately $309 billion on energy efficiency and environmental protection measures[62] and today, four of the world's five largest photovoltaic solar cell manufacturers are Chinese

[59] *ibid*
[60] People's Republic of China, *12th Five-Year Plan for the Solar Photovoltaic Industry*, trans. Wiley Rein (Washington: Wiley Rein, 2011).
[61] "China plans African Ventures," *China Daily* 8 June 2011: n. pag. Web. 8 May 2012.
[62] "China's Five-year Plan & Renewable Energy – A Detailed Explanation" DEBLOCK Consulting Ltd. 23 Mar. 2011. Web. 8 May 2012.

companies, as are three of the world's five largest module manufacturers (see *Section 1.4*). China also now produces approximately 17 percent of the global silicon supply, once dominated by the U.S.[63] Over the next five years, as with clean energy technology in the previous five, the Chinese central and local governments "are expected to devote significant resources to all seven SEIs, creating both potential opportunities and challenges for foreign firms."[64]

The Five Year Plan (2011-2015) developed specifically for the solar industry was officially released in February 2012 by the Ministry of Industry and Information Technology. Key provisions include:

- Reduce the cost of domestic solar power to 0.8 yuan (about $0.13) per kWh by 2015 and 0.6 yuan (about $0.10) per kWh by 2020
- The cost of solar panels in China will drop to 7,000 yuan (about $1100) per kW by 2015 and 5,000 yuan (about $800) per kW by 2020
- The plan requires China's leading polysilicon manufacturers to reach a 50,000-ton annual production capacity (per company) and leading solar panel makers to reach 5 gigawatts (annually per company) by 2015
- China will further help solar companies increase their annual sales, with at least one company reaching 100 billion yuan (about $16 billion) in sales and 3 to 5 companies reaching 50 billion yuan (about $8 billion) in sales by 2015
- Increase the conversion efficiency of monocrystalline silicon solar cell to 21 percent, polysilicon cell to 19 percent and amorphous silicon cell to 12 percent by 2015
- Eighty percent of solar equipment and auxiliary materials will be produced domestically[65]

This plan, according to Gordon Brinser, President of SolarWorld Industries America, is one of the key reasons why China's solar manufacturers have grown so big so fast (from just 2 percent of the market in 2003 to 45 percent in 2010). "[China has] selected seven different industries to target for global production and global dominance. Solar is one of those industries. So they've taken a very holistic approach into how to control the solar industry. They've installed production capacity in China that by the end of 2010 was 32 times their domestic consumption, and 95 percent of their product was being exported, so that's clearly what their direction was."

Jigar Shah, founder of SunEdison and president of the Coalition for Affordable Solar Energy (CASE), which opposes SolarWorld's petition, openly acknowledges that China is "very sophisticated about how it supports its manufacturers." And, he adds, that's no different than any of the other industries China has identified as strategic. "This is the thing that is lost in most of the articles written on this area: what China is doing in solar is not different than what it is doing in every other sector."

Shah argued, "So the thing is that everyone says that China is doing all these things that are illegal, but what China did is have a plan. The U.S. hasn't had a plan for manufacturing since Jimmy Carter. When Larry Summers took over within the Obama White House, he refused to have a manufacturing plan in the U.S. He said that having an industrial policy was against American principles." And the fact is that other manufacturing powerhouses – notably Germany and Japan – have industrial policies too.

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[63] Jacob Funk Kirkegaard, et al., ―Toward a Sunny Future? Global Integration in the Solar PV Industry,‖ *Working Paper*, May 2010. p. 21. *http://pdf.wri.org/working_papers/toward_a_sunny_future.pdf.*
[64] People's Republic of China, 12th Five-Year Plan for the Solar Photovoltaic Industry, trans. Wiley Rein (Washington: Wiley Rein, 2011).
[65] Liu Yiyu, "Solar Industry 12th Five-Year Plan Issued," *China Daily* 24 Feb. 2012: n. pag. Web. 8 May 2012.

But while China's goals for the solar industry are very clear, it's not clear all the ways that the national and local governments will specifically support those goals. Generally, China has promoted the solar industry on two fronts. One is direct manufacturing policies, including preferential loans; tax incentives (including sales/value added tax waivers, preferential tax rates, income tax credits, property tax credits); research and development support; central government planning; local and provincial policies; domestic proprietorship requirements; and facilities, land, and training grants. The other is indirect deployment policies designed to promote demand for photovoltaic solar, including central government planning and goals; direct subsidies; feed-in-tariff; and local and provincial policies.

In 2006, China made key solar PV technologies part of the Pillar R&D Support Scheme, which provided funding for the commercialization of solar technologies by Chinese manufacturers. Recipients include solar PV manufacturers, including Wuxi Suntech, Baoding Yingli Green Energy, Changzhou Trina Solar and Xinjiang New Energy, and silicon manufacturers including Sichuan Xinguang Silicon and Luoyang Silicon High-Tech.[66]

Shah said that support for solar manufacturers in China comes, in part, as loans from local governments. But, he emphasized "Loans. Not grants. Not soft loans. So if Suntech does a bad job of giving credit to a local installer and that local installer screws Suntech and doesn't pay them back, Suntech still has to pay back the government."

There are rumors, according to Shyam Mehta, Senior Analyst at GTM Research, that Chinese solar manufacturers continue operating even if they're losing money just to keep people employed (and for that reason the government funds the gap). But such rumors have not been substantiated, even after the thorough initial investigation by the Department of Commerce.

About the idea that Chinese solar manufacturers get loans that don't really have to be repaid, said Shah, "It's not true. It's never been true. And yes, if you go bankrupt then the Chinese government is left holding the bill, but there are no loans that are forgiven."

According to Shah, "People say, 'The Chinese government gave $30 billion to its solar companies,' and that's not true. The Chinese government issued a non-binding MOU for $30 billion and the Chinese solar companies had to go through six months of work to get access to some of that money, which is why most didn't take it."

Indeed, it is no secret that the China Development Bank opened a line of credit of about $30 billion for Chinese solar cell and module manufacturers. But it's not clear how much of that credit was ever given out. One report cited Suntech as saying that the company received a $7 billion credit from China Development Bank, but that less that 10 percent of it (still a not insignificant $700 million) was drawn down.[67] Mehta also questioned how much of the $30 billion had actually been drawn down by Chinese manufacturers. "Chinese firms' debt-to-equity ratios are not great, but they're better than European firms'" he said.

According to the online investment magazine *Motley Fool*, LDK Solar has a credit line of up to $8.97 billion from the China Development Bank over five years to build out its facilities to compete in the solar business. JA Solar has credit of up to $4.42 billion, Suntech $7.29 billion, and Trina Solar another $4.3 billion. "This type of financing would be impossible to obtain in the open market since they have little to

[66] Li Junfeng, et al. China Environmental Science Press. 2007 China Solar PV Report. .2007: Web. 8 May 2012.
[67] Alim Bayaliyev, et al. "China's Solar Policy: Subsidies, Manufacturing Overcapacity & Opportunities" Capstone Project, George Washington University, 2011.

differentiate themselves from the competition."[68] Again, it's not clear how much of their credit lines these or other Chinese manufacturers have actually drawn.

But Chinese firms claim that U.S. solar cell and module manufacturers have benefited from subsidies as well. In fact, in November 2011 China's Ministry of Commerce launched an investigation into six renewable energy programs in the states of Washington, Massachusetts, Ohio, New Jersey, and California. The investigation was applied for by the China Chamber of Commerce for Imports and Exports of Machinery and Electronic Products, as well as the new energy chamber of the All-China Federation of Industry and Commerce.[69]

1.3.4 Chinese provincial subsidy programs

In *Shining a Light on U.S.-China Clean Energy Cooperation*, Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, writes, "Since Beijing prioritizes clean energy development, provincial and local governments have a strong incentive to develop their own support policies. Some local officials simply implement national directives such as the Ministry of Finance directives calling on local financial bureaus to raise and distribute green energy development funds. Other local governments see clean energy as a prime growth opportunity and go well beyond national policy requirements in an attempt to turn their provinces into clean energy manufacturing hubs. Case in point: Jiangsu Province has particularly aggressive solar development policies. Jiangsu's 2009 three-year solar PV development plan set ambitious targets for solar module production and called on local officials to cultivate name-brand products and internationally competitive enterprises by providing state assistance for product development and supply-chain verticalization. The result is a province responsible for two-thirds of China's total solar PV equipment production in 2010 – more than 90 percent of those products were exported to overseas markets."[70]

But determining the specific mechanisms that the provincial governments use to build the solar industry is "extremely difficult," Hart writes. "China's subsidy programs are often nontransparent, particularly at the provincial and local levels. It is very common, for example, for local officials to provide land, electricity, and other resources at below-market rates to attract economic development (and the associated tax revenue) even when the central government does not support those tactics. Loan subsidization is also common. China's tier-one manufacturers claim they are paying market interest rates for their massive and controversial China Development Bank loan guarantees, but some local governments reportedly reimburse those companies for most of their interest payments, thus reducing the effective interest rate to nearly zero (or, depending on inflation, possibly even below zero). In many cases local governments provide these supportive measures on a case-by-case basis instead of via clear development policies that apply to all firms across the board. These measures can make China's local level clean energy support programs very difficult to measure."[71]

Illegal or not, China's industrial policy support for solar manufacturers has legitimate benefits as well as downsides. For one, it has allowed for the dramatic reduction in the cost of solar modules around the world, which makes solar power a more attractive alternative to traditional energy sources, thus furthering

[68] Travis Hoium "Can the U.S. Learn from China's Solar Manufacturing Subsidies?" *The Motley Fool* 3 Jan. 2012. Web.
[69] "China Starts Investigation into U.S. Support for Renewable Energy Sector," *Xinhua* 25 Nov. 2011: n pag. Web. 8 May 2012.
[70] Melanie Hart. *Shining a Light on U.S.-China Clean Energy Cooperation*. Center for American Progress, Feb. 2011: Print.
[71] *ibid*

environmental objectives (e.g. reduced greenhouse gas emissions) and reduced dependence on foreign oil imports.[72]

At the same time, though, China's solar industrial policy might lead to industry concentration – already the top solar module manufacturers are dominated by Chinese firms (3 of the top 5). If that industry concentration leads to a lack of competition (which it doesn't necessarily; Chinese firms compete against each other) then that could harm the global solar industry, with decreased innovation and even increasing prices over time.[73]

As Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, pointed out, subsidies are generally not deemed illegal unless they specifically target exports. In response to claims from respondents that the company received tax breaks and public subsidies, Solar World acknowledged that it did in fact receive "a few million dollars" in subsidies, but that those were for research, not exports.

According to Tim Brightbill, Partner in the International Trade practice of Wiley Rein LLP, testifying before the U.S.-China Economic and Security Review Commission in February 2012, "The Government of China subsidizes export-oriented renewable energy producers. For example, to support the export of products listed in China's Catalogue of Chinese High-Tech Products for Export, which includes solar energy products, the Export-Import Bank of China provides export-contingent loans at preferential rates. In 2010 alone, new medium- and long-term official export credits from China amounted to $45 billion."[74]

The petitioners in the trade case argue that subsidies in China by default support exports, given that 95 percent of the solar cells and modules produced in China are exported out of the country. But the same is true for the U.S., which accounted for just 5 percent of the global solar demand in 2010, and exported 153 percent more solar-related products than it imported in 2010 (according to preliminary estimates that percentage dropped to 76 in 2011).

It is clearly difficult to parse the subsidies actually being given to Chinese solar manufacturers – and how those compare to subsidies actually being given to U.S. solar manufacturers. Because U.S. solar manufacturers receive subsidies, too – many of them quite similar in nature. Unfortunately, it's impossible to more definitively and specifically answer the question, "Who received subsidies, and how much?" for China. The best we can do is take the Department of Commerce preliminary decision on Chinese subsidies – actually quite small – as a reflection of what's really going on there (understanding that the Department of Commerce has not made its final subsidy determination).

1.4 Who are the players and what are they doing, where?

The development of solar energy has truly been a global phenomenon. "In 1954, Bell Labs in the United States made PV technology marketable for the first time, with up to 6 percent efficient solar cells that cost roughly $250 per watt. Ten years later, Sharp Corporation in Japan produced one of the first viable solar modules for terrestrial applications. Since then, global competition spurred decades of efficiency improvements and cost reductions across a variety of PV technologies and industry segments. SunPower, based in the U.S., was the first company to effectively commercialize Stanford's rear point contact cell technology, which set several world records for commercial monocrystalline silicon module efficiency.

[72] *Green Industrial Policies: Trade and Public Policy*, slide show, Larry Karp and Megan Stevenson - Green Industrial Policies, 2012.
[73] *ibid*
[74] United States, Export-Import Bank of the United States, Report to the U.S. Congress on Export Credit Competition and the Export-Import Bank of the United States (Washington: GPO, 2010). Web.8 May 2012.

Suntech, based in China, was the first company to effectively commercialize UNSW's PERL technology, which immediately set a world record for multicrystalline silicon module efficiency."[75]

Shyam Mehta, Senior Analyst at GTM Research, offers an overview of the last decade in the global solar industry: "May 2000 began very rapid growth in the solar industry because of the introduction of subsidy programs in Spain and Germany. Those subsidies ended up as profits in the hands of manufacturers. So in 2003, 2004, 2005 China made a conscious decision to grow its solar manufacturers. The China Development Bank opened lines of credit to Chinese manufacturers and generally launched a policy of consistent support for solar manufacturers – but that government support was easily justified because of profits the companies produced."

China's solar manufacturers, Mehta explained – like those in Germany, Japan, and the U.S. – benefited from a very supportive environment, characterized by subsidies for solar installations (demand subsidies, which allow solar to be cost-competitive with fossil fuels), shortage of supply, and a market that was doubling in size every year. "So China very quickly scaled up and by 2008 and 2009 had more scale than manufacturers in the West or even Japan. And that's critical in an industry with a commoditized product like solar PV – among the top tier manufacturers around the world (including in China), there's really no difference in quality. So then the comparative differentiator is price, which depends on scale (higher scale = lower cost). And once the China ball was rolling it would be very hard to stop."

At the same time, the price of polysilicon, a key input for CSPV cells, had declined significantly from its 2008 peak (see *Section 1.2.4.1*), which drove further declines in cell and module prices. And as Robert Petrina, Managing Director at Yingli Green Energy Americas, Inc., pointed out to the U.S. International Trade Commission, "When prices make solar energy more competitive with non-renewables, demand for solar expands, and 2010 was a great year for the entire industry, from SolarWorld to Yingli."[76] Manufacturers across the globe ramped up production.

But that frenzy led to an oversupply, exacerbated by demand contraction that was due in part to the global recession and in part to changing policies in Europe. That began what Mehta called a "shakeout process." Because demand had shrunk, only the firms best able to compete would survive, and that's when we began in late 2010 and 2011 to see the high-profile bankruptcies.

"The top-tier Chinese firms, in this shakeout, were able to aggressively lower their prices and still make a profit because of their huge scale," Mehta said. "And while Western and Japanese solar manufacturers were hunkered down, Chinese firms continued their capital expansion – which even further built scale. Because of the lines of credit from the China Development Bank the Chinese manufacturers had the capital necessary to continue expanding when the market resumed demand growth." At the same time, China was developing its solar industry supply chain – polysilicon and to a limited extent equipment – which further lowered the cost of production for Chinese manufacturers and increased their competitive position vis-à-vis firms in Japan, Germany, and the U.S.

Table 4: Top 15 Solar Cell Manufacturers in 2010

Company	HQ Country	MW
Suntech Power	China	1,584
JA Solar	China	1,464
First Solar	United States	1,400

[75] Martin Green, "A Solar Trade War Could Put Us All in the Dark," *Technology Review* 19 Dec. 2011: n pag. Web. 8 May 2012.
[76] Robert Petrina, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.

Yingli Green Energy	China	1,117
Trina Solar	China	1,116
Q-Cells	Germany	939
Gintech	Taiwan	800
Sharp	Japan	745
Motech	Taiwan	715
Kyocera	Japan	650
Hanwha SolarOne	China	532
Neo Solar	Taiwan	530
Canadian Solar	China	523
Sunpower	United States	520
REC	Norway	517

Source: Shyam Mehta, "PV News Annual Data Collection Results: 2010 Cell, Module Production Explodes Past 20 GW," Greentech Media, 9 May 2011.

Figure 13: Top 15 Solar Cell Manufacturers in 2010

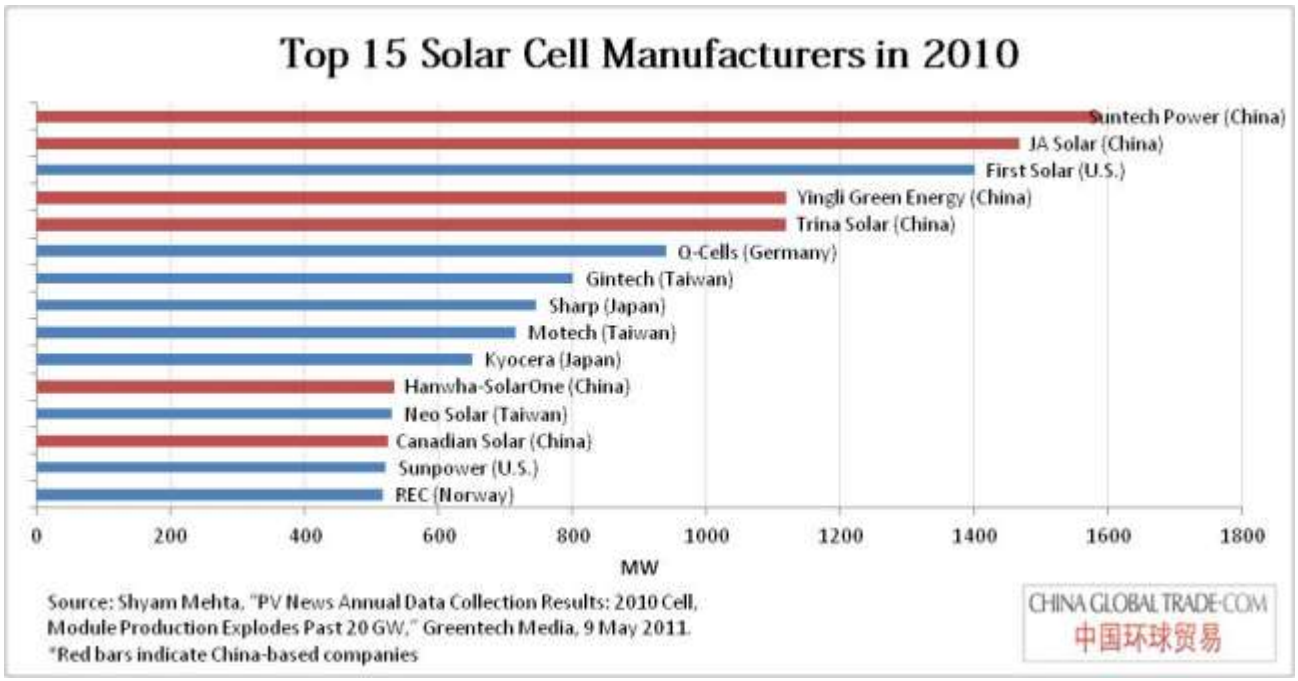


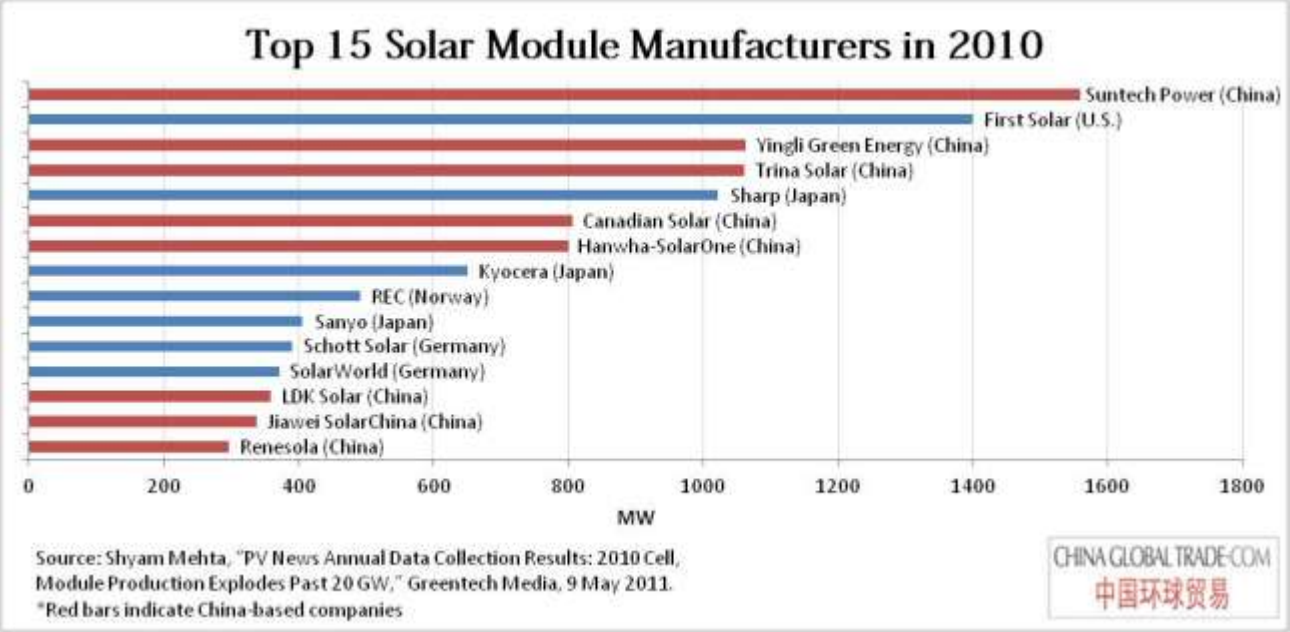
Table 5: Top 15 Solar Module Manufacturers in 2010

Company	HQ Country	MW
Suntech Power	China	1,558
First Solar	United States	1,400
Yingli Green Energy	China	1,061
Trina Solar	China	1,060
Sharp	Japan	1,022
Canadian Solar	China	804
Hanwha SolarOne	China	798
Kyocera	Japan	650
REC	Norway	491

Sanyo	Japan	405
Schott Solar	Germany	390
SolarWorld	Germany	371
LDK Solar	China	356
Jiawei Solar China	China	337
ReneSola	China	295

Source: Shyam Mehta, "PV News Annual Data Collection Results: 2010 Cell, Module Production Explodes Past 20 GW," Greentech Media, 9 May 2011.

Figure 14: Top 15 Solar Module Manufacturers in 2010



1.4.1 Suntech Power

Suntech Power was in 2010 the world's biggest producer of solar cells and solar modules. The Chinese company was founded in 2001 by Dr. Shi Zhengrong, who had been a research director of Pacific Solar Pty., Ltd., an Australian PV company, and before that, a senior research scientist at the Thin Film Solar Cells Research Group in the Centre of Excellence for Photovoltaic Engineering at the University of New South Wales in Australia.

Shi has continued to run the company as CEO. Suntech was the first non-US-owned hi-tech company to be listed on the New York Stock Exchange, in 2005.[77] It built its first manufacturing plant in the U.S. in Goodyear, Arizona in 2010, making it the first Chinese cleantech company to set up a manufacturing facility in the U.S. The 50MW module assembly plant enables Suntech to label solar modules assembled there as "made in U.S.A." As a result, Suntech now qualifies for federal "Buy American" subsidies. [78] (The company also received a $260,000 grant from Arizona as an incentive to locate there.)

[77] Li Junfeng, et al. China Environmental Science Press. *2007 China Solar PV Report*. .2007: Web. 8 May 2012.
[78] Keith Bradsher, "Chinese Trade Case Has Clear Targets, Not Obvious Goals," *New York Times* 20 October 2011: B3.

Suntech is often cited as an example of Chinese quality and innovation in solar cell and module manufacturing. In 2010, when U.S. Secretary of Energy Steven Chu gave a speech to the National Press Club laying out his case that the United States was falling behind in advanced manufacturing, Suntech was his Exhibit A. He had toured its factory, and he was impressed by what he'd seen. "It's a high-tech, automated factory," he said. "It's not succeeding because of cheap labor." Not only that, he noted, but Suntech had developed a type of solar cell with world-record efficiencies.

1.4.2 First Solar

U.S.-based First Solar, a manufacturer of thin-film cells and modules (not crystalline silicon photovoltaics), held the top spot among solar cell and module manufacturers in 2009. It is still the world's largest producer of thin-film solar modules, accounting for more than 40 percent of world output. First Solar is headquartered in Tempe, Arizona, but the "lion's share" (68 percent in 2010) of its output is produced in Malaysia.[79]

The company was founded in 1999 and launched production of commercial products in 2002. It listed on the NASDAQ stock exchange in 2006. For a while, the company looked like it might largely avoid the pain other solar manufacturers were feeling since 2009 – in 2010 First Solar was the most profitable cell producer, with a gross profit margin of more than 48 percent.[80] But since the beginning of 2012, this company has fallen on hard times too; it announced plans to lay off 30 percent of its workforce (2,000 employees worldwide). The company's stock fell to a record low after it released its first quarter 2012 earnings report.[81]

1.4.3 Yingli Green Energy

Yingli Green Energy is a vertically-integrated photovoltaic manufacturer headquartered in Baoding, China. The company designs, manufactures, and sells PV modules, and designs, assembles, sells and installs both grid-connected and stand-alone PV systems. It is one of the largest manufacturers of PV products in China, including polysilicon ingots and wafers, cells, and modules.[82]

Yingli has been listed on the New York Stock Exchange since 2007. The company was founded in 1998 by Liansheng Miao, who has continued to serve as CEO. The company's Chief Technology Officer is Dr. Dengyuan Song who, before Yingli, worked at the ARC Photovoltaics Centre of Excellence at the University of New South Wales in Sydney, Australia.

According to Robert Petrina, Managing Director of Yingli Green Energy Americas, Yingli has been in the U.S. since late 2009. "At that time was grossly underserved. The size of the U.S. market was growing, but supply had not kept up. The supply shortage was so great that U.S. customers were at times waiting for six months to receive product. The bulk of worldwide production, including U.S. production at that time, was going to Europe, and particularly Spain, Germany, and Italy, where pro-solar energy policies were creating a bonanza for companies that were selling to those markets."[83]

[79] Garrett Hering, "Year of the Tiger," *Science & Technology* Apr. 2010: 186-218. *Photo-International*. Web. 2010.
[80] *ibid*
[81] Justin Doom "First Solar Falls After Reporting $401 Million Charge," *Bloomberg* 4 May 2012: n. pag. Web. 4 May 2012.
[82] Li Junfeng, et al. China Environmental Science Press. 2007 China Solar PV Report. .2007: Web. 8 May 2012.
[83] Robert Petrina, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.

1.4.4 Trina Solar

The oldest of the big Chinese solar manufacturers, Trina Solar was founded in 1997 by Jifan Gao and a small group of scientists. For the first several years, the company focused on R&D and installation of solar power systems for government-subsidized projects in China. Trina Solar began manufacturing solar modules in 2004, monocrystalline ingots in 2005, and wafers and cells in 2006. The company was listed on the New York Stock Exchange in 2006.

Now the "module cost-leader,"[84] Trina Solar's vertical integration is an important competitive advantage. It allows the company to:

- Reduce costs, such as those associated with packaging and transportation
- Reduce the amount of breakage loss associated with toll manufacturing that typically occurs during shipment between production locations
- Reduce reliance on 3rd party suppliers
- Shorten production cycle and improve value chain coordination
- Reduce reliance on toll manufacturing and capture upstream and downstream profit margins[85]

Trina Solar has also benefited from strategic partnerships with research groups around the world. The company has a "liaison program" with MIT, which allows Trina Solar access to MIT and its resources, as well as access to technology conferences and opportunities to collaborate with MIT researchers, helping the company "to remain at the forefront of advanced technological developments." The company also collaborates with SERIS, Singapore's national instate for applied solar energy research, to develop cell processing technology. And Trina Solar has a research agreement with Australia National University "for the development of industry-ready n-type monocrystalline solar cells with efficiency up to 20 percent and increasing the efficiency in production of Trina's multicrystalline solar cells to 19 percent."[86]

1.4.5 Sharp

Probably the oldest solar PV producer still around, the Japanese company Sharp (founded by Tokuji Hayakawa) began development of solar cells in 1959; by 1963 it succeeded in the mass production of solar cells. For much of the 2000s, Sharp was the world's largest manufacturers of solar cells and modules. In 2003, the company built its first overseas manufacturing facility, in Memphis, Tennessee.

In 2010, according to industry magazine *Photon* International, "the open secret is that Sharp did not manufacture all of the cells it shipped. Instead, the company outsourced the production of an unknown amount of cells to Taiwan."[87] The company is listed on the Tokyo, Osaka, Nagoya, Fukuoka, and Sapporo stock exchanges.

1.4.6 JA Solar

JA Solar first began in 2005 as JingAo Solar Co., Ltd, a joint venture between the JingLong Industry and Commerce Group Co., Ltd.; the Australia PV Science & Engineering Company; and the Australia Solar Development Company. The company was founded by Yang Huaijin, an Australian who had co-founded China Sunergy in 2004, Suntech Power in 2001, and Southern Sunshine International Australia Pty., Ltd in 1997. In 2006 JA Solar was established as the holding company of JingAo Solar Co., Ltd. It was publicly listed on the NASDAQ in 2007.

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[84] Garrett Hering, "Year of the Tiger," Science & Technology Apr. 2010: 186-218. Photo-International. Web. 2010.
[85] *2011 Company Profile*. (Trina Solar, 2011).1-30.
[86] *ibid*
[87] Garrett Hering, "Year of the Tiger," Science & Technology Apr. 2010: 186-218. Photo-International. Web. 2010.

Today, the company is headquartered in Shanghai, China, with operations around the world, including the U.S. The company calls its business model a "selectively optimized vertical integration model."[88] It manufacturers wafers, cells, modules, and offers PV system project development services.

Life has been hard for all of these solar manufacturers in the last several years, since prices fell precipitously (44 percent in 2011 alone) after spiking in 2006. Some blame that difficulty on Chinese manufacturers. In a speech at the Conference on the Renaissance on American Manufacturing, SolarWorld President Gordon Brinser said, "Since 2010, employees of at least 12 U.S. solar manufacturing companies – in Arizona, California, Florida, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Texas and Wisconsin – have become road kill along China's five-year planning superhighway."

Indeed, in the U.S., solar manufacturers have had a rough two years, with six companies filing for bankruptcy in 2011, including the most famous Solyndra, which had received a $535 million loan guarantee from the U.S. federal government. All told, "at least 12 U.S. manufacturers have suffered layoffs, plant shutdowns or bankruptcies over the past two years."[89] More than 1,700 workers have reportedly lost their jobs as a result[90]. To put this into context, it is worth noting that the total number of U.S. solar industry jobs doubled from about 50,000 in 2009 to about 100,000 today.[91]

About the American solar manufacturers that have filed for bankruptcy, Jigar Shah, President of the Coalition for Affordable Solar Energy, said "They were all going to go bankrupt anyway. Evergreen Solar was teetering on bankruptcy every year since 2004. They never turned a profit, even in 2007 when the module prices were sky high…The narrative is so easy to craft that China is the big, bad country that hurts U.S. manufacturers. That's easy to say, and think about how many voters you get by saying that."

Indeed, while the petitioners in the solar trade case argued that Chinese subsidies and dumping are to blame for the layoffs, plant shutdowns, and bankruptcies in the U.S., respondents countered those claims with evidence pointing to other reasons for particular firms' ruin. Consider SpectraWatt, for example. The Intel solar spin-off laid off most of its employees and closed its doors in 2010, then filed for Chapter 11 reorganization bankruptcy in 2011.[92] "Market analysts have attributed SpectraWatt's failure to its undifferentiated solar cells and an inability to achieve economies of scale that would help to reduce costs. They also note that, although the company blamed winter weather conditions in Europe for a lack of demand for its solar cells and subsequent shutdown of its factory, the company also had made several missteps by trying to raise financing for the factory when the market collapsed in 2008 and by commencing production when major players in the industry had already established their market positions."[93]

SOLON Corp., the U.S. subsidiary of German SOLON Group, shut down its Tucson, Arizona manufacturing plant in August 2011. According to SOLON's CEO Dan Alcombright, SOLON had "proactively decided to change [its] strategy from selling what the market perceives as a 'me-too

[88] "JA Solar." *JA SOLAR*. 2011. Web. 8 May 2012.
[89] Michele Nash-Hoff, "Viewpoint: What's Really Happening to America's Solar Industry?" *Industry Week* 22 Feb. 2012. Web. Apr. 2012.
[90] Timothy C. Brightbill, "Written Statement of Timothy C. Brightbill Before the U.S.-China Economic and Security Review Commission," 15 Feb. 2012, Hearing on Chinese State-Owned and State Controlled Enterprises, USITC Hearing.
[91] "Facts on America's Solar Industry." Solar Energy Industries Association. 5 Mar. 2012. Web. 8 May 2012.
[92] Michael Kanellos, "SpectraWatt Sequel: After Collapsing, Company Declares Bankruptcy," *Greentech Solar* 24 Aug. 2011: n. pag. Web. 8 May 2012.
[93] Neil R. Ellis, et al. "Investigation Nos, 701-TA-481 and 731-TA-1190", Post-conference brief. Washington: 15 Nov. 2011.

module'" – i.e., standard modules that were undifferentiated from others in the market – to designing and supplying differentiated products with higher value.[94]

In an interview, Rob Wanless, Director of Business Development, SOLON Corporation, said that during the time when the company was manufacturing in the U.S. – 2007 to 2011 – the cost of a module was about $4 per watt. And, there weren't many Chinese manufacturers in 2007; the others were German, Japanese, and Korean. Over time the Chinese solar manufacturers ramped up manufacturing (as did U.S. manufacturers, including First Solar and SolarWorld), which caused prices to fall. As manufacturers continued to ramp up production, that led to a glut in panel supply, which led prices to fall even further. That story was echoed by an executive at a Chinese module manufacturer as well – that beginning in 2008 Chinese companies began to enter the market, attracted by the high price of solar panels.

Companies of course were trying to lower their manufacturing costs, but prices were falling faster. By 2012 the cost of solar panels from Chinese manufacturers was about $1 per watt, and $1.20-1.30 per watt from U.S. manufacturers. "With prices like that, SOLON can't compete for modules by producing in the U.S. market," Wanless said. So the company stopped manufacturing in the U.S. Now, it has OEM contract manufacturers in Asia because to compete against other forms of energy, the total system cost of solar has to be as low as possible (and modules make up about a third of the system cost).[95] But Wanless himself acknowledges that doesn't mean the Chinese producers were receiving massive illegal subsidies or dumping into the U.S.; there are other reasons they can produce cells and modules much less expensively (see *Section 2.2*).

About the poster child for solar industry failures in the U.S. – Solyndra – which filed for bankruptcy in 2011, respondents said, "Solyndra failed under unique circumstances that were unrelated to [Chinese] imports. As polysilicon prices plummeted [in 2009], the unusual cylindrical panels of thin-film solar cells developed by Solyndra rapidly lost competitiveness, and combined with financial mismanagement, precipiated severe losses at the company."[96]

The solar market has been difficult for Chinese manufacturers too. Many of the smaller, weaker Chinese producers have already folded. And even among the world's top manufacturers, the past three years have eroded stock values dramatically:

- Suntech's stock has fared about the same, from a high of $85.16 a share in December 2007 to $2.69 at the end of April 2012 (a decline of 97 percent).
- First Solar's stock has been stronger, but still, it fell from a high of $311.14 in May 2008 to $18.35 at the end of April 2012 (a fall of 94 percent).
- Yingli Green Energy's stock fell from a high of $38.39 in December 2007 to $3.76 at the end of April 2012 (a decline of 90 percent).
- Trina Solar's stock fared a bit better; it fell from a high of $35.43 in July 2007 to 7.75 at the end of April 2012 (a decline of 78 percent).
- Since Sharp Solar is a division of Sharp Corporation, which manufacturers many other electronic products in addition to solar cells, it's hard to tie stock performance specifically to solar division.

[94] Neil R. Ellis, et al. "Investigation Nos, 701-TA-481 and 731-TA-1190", Post-conference brief. Washington: 15 Nov. 2011.
[95] GTM. U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States. Washington: GTM, 2011. Web. 2012.
[96] Neil R. Ellis, et al. "Investigation Nos, 701-TA-481 and 731-TA-1190", Post-conference brief. Washington: 15 Nov. 2011.

The corporation's stock has fallen from a high of $25.70 in December 1999 to $5.37 at the end of April 2012 (a decline of 79 percent).

- JA Solar's stock has fallen from a high of $25.75 a share in April 2008 to $1.37 a share at the end of April 2012 (a decline of 95 percent).
- While not one of the world's top five solar cell or module producers, as the lead petitioner in the solar trade case, it's worth mentioning SolarWorld's performance: it's stock fell from a high of 66.52 euros (about $87) in June 2007 to 1.59 euros (about $2.08) at the end of April 2012 (a decline of 98 percent).

Solar manufacturing is currently experiencing a global "shakeout" due to difficult global business conditions, stiff competition particularly from Chinese manufacturers, and slowing demand for solar panels.[97] While lower-cost Chinese producers play a significant role in this "shakeout" they are themselves not immune to the other global pressures – notably reduced subsidies in Europe that will likely lead to a reduction in demand (or, at least, demand growth) there.

1.4.7 Other global PV producers

The supply chain for PV products is global. In 2010, the U.S. imported more PV products from China than any other country; Mexico, Japan, Taiwan, Malaysia, Germany, and the Philippines were the other top countries of origin for U.S. PV imports.

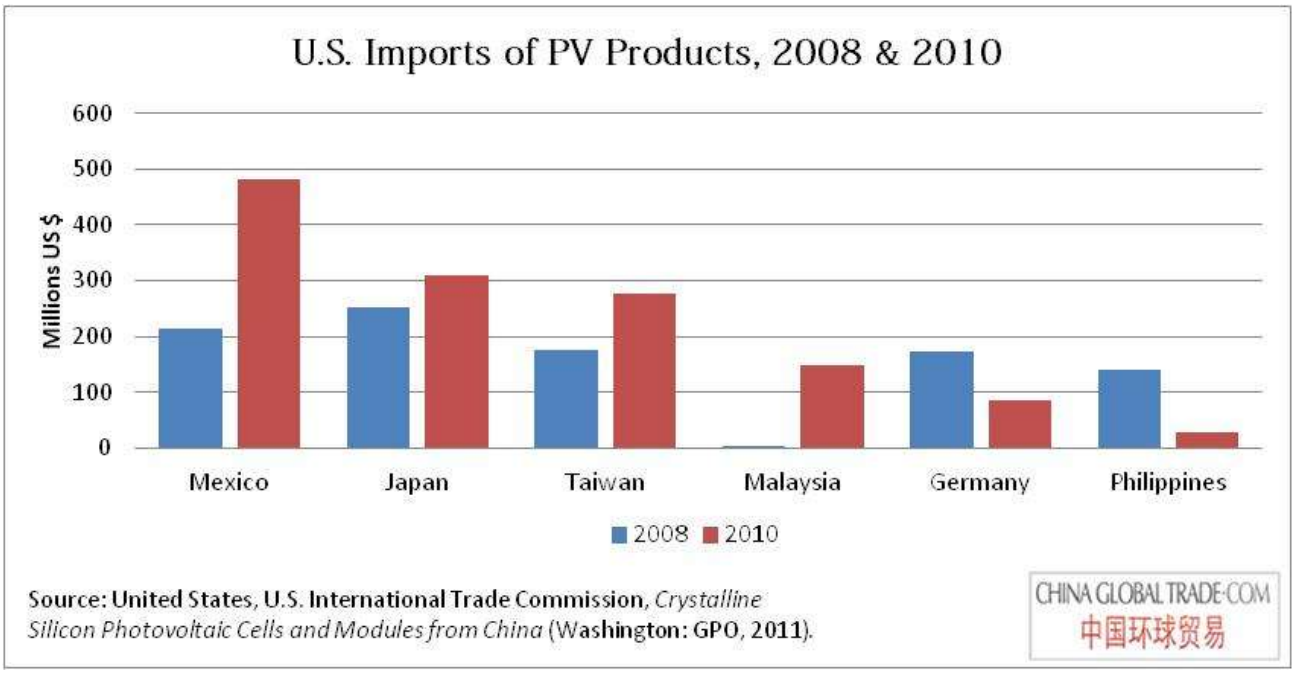
Table 6: U.S. Imports of PV Products (millions US $)

Country of Origin	2008	2010	% Change 2008-2010	2010 Q1-3	2011 Q1-3	% Change 2010Q1-3 to 2011Q1-3
Mexico	213.3	481.3	126%	330.5	355.4	8%
Japan	253.4	308.8	22%	190.9	313.8	64%
Taiwan	176.3	276.8	57%	212.6	108.2	-49%
Malaysia	1	148.1	14710%	139.8	309.8	122%
Germany	172.5	86	-50%	55.3	108.9	97%
Philippines	140.9	28.3	-80%		165.8	

Source: United States, U.S. International Trade Commission, *Crystalline Silicon Photovoltaic Cells and Modules from China* (Washington: GPO, 2011).

[97] Michaela D. Platzer. Congressional Research Service. *U.S. Solar Manufacturing: Industry Trends, Global Competition, Federal Support*. Washington: Congressional Research Service, 2012. Print.

Figure 15: U.S. Imports of PV Products



Behind China, Mexico is the second-largest supplier of PV products into the U.S. market. The Mexican CSPV industry is made up exclusively of companies that assemble modules, and most production is exported, primarily to the U.S.[98] Japanese module producers Kyocera and Sanyo have assembly facilities in Mexico, as do Spanish producer Siliken and American Jabil Circuit (which is a contract manufacturer for multiple companies, including JA Solar and SunPower). Mexican producers include ERDM and Solartec.[99] U.S.-based SunPower announced plans in 2011 to open a plant in Mexico.

Japan was the third-largest supplier of PV products into the U.S. in 2010. Japanese companies typically produce CSPV cells in Japan and assemble modules either in Japan or close to major markets. Japanese CSPV cell production is led by four companies, Kyocera, Mitsubishi Electric, Sanyo, and Sharp, of which Kyocera and Sharp were among the top ten global CSPV cell and module producers in 2010 and Sanyo was the 10th largest module manufacturer. In addition to facilities in Japan, Kyocera also has production facilities in China, the Czech Republic, Mexico, and the U.S. Sanyo also has facilities in Hungary and Mexico. Sharp also operates in the United Kingdom and U.S.[100] A significant portion of Japanese production is likely exported, as the Japanese PV market totaled 990 MW, significantly less than CSPV production (1,880 MW), and some of that demand was met through the $919.5 million in Japanese PV imports in 2010 and domestic thin film production.[101]

Taiwan was the fourth-largest supplier of PV products into the U.S. in 2010. Two Taiwan-based companies, Gintech and Motech (which also has production outside of Taiwan), were among the top ten global manufacturers of CSPV cells in 2010. Six other Taiwan-based companies produced at least 100 MW of PV products each in 2010: DelSolar, E-Ton Solar, Neo Solar Power, Solartech Energy, Sunrise

[98] United States, U.S. International Trade Commission, *Crystalline Silicon Photovoltaic Cells and Modules from China* (Washington: GPO, 2011).
[99] *ibid*
[100] *ibid*
[101] *ibid*

Global Solar Energy, and Tainergy Tech.[102] Taiwan's solar manufacturers primarily produce cells, though some companies have vertically integrated into module production. No Taiwanese companies were among the top module producers. Taiwan has a small domestic market, with only 12 MW in installations in 2010, so most production is exported[103] – more than half to China.[104]

The Philippines was the fifth-largest supplier of PV products into the U.S. in 2010, due to the manufacturing presence of SunPower. SunPower, the U.S.-based cell and module manufacturer, accounted for all 558 MW of CSPV cell production in the Philippines in 2010; the company also has 220 MW of CSPV module production capacity there.[105]

Germany was the sixth-largest supplier of PV products into the U.S. in 2010. Ten firms – Arise Technologies, Bosch, Coenergy, Q-Cells, Scheuten, Schott Solar, SolarWorld, Solarwatt, Sovello, and Sunways – accounted for all of Germany's CSPV cell production between 2008 and 2010. Germany had the largest global PV market in 2010, but it is also a major PV exporter, with most of its exports going to other EU members.[106]

Malaysia was the seventh-largest supplier of PV products into the U.S. in 2010. The majority of Malaysia's production is thin film products (including First Solar's), with 933 MW of thin film cell production and 474 MW of CSPV cell production in 2010.[107] Malaysia's domestic market was less than 2 MW in 2010, so most production was exported.[108]

[102] "Year of the Tiger," *Photon International*, March 2011.
[103] *Global Market Outlook for Photovoltaics until 2015*.
[104] GTIS, Global Trade Atlas Database
[105] "Year of the Tiger," *Photon International*, March 2011; SunPower, "Form 10-K," February 28, 2011.
[106] *Global Market Outlook for Photovoltaics until 2015*.
[107] USITC Dataweb/USDOC; "Year of the Tiger," *Photon International*, March 2011.
[108] International Energy Agency, Photovoltaic Power Systems Programme, *Trends in Photovoltaic Applications*, Preliminary Statistical Data, 2011.

2 Why has China's solar industry grown so big so fast?

There is no doubt that China's solar manufacturing industry has grown very big very fast – from producing just 1 percent of the world's photovoltaics in 2001 to 45 percent in 2010. In comparison, Japan, which was the world's largest PV producer until 2008, took twice as long to achieve a similar share of the world market.

But why is it that China's solar manufacturing industry has grown so fast? Is it because the Chinese government has invested huge amounts of money to fuel the growth of these companies? Is it because the Chinese have brought in foreign enterprises to transfer technology? Is it because Chinese manufacturers sell their products below cost? Is it because Chinese solar manufacturers can produce cells and modules of comparable quality for lower prices – because they're simply more competitive? Is it because Chinese producers predict huge domestic demand?

In the section that follows we'll explore each of those questions in turn.

2.1 How much has government support fueled industry development?

While it is, as discussed in *Section 1.3*, difficult to parse exactly which companies are receiving what kinds of subsidies from whom in China, it is clear that the Chinese government strongly supports the development of a world-leading solar manufacturing industry there. And to that end, China has indeed promoted an industrial policy with measures that include loans, tax credits, and grants. These are very much akin to the kinds of supportive policies that the government promotes in Japan and Germany. So it is difficult to say specifically how much of the growth of China's solar manufacturers is due to supportive government policies, but there is no doubt that government support has fueled the rapid development of the solar industry in China.

See *Section 1.3* for a more detailed analysis of government support in China and a comparison to U.S. policies.

2.2 Do Chinese manufacturers have a cost advantage?

Earlier we discussed the five principle reasons for general global price declines for solar cells and modules, including declining polysilicon prices, competition from thin film products, waning government incentives, increasing economies of scale and efficiency, and oversupply (see *Section 1.2.4*). Beyond those overall long-term global price declines, by most accounts China's leading solar cell and module manufacturers price their products lower than their competitors in other countries. But does that mean China's producers have a cost advantage?

Not necessarily. If Chinese manufacturers do not have a cost advantage, then selling solar cells and modules at much lower costs than U.S. manufacturers does look like dumping. If, on the other hand, Chinese manufacturers do have a cost advantage, then the question becomes: Is that advantage the result of illegal subsidies from the Chinese government? Or are there other factors that drive the cost advantage?

Estimates of the cost advantage of top tier Chinese cell and module manufacturers compared to their U.S. counterparts range from about 18 percent to 30 percent. According to GTM Research analyst Shyam Mehta, the cost differential between U.S. and Chinese manufacturers is about 25 to 30 percent in 2012. Rob Wanless, Director of Business Development, SOLON Corporation, said that the cost of solar panels from Chinese manufacturers is about $1 per watt, and $1.20-1.30 per watt from U.S. manufacturers. One executive at a Chinese module manufacturer suggested similarly, that China has about a cost advantage of about $0.20 per watt on modules and about $0.10 per watt on cells.

In a study that was publicized by many solar-related media outlets, analysts at the National Renewable Energy Laboratory (NREL) conducted an analysis of cost of solar cell and module production in China and in the U.S. All of the popular reports on the study argued that it demonstrates that Chinese solar manufacturers have a 5 percent cost disadvantage compared to U.S. manufacturers when the cost of shipping from China to the U.S. is included.[109]

But that was, in fact, not the conclusion of the study at all. The cost difference data was included in a section titled *The Case for Foreign Direct Investment*. In a presentation at the Stanford University Precourt Institute for Energy, Alan Goodrich, a solar PV cost analyst at NREL and one of the analysts who conducted the study, explained, "So we're considering in this case shipping finished modules from Shanghai to Los Angeles by boat and then by truck to Mesquite, Arizona, which is the site of Suntech's 300 MW solar farm. Versus making all the cells in China but making all the modules in Goodyear, Arizona, which is 20 miles away from the solar farm. It's about a $0.05 cost benefit for manufacturing the module in the U.S. So if we look at the core cost advantage of making the cells in China and making the modules in the U.S. versus making cells *and* modules in China and shipping them all we see that the China direct cost advantage is about 1-2 percent but the cost advantage including shipping is about -5 percent; there's a 5 percent cost disadvantage."

In other words, in this particular case it would make more sense for Suntech to manufacture cells in China, ship those cells to Goodyear, Arizona, assemble the cells into modules, and then drive the modules 20 miles down the road to the 300 MW power plant under construction. Which is, incidentally, exactly what Suntech does.

The cost advantage in this case depends on the module assembly facility being close to the end customer – in this case the 300 MW power plant under construction – and requires that the end customer have enough scale to justify locating near it. So the NREL analysis is not a blanket case for locating module assembly facilities in the U.S., rather it makes the case for locating module assembly facilities close to the end customer, when that customer's demand is "significant enough."

Watch Alan Goodrich's video presentation here.

So what the NREL analysis actually demonstrates is that when comparing the cost of manufacturing cells in China and assembling those cells into modules in China to manufacturing cells in China and assembling them into modules in the U.S., the manufacturers who make cells and assemble them into modules in China have about a 5 percent cost disadvantage when compared to the manufacturers (like Suntech, for example), that manufacture their cells in China and assemble modules in the U.S., close to the end user (Suntech's Arizona module assembly plant is 19 miles away from the 300 MW solar power plant at which the modules are being used).

The NREL analysis does say something about the cost competitiveness of China-based cell manufacturers versus U.S.-based cell manufacturers: China's have an 18-20 percent core cost advantage. But the NREL analysis doesn't say anything about the cost difference between a manufacturer like SolarWorld that makes its cells and assembles its modules in the U.S. and a manufacturer that manufactures and assembles in China. Nor, for that matter, does the NREL analysis say anything about the cost difference between a vertically-integrated U.S.-based manufacturer like SolarWorld and a company like Suntech that manufactures in China and assembles in the U.S.

[109] See, for example, CleanTechnica and the Coalition for American Solar Manufacturing

And if the changed scope of the countervailing and anti-dumping petition is any indication, it is Chinese solar cells that are the real culprit in the eyes of the petitioners – not modules. After all, tariffs will apply to modules made of Chinese cells, no matter where those modules are assembled. Yet the NREL analysis makes very clear that Chinese manufacturers do have a legitimate cost advantage in solar cell production.

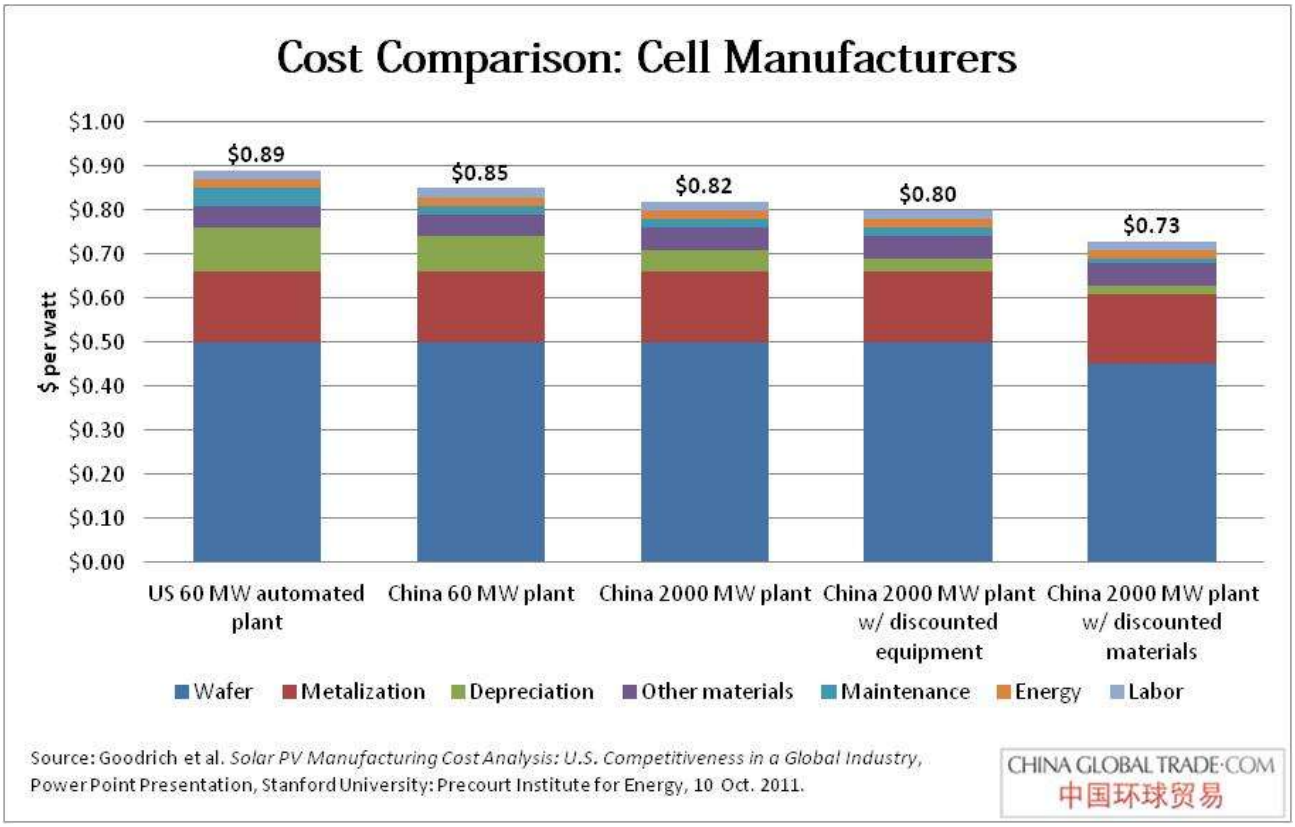
That advantage comes from three broad factors:

1. scale and vertical integration;
2. discounted equipment and materials, and to a lesser extent;
3. labor.

These three factors will be discussed in turn in the subsections below. It is worth mentioning here that while Chinese manufacturers clearly have a legitimate cost advantage, it is possible they came by that advantage as a result of government support (perhaps in violation of WTO or other international trade laws or obligations).

According to NREL, China's core cost advantage in cell manufacturing comes largely from manufacturer scale and vertical integration; the analysts compare a 60 MW plant in the U.S. to a 2,000 MW plant in China. That scale and integration gives China's manufacturers a 10 percent discount on all materials ("due to supplier leverage and captive production strategies") and a 50 percent discount on equipment from Chinese equipment vendors.

Figure 16: Cost Comparison: Cell Manufacturers



Comparing a 60 MW CSPV cell manufacturing plant in China to a 60 MW CSPV cell manufacturing plant in the U.S., China's core cost advantage is about 4.5 percent – and is due primarily to lower labor,

energy, and equipment costs. Adding the cost advantages that come from scale and vertical integration, discounted equipment, and discounted materials (all described in the subsections that follow), Chinese cell manufactures have about an 18-20 percent core cost advantage, not including shipping costs. Shipping costs for CSPV cells are relatively low – less than a penny in some cases, according to Goodrich. But shipping modules is relatively expensive – because of the heavy, bulky glass.

2.2.1 Scale

In the NREL analysis, accounting for scale – taking the 60 MW Chinese cell plant to a 2,000 MW facility – raises the Chinese cell manufacturer's cost advantage to 7.9 percent. According to NREL's Goodrich, "When you go to significant scale, say a 2 GW factory, you first get some economies of scale benefits just for having a large factory, but there are diminishing returns beyond about 250 MW."

As Rob Wanless, Director of Business Development, SOLON Corporation, points out, most of the facilities in China – especially those of the leading manufacturers – are far larger on average than facilities in the U.S. The typical top tier manufacturing plant in China produces about 500-1,000 MW a year on average, Wanless said, compared to 40-100 MW in the U.S. Estimates from Shyam Mehta, Senior Analyst at GTM Research, are similar: 500 MW on average in China compared to 30-50 MW in the U.S. Scale, according to Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, is one thing that China, as a "manufacturing powerhouse," does really well.

2.2.2 Vertical integration

In addition to scale ten or more times that of U.S. manufacturers, a number of the top tier Chinese manufacturers also benefit from vertical integration. Manufacturing both cells and modules, for example, adds to a manufacturer's economies of scale and allows for cost savings. Perhaps most importantly, owning their upstream suppliers and downstream buyers allows companies to capture margin at every stage (or, at least, more stages) of the value chain. Vertical integration, then, is what one analyst group called the "coveted brass ring of most manufacturers" and a critical competitive advantage in the "increasingly competitive international solar power market."[110]

Table 7: Areas of Production for Top Solar Manufacturers

	Polysilicon	Wafers/ Ingots	Cells	Modules	Systems
JA Solar (China)	x	x	x	x	In development
Trina Solar (China)		x	x	x	Part of strategic plan
Canadian Solar (China)		x	x	x	x
Suntech (China)		x	x	x	x
Yingli Green Energy (China)	x	x	x	x	
Hanwha SolarOne (China)	x	x	x	x	
First Solar* (US)	NA	NA	x	x	x
SolarWorld (US & Germany)	x	x	x	x	x
Q-Cells (Germany)			x	x	x
SunPower (US)		x	x	x	

**First Solar manufactures thin film solar products that do not use polysilicon or wafers in their production processes.*
Source: Alim Bayaliyev, et al. "China's Solar Policy: Subsidies, Manufacturing Overcapacity & Opportunities" Capstone Project, George Washington University, 2011.

[110] *Power & Energy*, "Vertical Integration, the path to success in a competitive market."

According to SolarWorld President Gordon Brinser, SolarWorld is verticalized in the U.S., but it's the only such company left. He said, "It makes no sense to us why you would manufacture a renewable energy product in another country and ship it all the way across the ocean just to install it here. What's worse yet is a lot of the raw inputs – equipment and polysilicon that goes into manufacturing these products – are shipped from the U.S. into China just to make the product and then ship it back again. From an environmental standpoint, the footprint is pretty atrocious what happens there…We are the only vertically integrated manufacturer in the U.S. that is still left today. The rest have gone out of business because of [China's] illegal aggression. We want to see the industry grow, we want to see vertical integration in the industry grow because that's how we maintain the environmental footprint and the cost to the product and so forth."

But according to Jigar Shah, President of the Coalition for Affordable Solar Energy, the reason why more U.S. solar manufacturers aren't verticalized – and why far more manufacturing is happening overseas – is because there's not a supportive ecosystem for solar manufacturing in the U.S. "Not all of the components necessary to make a solar module are made in the U.S." And that, he said, is the reason many solar companies don't manufacture in the U.S. – "the U.S. doesn't have an efficiently designed supply chain for solar."

One of China's significant advantages, according to Shah, is that "they make a lot of glass, they make silver aluminum paste, and a lot of chemicals – Dow and DuPont have huge facilities in China – so they have the supply chain of all these products in China. The one thing they didn't have was silicon. So even today the largest solar export from the U.S. is silicon. So China says, 'We're going to develop silicon manufacturers in China.' And they hired huge companies like Black & Veatch and others – Western companies that had built silicon manufacturing plants in the U.S. – to build them in China."

Beyond vertical integration, Chinese manufacturers (even non-integrated ones) also benefit from regional clusters of PV-related companies. The Suzhou-Wuxi-Changzhou Industrial Belt in Jiangsu Province, the Xingtai-Baoding Industrial Belt in Hebei Province, the Xinyu Industrial Belt in Jiangxi Province, the Leshan-Chengdu Industrial Belt in Sichuan Province, and the Shenzhen-Hong Kong Industrial Belt "have gathered many enterprises to form feature regional industrial clusters with mutual support." [111] Jiangsu Province, for example, is a leader in solar cells; Hebei Province in cell wafer and modules; Jiangxi Province in silicon wafers; and Sichuan Province in polycrystalline silicon.

2.2.3 Discounted equipment

In the NREL analysis, adding the advantage of discounted equipment that comes from the "massive" scale and vertical integration of China's manufacturers, takes the advantage to about 10 percent. According to Goodrich, "You get a benefit from having a more well-developed supply chain to support those huge factories; so in China you have Chinese companies that supply the equipment that only supply equipment to Chinese factories. In some cases the equipment in China is 30 percent the cost of equipment in the U.S; we've assumed a 50 percent discount."

2.2.4 Discounted materials

According to the NREL analysis, discounted materials bring the China-based cell manufacturer's core cost advantage over the U.S.-based cell manufacturer to 18 percent. Goodrich: "You get a volumetric

[111] China. China Renewable Energy Entrepreneurs Club Topology Research Institute. China Photovoltaics (PV) Report 2008-2009 (General Edition). Mar. 2012. Web. 2010.

purchase break of about 10 percent on all materials you buy – and considering the scale here, 10 percent is fairly conservative."

Shyam Mehta, Senior Analyst at GTM Research, agreed that NREL is probably too conservative on its estimates of the discounts Chinese manufacturers get for materials, including glass, aluminum frames, chemicals – as well as overhead costs (including utility costs) and labor, which are all much lower priced in China than in the U.S. The now bankrupt Evergreen Solar, for example, told Mehta that it cost them less to import a finished aluminum frame than to buy raw aluminum in the U.S. "That speaks to the importance of the supply chain and one source of Chinese manufacturer's significant cost advantage," Mehta said.

2.2.5 Labor

In the NREL analysis the analysts have assumed that the U.S. manufacturing facility is highly automated while the Chinese facility is more labor intensive. That washes out the labor cost differential, but labor costs are not a large percentage of total production costs anyway, and in fact many top tier Chinese manufacturers are increasing their levels of automation as well (in response to rising wage rates in China).

Even comparing to facilities with similar levels of automation, lower labor costs do not play a significant role in China's overall cost advantage. Most estimates put the percentage of total manufacturing costs accounted for labor at 5-10. "Making solar cells requires such expensive equipment and materials that labor contributes just a small fraction of the overall cost."[112] As U.S. Energy Secretary Steven Chu has noted, Suntech, the world's largest solar PV manufacturer (and a Chinese company), "is not succeeding because of cheap labor."

That said, labor costs are certainly lower in China than in the U.S., Germany, or Japan. The cost per hour of an unskilled laborer is 84 percent lower in China than in the U.S. But, because of relatively higher wages, solar cell and module facilities in the U.S. tend to be more highly automated. That increases capital expenditures but decreases labor costs. And, in fact, a number of top tier Chinese manufacturers are moving toward greater levels of automation as well, given the double digit increases in Chinese manufacturing wage rates.

2.3 What has been the role of foreign direct investment (FDI) and technology transfer?

The development of some industries in China – integrated circuits and automotives, for example – has been fueled at least in part by foreign invested enterprises. Intel's investment, for example, has helped fuel the growth of higher-value production on the semiconductor supply chain, including front-end fabrication and design.[113] GM has helped promote technical innovation along the automobile supply chain.[114]

The presence of foreign invested enterprises (FIEs) fuels development of China's own industry in a couple of ways, according to Nobel Laureate Ed Prescott:[115]

[112] Kevin Bullis, "The Chinese Solar Machine," *Technology Review* Jan./Feb. 2012: n. pag. Web. 2012.
[113] Falan Yinug, "Challenges to Foreign Investment in High-Tech Semiconductor Production in China," *Journal of International Commerce and Economics* May 2009. 1-30. Web. 2009.
[114] Glenn Leibowitz and Erik Roth, "Innovation in China's Automotive Market: An Interview with GM China's President,: *McKinsey Quarterly* Feb. 2012
[115] "Who the Heck Cares About Trade," ChinaGlobalTrade.com August 2009. Web. 2009.

1) FIEs give the less-developed trading nation (e.g., China relative to the U.S.) access to foreign know-how, which it can then adopt to become more productive across the industry
2) The presence of FIEs allows for more rapid diffusion of knowledge (than, say, learning in an educational setting or licensing technology) – and that is key to productivity growth

Sometimes, of course, technology transfer is forced, sometimes intellectual property is stolen, and sometimes the Chinese government mandates that foreign invested enterprises establish joint ventures with China firms. All of those magnify the effects of the natural technology transfer that Prescott talks about.

Can the same be said for the development of China's solar manufacturing industry?

2.3.1 FDI

While there has certainly been foreign direct investment (FDI) into China in the CSPV sector, that FDI has been more significant in upstream segments of the supply chain than in solar cell or module manufacturing. And it has been a relatively recent phenomenon. FDI in the *traditional* sense of foreign invested enterprises, technology transfer, and knowledge spillover, has not been a decisive factor in the development of China's CSPV cell and module manufacturing industry; it is a predominantly homegrown industry.

Table 8: FDI links of top Chinese PV manufacturers

Company	Date Founded	FDI Link
Suntech Power	2001	None
Yingli Green Energy	1998	None
Trina Solar	1997	None
JA Solar	2005	Australia
Canadian Solar	2001	Canada
Hanwha SolarOne	2004	None
LDK Solar	2005	None
Jiawei Solar China	1993	None
ReneSola	2005	None
Source: Company websites		

There are nine companies operating in China that were among the world's 15 largest solar cell or module producers in 2010. Of those nine, two had foreign direct investment. Canadian Solar was founded in 2001 and has seven wholly-owned manufacturing subsidiaries across China. JA Solar was founded in 2005 as a joint venture between the JingLong Industry and Commerce Group Co., Ltd., the Australia PV Science & Engineering Company, and the Australia Solar Development Company. Hanwha SolarOne, it is worth noting, is the result of the Korean Hanwha Group's 2010 acquisition of China's Solarfun Power, which was founded in 2004.

So, of the two companies that were founded as a wholly owned subsidiary of a foreign company or as a joint venture with a foreign company, JA Solar was a relatively late entrant to the Chinese PV industry, coming well after homegrown firms like Suntech, Yingli, Trina, and Jiawei Solar China. While Canadian Solar was founded in 2001, there is no indication that its manufacturing subsidiaries alone drove enough technology transfer to fuel the growth of China's solar industry.

In fact, more common than FDI in the solar industry is contract manufacturing. So instead of building and running a manufacturing facility in China (as Canadian Solar does), many manufacturers simply outsource their manufacturing to an OEM or contract manufacturer there (Jiawei, Hanwha, and ReneSolar are among the most prominent) – much like Apple outsources the production of iPads to Foxconn.

Still, there is the potential for technology transfer associated with contract manufacturing (the OEM learns how to make solar modules to Western specifications, then simply starts making them on its own, tacking on a heftier margin). But there is no indication this has happened significantly in the Chinese solar industry. Today, solar cells and modules are very nearly commodities (among the Tier 1 producers anyway) so the lowest-cost Tier 1 producer wins.

And while in some industries foreign enterprises fear joint ventures in China because they are forced to transfer technology to their JV partner – or intellectual property is stolen outright – that is not likely the case in the crystalline silicon photovoltaic manufacturing industry, which most analysts describe as well commoditized. Said Gordon Brinser, President of SolarWorld Industries America, "From the quality perspective, today we don't see a quality difference between a panel that we produce and a Chinese product coming in. It is an equivalent."

What's more, it's not clear that Western or Japanese CSPV manufacturers have technology that the Chinese need; a number of the top tier Chinese manufacturers are innovation leaders. As Shyam Mehta, Senior Analyst at GTM Research, explained, "China has made more progress than other PV manufacturers on innovation. So Chinese manufacturers don't want Japanese, German, or American crystalline silicon PV technology." (That's not to say, however, that Chinese manufacturers don't want to partner with research organizations or firms up the supply chain, see *Section 2.3.2.2*).

The same is not true for other types of solar cells and modules, including thin film. While First Solar agreed in 2009 to build a 2,000 MW solar power plant in Inner Mongolia, the company emphasized that the project would not entail technology transfer to China. "We have not done that to date with anybody. Our manufacturing processes are the crown jewels of our technological advantage."[116] First Solar manufactures much of its thin-film cells and modules in Malaysia.

2.3.2 Non-FDI technology transfer

So, foreign direct investment has not played a significant role in the development of China's solar manufacturing industry. Instead, China's solar manufacturers have been the beneficiaries of other types of technology transfer, including human capital from the Chinese diaspora and technology transfers from equipment manufacturers, through licensing, and by collaborating with solar PV research institutions around the world.

2.3.2.1 Technology transfer from equipment manufacturers

Manufacturing equipment can be a form of technology transfer when it can be plugged into production processes and used to improve productivity. Chinese firms have acquired a significant amount of technical know-how this way: by purchasing manufacturing equipment, turnkey production lines in particular, from equipment makers in Germany, Switzerland, and the U.S.[117]

[116] Peter Behr, "Clean Technology in China – a Difficult Balance Between Cooperation and Competition," *The New York Times* 17 Jan. 2011: n. pag. Web. 17 Jan. 2011.
[117] Arnaud de la Tour, Matthieu Glachant and Yann Ménière, "Innovation and International Technology Transfer: The Case of the Chinese Photovoltaic Industry," *Energy Policy* 39 (2011) 761-770.

This is possible, of course, because technological barriers to entry in manufacturing cells and modules are relatively low. "Unlike upstream segments [polysilicon production and wafer manufacturing], turnkey production lines can be bought and run without much prior experience in manufacturing cells."[118] Technology is transferred in this way in large part through training sessions for the engineers and technicians who will be operating the production line in China. As the Chinese firm becomes more comfortable with the technology, it can begin adapting its production chain to local conditions; substituting automation equipment with a less expensive workforce, for example.

The arrangement benefits equipment manufacturers, too, especially given the fact that China is now their largest single customer. Manufacturers there share their feedback with the equipment suppliers, who may incorporate it into their next product, and then share that know-how with all of their customers – "thereby accelerating the circulation of knowledge across the industry."[119]

As Chinese solar manufacturers continue to become more sophisticated, and more successful, they are looking to integrate more deeply with equipment suppliers. As Roger Efird, President and CEO of Suntech America explained during the U.S. International Trade Commission hearing, "We purchased a company in Germany several years ago that manufactures equipment used to automate factories."[120] Efird's comment goes to an important point: there is no indication that these top tier Chinese manufacturers are reverse engineering manufacturing commitment, or stealing process knowledge from equipment suppliers. They're buying it, and by every indication the German, American, and Swiss suppliers are happy to sell.

2.3.2.2 Technology transfer through licensing and research collaboration

The most obvious or explicit mode of technology transfer is through licensing. And there have been a few select cases of technology licensing between Chinese solar manufacturers and Western firms, where the Western company sells the codified technology and right to exploit it commercially to the Chinese firm. And even more prevalent than commercial licensing agreements are cross-border research and development collaborations.

One example is the three-way collaboration between Chinese PV manufacturer Yingli; the Energy Research Centre of the Netherlands (ECN), a leading solar research center in Europe; and Amtech, a global supplier of production and automation systems and related supplies for the manufacture of solar cells. In 2009, the three entered into a research collaboration on the N-type Metal Wrap Through PV cell and module technology, pioneered by ECN.

About the collaboration, Robert Kleiburg, Technology Director of ECN, commented, "We are very pleased to combine our MWT technology with Yingli's years of experience to commercialize cutting edge technologies. This cooperation is in line with our long-term mission: transfer high-level knowledge and technology to the market."[121]

Licensing agreements and research collaborations are an effective means for manufacturers of CSPV products to infuse innovation into their products. And that's important because while many observers call CSPV cells and modules a "commodity" – and it is indeed true that at set standards of cell efficiency, quality is fairly uniform among the top tier suppliers – there are nevertheless tremendous gains to be

[118] Arnaud de la Tour, Matthieu Glachant and Yann Ménière, "Innovation and International Technology Transfer: The Case of the Chinese Photovoltaic Industry," *Energy Policy* 39 (2011) 761-770.
[119] *ibid*
[120] Roger Efird, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.
[121] Yingli Solar Press Release, "Yingli Green Energy, ECN and Amtech Join Efforts to Develop N-type MWT High Efficiency PV Cell and Module," 7 Sep 2011.

realized from increasing the efficiency of PV cells. And that requires significant R&D effort. To that end, Varian Semiconductor is partnering with Chinese PV firms to utilize its ion-implantation technology and increase cell efficiencies.[122]

China looks to be following a similar path into polysilicon production – a part of the solar supply chain still dominated by firms in the U.S. and Germany, and characterized by higher technological barriers to entry. So how has China begun to develop its domestic polysilicon industry? "They hired Western companies with experience and expertise in building polysilicon manufacturing plants in the U.S.," explained Jigar Shah, President of the Coalition for Affordable Solar Energy. "They didn't steal [the know-how]. They hired it."

Understanding how the presence of foreign invested enterprises benefits domestic producers actually sheds light on why China welcomes – even seeks out – foreign direct investment in some industries (like semiconductors) and not in others (like CSPV solar manufacturing). As one semiconductor industry leader put it, China is still far behind the United States when it comes to cutting-edge semiconductor manufacturing – and that's not technology that can be developed by purchasing the manufacturing equipment. In other words, if China wants to develop its semiconductor industry, it needs the likes of Intel.

With solar cell and module manufacturing, on the other hand, it is possible to learn the processes by working or studying in the West, purchase the manufacturing equipment, perhaps license some technology, and then produce cells and modules that are of like-quality as those produced elsewhere. That is how China's solar manufacturers got their start. From there, of course, they were able to grow and innovate on their own, and in many cases are now industry leaders on quality and innovation.

So, in other words, China's reception of foreign direct investment depends on whether it needs foreign invested enterprises to spur industry growth, or whether it can home grow its own industry – in any or all of the ways described in this section.

2.3.2.3 Know-how from the Chinese diaspora

Technology transfer through both equipment manufacturers as well as licensing and global partnerships is made possible in large part by the presence of the people with the knowledge to put equipment training and licenses into production. "A major part of the technology concerns the operation of manufacturing processes, which mainly consists of know-how. In this context, the manufacturing experience of skilled employees is a key asset."[123] In addition, these board members, founders, and executives also bring with them access to professional networks that make striking technology licensing deals and forming research collaborations easier.

The founder of Suntech, for example, had been a research director of an Australian PV company, and before that, a senior research scientist at the Thin Film Solar Cells Research Group in the Centre of Excellence for Photovoltaic Engineering at the University of New South Wales in Australia. Four of the six members of the Suntech Board studied or worked in the U.S. or the UK. At Trina Solar, half of the 12-person management team have studied or worked abroad. The CEO of Yingli has studied abroad and the company's Chief Technology Officer had worked at the Photovoltaics Centre of Excellence at the

[122] "US-China Quarterly Market Review," American Council on Renewable Energy and Chinese Renewable Energy Industries Association. 2012. Web. 2012.
[123] Arnaud de la Tour, Matthieu Glachant and Yann Ménière, "Innovation and International Technology Transfer: The Case of the Chinese Photovoltaic Industry," *Energy Policy* 39 (2011) 761-770.

University of New South Wales. On average, 61 percent of the board members of the three largest Chinese PV firms have studied or worked abroad.[124]

Furthermore, the existence of the Chinese diaspora around the world fuels continued connectivity and collaboration between Chinese running solar companies in China and those working at companies or studying in other countries – and that connectivity and collaboration fuels innovation. A 2011 cover story in *The Economist*, "The magic of diasporas," highlighted research by the Kauffman Foundation that showed 81 percent of entrepreneurs returning to China maintain at least monthly contact with family and friends in America, and 55 percent are in contact at least that often with former colleagues. What do they talk about? Customers, markets, technical information, and business funding.[125]

2.4 The role of trade credits

Another advantage that China's manufacturers have is the ability to provide what Jigar Shah, President of the Coalition for Affordable Solar Energy, calls "trade credits" – more often referred to as vendor financing. Instead of requiring payment from customers before shipping the solar cells or modules, a number of top tier Chinese manufacturers offer 60-day payment windows.

The petitioners in the trade case also suggested that Chinese manufacturers offer longer-term financing for utility scale projects (provided their products are used, of course), but the respondents – including Suntech, Yingli, Canadian Solar, and Trina Solar – all told the U.S. International Trade Commission that they have never provided that kind of longer term vendor financing.

Nevertheless, even a 60-day payment window can be a tremendous benefit to solar customers – one that could easily tip the scales in favor of the Chinese manufacturer. "When you sell a system you do a solar lease or a solar power purchase agreement, so the customer is only paying for the power that gets generated once it starts being generated," Shah explained. Covering the gap between the time construction expenses are incurred and electricity is actually being generated can be difficult. "One way to do it is to take out a home equity loan on your house, that's how I started my company [SunEdison]. Some people have working capital loans. And others have trade credits. The Chinese are really good at providing trade credits."

But what Shah called a fair competitive differentiator, Kevin Kilkelly, President and Sales Manager at SolarWorld Industries America, LLC, called predatory. Speaking to the U.S. International Trade Commission, Kilkelly said, "[Vendor financing] is becoming increasingly more and more of a value proposition within the last five months. This is predatory in nature. [The Chinese manufacturers'] cost of capital, no one in the world can touch. No single company can acquire that risk capital at those interest rates, or zero interest rates."[126]

According to Shah, one of the perhaps unintended consequences of the trade case against Chinese solar manufacturers is that it is now far more difficult for U.S. solar installers to bridge the gap between when they have to pay for the modules (upfront) and when they get paid (once the electricity starts flowing). "One of the biggest problems that we've had in the last four months in the U.S. is that solar installers, because of the trade case, have had to consider [non-Chinese] solar manufacturers, and those other solar manufacturers aren't as generous with providing trade credit. So if I bought a container of modules from SolarWorld, they would say: 'You have to pay me before I'll ship.' Whereas Suntech might have said:

[124] Arnaud de la Tour, Matthieu Glachant and Yann Ménière, "Innovation and International Technology Transfer: The Case of the Chinese Photovoltaic Industry," *Energy Policy* 39 (2011) 761-770.
[125] *The Economist*, "The magic of diasporas," 19 November 2011.
[126] Kevin Kilkelly, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.

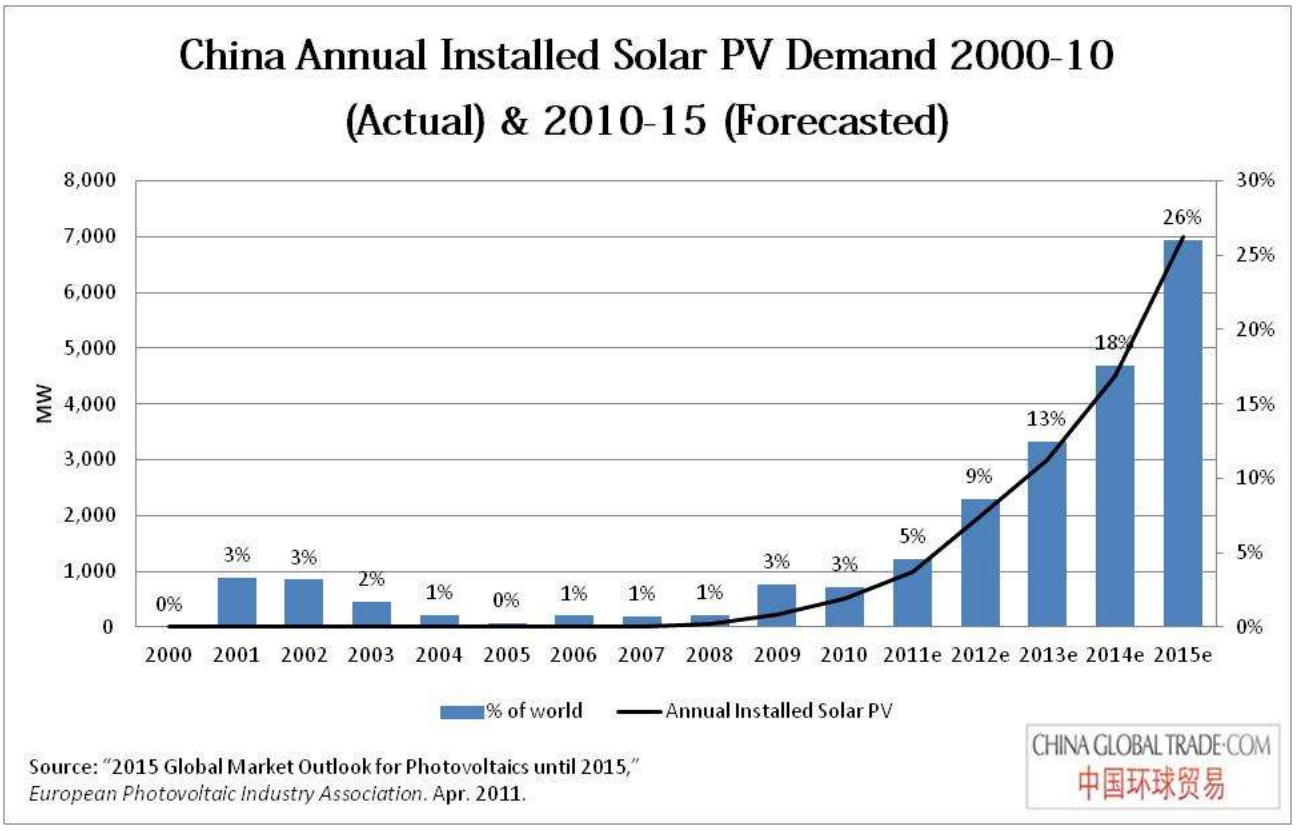
'You can pay me 60 days after you receive the panels.' So that's a big problem for installers; they don't know how to finance the gap."

2.5 The role of Chinese domestic demand

In *Section 1.2.2* above we considered global demand for CSPV solar systems. Clearly, subsidies in Germany, Spain, Italy, the United States, and Japan – which are designed to make solar power cost-competitive with traditional power sources – had a huge role in spurring the growth of the solar manufacturing industry. And, accordingly, reductions in subsidies in some of those countries had a huge role in spurring the recent "shakeout" among solar manufacturers.

We also noted in *Section 1.2.2* above that China has not to date been a very large market for solar power installations. But that is clearly changing. In this section we outline the policies China has enacted to drive solar power adoption there, and we consider how that might be affecting the production capacity decisions of Chinese manufacturers.

Figure 17: China Annual Installed Solar PV Demand 2000-10 (Actual) and 2010-15 (Forecasted)



In 2010 China's annual installations of CSPV solar was just 3 percent of the world total. But by the end of 2013 analysts expect China's share to have grown to 21 percent. That growth is driven most fundamentally by huge increases in demand for electricity, which rises 15 percent per year in China. "To meet demand in the coming decade, China will have to add *nine times as much* capacity as the United

States will during the same period."[127] But China's move away from coal toward renewable energy sources, including solar, to meet that electricity demand is driven by a number of recently implemented policies.

2.5.1 Demand subsidy policies

The two most significant drivers of domestic demand for solar power in China are feed-in-tariffs, at both the regional and the national levels, and the national Golden Sun program.

Feed-in tariffs (FITs): In 2006, China's Renewable Energy Law provided for a feed-in-tariff price, determined according to the principle of "cost plus reasonable profits," to be applied to electricity generated by on-grid PV systems. When the market cost of solar power is higher than the market cost of other forms of electricity generation (as it still is in most places), a feed-in-tariff or other subsidy is critical; otherwise, there will be no incentive for private developers to front the cost of building the power plant. "A feed-in tariff typically guarantees generators of renewable electricity a long-term purchase price for each kilowatt-hour they produce and 'feed into' the grid, providing a powerful incentive for installing such systems."[128]

The national feed-in-tariff was initially put on hold "indefinitely" because the cost of generating solar power was deemed still too high. But in August 2011 the Chinese government announced that it would reinstate the national PV FIT. In addition, several provinces, including Zhejiang, Shandong, and Jiangsu, have already introduced their own FITs.[129]

Golden Sun: The Golden Sun program, launched in 2009, provides subsidies to cover 50-70 percent of the costs of qualifying utility-scale solar projects, plus related grid connection and transmission costs. The program was originally intended to subsidize the development of 500 MW of solar capacity. But it will now be extended beyond its original 2012 end date and include subsidies for another 1,000 MW of solar plants.

12th Five Year Plan targets: The National Development & Reform Commission (NDRC) sets targets for solar power generation just as it does for almost everything else deemed "strategic" in China. The Five Year Plan set an official minimum installed capacity target of 5 GW by 2015 and 20-30 GW by 2020. Those targets have reportedly risen to 10 GW by 2015 and 50 GW by 2020.[130] At least some of that capacity will be installed in large-scale power plants in the Chinese desert.

Township Electrification Program: Launched in 2002, this program aimed to make electricity available in rural areas of China that had not been, and were not easily connected to the power grid. By the end of 2005, 721 wind-solar PV power stations had been completed in West China, providing electricity to 1.3 million people.

2.5.2 Are Chinese manufacturers gearing up to meet domestic demand?

To put China's installed capacity targets in perspective, consider that total installed capacity for the whole world was just under 40 GW in 2010. China is planning to have that much capacity on its own within the

[127] Larry Karp and Megan Stevenson."Green Industrial Policy: Trade and Theory," *Green Growth Knowledge*, 3 Jan. 2012. Web. 2012.
[128] "Eco-Economy Indicators – Solar Power." *Earth Policy Institute*. 27 Oct. 2011. Web. 27 Oct.2011.
[129] "2015 Global Market Outlook for Photovoltaics until 2015," *European Photovoltaic Industry Association*. Apr. 2011. Web. Apr. 2011.
[130] "Eco-Economy Indicators – Solar Power." Earth Policy Institute. 27 Oct. 2011. Web. 27 Oct.2011.

decade. Even given current oversupply of cells and modules, Chinese manufacturers will have to continue producing at very high levels to meet targeted domestic demand there.

According to Thomas Young, Senior Director of Investor Relations at Trina Solar Limited, speaking to the U.S. International Trade Commission, "We believe [China's aggregate installed solar capacity] will absorb an increasingly significant proportion of China's effective manufacturing capacity. Solarbuzz, a recognized solar industry marketing research and consulting firm, currently estimates the backlog of domestic projects at 16 GW. Indeed, both Trina Solar and its global public shareholders and analysts anticipate the China market will play an increasing role in the sector going forward."[131]

[131] Thomas Young, address, USITC Hearing, USITC, Washington, 8 Nov. 2011.

3 What might be the consequences – for all the stakeholders – if the Department of Commerce imposes significant tariffs on Chinese solar PV cells and modules?

3.1 How might China react?

It is important to consider China's reaction to the trade case in three different ways:

1. First, how China reacted to the filing of the trade case and the U.S. International Trade Commission's finding of injury;
2. Second, it's important to consider China's reaction to what analysts agree were smaller-than-expected preliminary countervailing duties; and
3. Finally, we must consider how China might react is the anti-dumping duties are significant and/or if the final countervailing duties are larger.

Not at all unsurprisingly, Chinese solar manufacturers reacted to the filing of SolarWorld's petitions by calling the move protectionist, and then accusing the U.S. government of its own illegal subsidies. Suntech, the world's largest solar panel maker, stated:"a misguided solar trade conflict against China…could threaten the livelihood of the global solar ecosystem, particularly solar jobs in the U.S."[132]

And two Chinese trade groups asked the China Ministry of Commerce (MOC) to start an investigation against U.S. into dumping and illegal subsidies.[133] The Ministry of Commerce agreed to start an investigation into the U.S. government's policy support and subsidies for its renewable energy sector over trade barrier concerns…The MOC will look into six renewable energy programs concerning wind, solar and hydroelectric energy in the states of Washington, Massachusetts, Ohio, New Jersey and California.[134]

But these are mostly face-saving measures that are not at all surprising and likely won't have any measurable practical impact on the solar industry. And the reaction to the preliminary countervailing duties, which ranged between 2.90 and 4.73 percent, was relatively mild. Predictable statements about the tariffs being misguided were issued, but most Chinese manufacturers breathed a sigh of relief, and then went on about business as usual (see *Section 1.1*).

How Chinese manufacturers react to significant duties, on the other hand, could have very real ramifications for the global solar industry.

3.1.1 China could stop its dumping and illegal subsidies

If Chinese manufacturers are found to have dumped their products on global markets, one potential outcome of the trade case is that China could remove its (relatively modest) subsidies and stop dumping. And there is precedent for that kind of outcome. In October 2010 the U.S. Trade Representative (USTR) launched an investigation into export restraints, subsidies, and discrimination against foreign companies

[132] Michele Nash-Hoff, "Viewpoint: What's Really Happening to America's Solar Industry?" *Industry Week*, 22 Feb. 2012. Web. Apr. 2012.
[133] Alim Bayaliyev, et al. "China's Solar Policy: Subsidies, Manufacturing Overcapacity & Opportunities" Capstone Project, George Washington University, 2011.
[134] "China Starts Investigation into U.S. Support for Renewable Energy Sector," *Xinhua* 11 Nov. 2011; n. pag. Web. 11 Nov. 2011.

and imported goods by China in green technologies. The pressure from the petition led to China removing local content requirements for wind technology.[135]

3.1.2 Chinese manufacturers could retaliate

There are a number of ways in which Chinese manufacturers could retaliate against imposed tariffs. That, in fact, is the principle reason why only three of the seven companies behind the petition have named themselves publicly (and two of those only after the preliminary countervailing duties were announced).

- The U.S. is still an important supplier of polysilicon, as well as CSPV manufacturing equipment. But Chinese manufacturers could ramp up their own production of polysilicon (which they have already begun doing) and turn to Germany and Switzerland to fill the equipment gap – effectively cutting out the U.S. firms that are still competitive in the solar supply chain. "It would be a travesty for the solar industry," said Tom Zarrella, a former chief executive of GT Solar, a New Hampshire supplier of solar manufacturing equipment.
- According to Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, "Retaliation can also spread beyond the actual petitioners to harm the U.S. economy more broadly." China could block market access for U.S.-based firms in other cleantech industries.

3.1.3 Chinese solar manufacturers could ramp up production in the U.S.

This has been called by some experts a "once-in-a-generation" case, akin to the 1970s and 1980s trade cases against Japanese automakers.[136] Those trade cases pushed Japanese auto makers to build their factories in the U.S. Chinese solar manufacturer Canadian Solar already said that would be one possible response to countervailing duties and anti-dumping duties in this case too.[137]

There is a case to be made for locating at least module assembly facilities in or very close to the end market. And many Chinese cell and module manufacturers have or plan to do just that. Suntech in Arizona is just one example. According to analysis by the Peterson Institute, the three most important solar PV markets in terms of annual added installation capacity (Spain, Germany, and the U.S.) were also the leading destinations for cross-border greenfield investment in manufacturing facilities between 2003 and 2007.[138]

But while that may be a growing trend driven by economic rationale (when low cost is paramount, cutting transportation costs by locating in or near the end market makes sense), it would not be a way for Chinese manufacturers to circumvent tariffs. The trade case applies to Chinese-made cells as well as modules comprised of Chinese-made cells, no matter where those modules are assembled (see *Section 1.1*).

So to avoid the tariffs, Chinese manufacturers would have to locate not just module assembly plants but cell production facilities in the United States as well. The trade case "will only accelerate the setting up of solar module and solar cell manufacturing in the United States," said the president of Grape Solar, a company based in Eugene, Ore., that is a big importer of solar panels from China, Korea and Taiwan, as

[135] Alim Bayaliyev, et al. "China's Solar Policy: Subsidies, Manufacturing Overcapacity & Opportunities" Capstone Project, George Washington University, 2011.
[136] Keith Bradsher, "Trade War in Solar Takes Shape," *The New York Times* 11 Nov. 2011: B1. and Keith Bradsher, "Chinese Trade Case Has Clear Targets, Not Obvious Goals," *The New York Times* 20 Oct. 2011: B3.
[137] "Canadian Solar Could Shift Production if US Tariffs Imposed," *Environmental Finance*, 23 Feb. 2012: n. pag. Web. 23 Feb. 2012.
[138] Jacob Funk Kirkegaard, et al., "Toward a Sunny Future? Global Integration in the Solar PV Industry," *Working Paper*, May (2010): 1-66.

quoted in the *New York Times*. "Grape Solar has already been in discussions with big Chinese panel makers on ways to move more manufacturing to the United States.[139]

If the trade case causes Chinese solar manufacturers to set up shop in the U.S., that's not an outcome that would bother SolarWorld President Gordon Brinser. "If a company wants to set up manufacturing in the U.S., we welcome that. This is about growing an industry in the U.S. that brings jobs, brings innovation, brings supply chain, brings installation; it brings a lot to the communities."

But to achieve the kind of scale and vertical integration that allow them to keep costs low, Chinese manufacturers would have to invest huge sums of money in the United States – to essentially recreate the Chinese solar supply chain here. It's not clear that the United States is a large enough market – not yet at least – to warrant that kind of capital investment.

3.1.4 Chinese firms could move manufacturing to Taiwan

While manufacturing cells and modules in the U.S. is certainly one potential outcome of significant subsidies against Chinese producers, they could also shift manufacturing to other countries. According to Shyam Mehta, Senior Analyst at GTM Research, Chinese firms could manufacture the components in Taiwan, or buy Taiwanese components, assemble the panels in Mexico, then sell them into the U.S. That keeps module assembly close to the end market, avoids tariffs on modules made of Chinese cells, and allows Chinese producers to maintain significant cost advantage over manufacturing in the U.S.

Moving production elsewhere is a step Chinese manufacturers are already gearing up to take, according to one executive at a Chinese solar module manufacturer. "A lot of companies are already doing that. They're going to Malaysia, Taiwan, Mexico to see if they can outsource to companies there to ship into the U.S." She said that for her company, "the U.S. remains a very important market, it just opened."

In fact, if manufacturing cells in Taiwan would allow Chinese manufacturers to keep their upstream supply chains intact, that could be their best solution. They could then assemble the modules anywhere in the world – in Taiwan, in China, in Mexico, in the end-use country. And if manufacturing and assembling outside the U.S. allows Chinese manufacturers to keep costs down and avoid U.S. tariffs, we might see that happen. There is far greater indication that this will be the route Chinese producers take – if they move production anywhere – rather than move cell manufacturing into the U.S.

According to Jigar Shah, President of the Coalition for Affordable Solar Energy, "If the U.S. makes the mistake of levying high tariffs against Chinese products, the U.S. is going to import solar modules from India, Malaysia, and Taiwan. They're not going to manufacture in the U.S. If the Chinese lose this case, we're not going to get the panels from the U.S.; we're going to get them from other countries that have an industrial policy. So we're going to sacrifice our downstream jobs in the U.S.; we're going to shift jobs in manufacturing from China to Taiwan. Why exactly are we doing this? I get that people hate China right now, but it seems like a foolish thing to do."

3.1.5 Chinese manufacturers could do nothing

If Chinese manufacturers are benefiting significantly from illegal subsidies (greater than the preliminary countervailing determination found), and/or are dumping their products on world markets, those behaviors may be the only thing keeping them afloat, so cutting the subsidies or dumping might in that case be akin to throwing in the towel. Moving production – either to the U.S., to Taiwan, or elsewhere –

[139] Keith Bradsher, "Chinese Trade Case Has Clear Targets, Not Obvious Goals," *New York Times* 20 October 2011: B3.

would also involve significant cost, in particular abandoning their fixed assets in China and reconstructing them elsewhere.

In other words, changing their current modus operandi would come with significant cost, and so would require tariffs that are even higher than that cost. Certainly the preliminary countervailing duties of between 2.90 and 4.73 percent don't qualify. Shyam Mehta, Senior Analyst at GTM Research, said that even if the U.S. imposed tariffs as high as 15 percent, if the Chinese cost advantage is 30 percent, then it may still be to Chinese manufacturers' advantage to keep doing what they have been. "If the tariffs are small," said Jigar Shah, President of the Coalition for Affordable Solar Energy, "like the preliminary countervailing duties, then the Chinese will just suck it up and pay the duties and keep moving on. But if they're punitive, the Chinese companies will move their supply chains to India or Malaysia or Taiwan."

3.2 The net economic effects of tariffs

If China does that – in fact, no matter what China does – the imposition of tariffs will affect the U.S. solar industry as well. As there always are, if the U.S. imposed significant (what some call "punitive") countervailing and anti-dumping duties, there would be winners and losers. We explore potential gains and losses in the sub-sections that follow.

3.2.1 Effect on sellers, distributors, and installers of solar PV in the U.S.

Somewhere around 100,000 Americans are employed in the solar industry in the U.S. About 24,000 are in manufacturing – including manufacturers of equipment and polysilicon producers. About 50 percent work in installation, construction, and engineering; another 18 percent in sales and distribution. Of the 24,000 people who work in solar manufacturing in the U.S., just about 5,000 manufacture cells or modules that compete with those made in China (and are the subject of the trade case).

In an op-ed in the *Wall Street Journal*, Andrew Beebe, Chief Commercial Officer at Suntech, wrote that the fact that 95 percent of U.S. solar-related jobs are outside of cell or module manufacturing, is the reason why "many large and small U.S. solar industry leaders – including AES Solar, Dow Corning, Grape Solar, GroSolar, GT Advanced Technologies, MEMC/SunEdison, REC Silicon, Rosendin Electric, SolarCity, Swinerton and Verengo Solar – have banded together in the Coalition for Affordable Solar Energy to oppose tariffs and defend free trade. They not only represent American consumers; they represent thousands of American manufacturing jobs and 95% of all American solar-industry jobs."[140]

Table 9: Domestic Solar Industry Jobs by Employment Sector, 2011

Sector	Number of jobs	Percent of all solar industry jobs
Manufacturing	24,064	24%
Sales and distribution	17,722	18%
Installation	52,503	52%
Other	5,948	6%
Total	**100,237**	

Source: National Solar Jobs Census 2011

Punitive tariffs against Chinese cell imports could affect solar PV sellers, distributors, and installers in the U.S. – and the 76,000 Americans they employ – in a number of ways. Most significantly, low-cost cell and module imports from China have dramatically reduced total PV system cost. And low total system

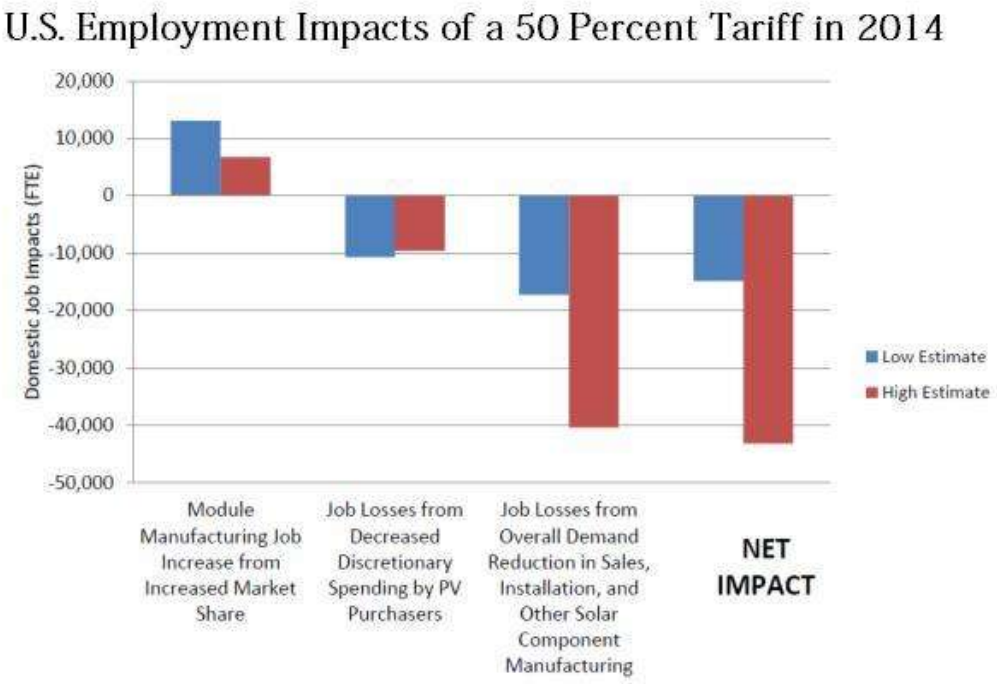
[140] Andrew Beebe "Inside a U.S.-China Solar Trade War," *The Wall Street Journal* 28 Mar. 2012: n. pag. Web. 28 Mar. 2012.

cost is critical to the growth of the solar industry given that solar power is still not, in many cases, cost competitive with traditional power sources. So if the imposition of tariffs causes costs to increase, that could cause demand for solar products to decline – and an associated reduction in American jobs in areas like installation, construction, engineering, sales, and distribution.

The Coalition for Affordable Solar Energy (CASE) – the group that opposes SolarWorld's petition – commissioned a study from The Battle Group on how tariffs might affect U.S. jobs. In the report, The Battle Group analyzed the effects of a 50 percent and a 100 tariff on Chinese-manufactured crystalline photovoltaic cells and modules. Clearly, those are tariffs dramatically larger than the preliminary countervailing duties assessed by the Department of Commerce in March, but they are in line with the amount of alleged dumping margins: 49.88 to 249.96 percent. The report found: [141]

- A tariff of 50 percent will result in between 14,877 and 43,178 fewer jobs in 2014, even accounting for the increase in jobs among cell and module manufacturers in the U.S.
- A tariff of 100 percent will result in between 16,917 and 49,589 fewer jobs in 2014, again accounting for the increase in jobs among cell and module manufacturers in the U.S.
- U.S. producers who are struggling now to compete with Chinese prices, would gain (the tariffs would put them on a more even playing field), but consumers would lose more than producers would gain, resulting in a net revenue loss of between $621 million and $2.6 billion

Figure 18: U.S. Employment Impacts of a 50 Percent Tariff in 2014



Source: Mark Berkman, Lisa Cameron and Judy Chang. The Employment Impacts of Proposed Tariffs on Chinese Manufactured Photovoltaic Cells and Modules (Washington: The Brattle Group, 2012) 1-26.

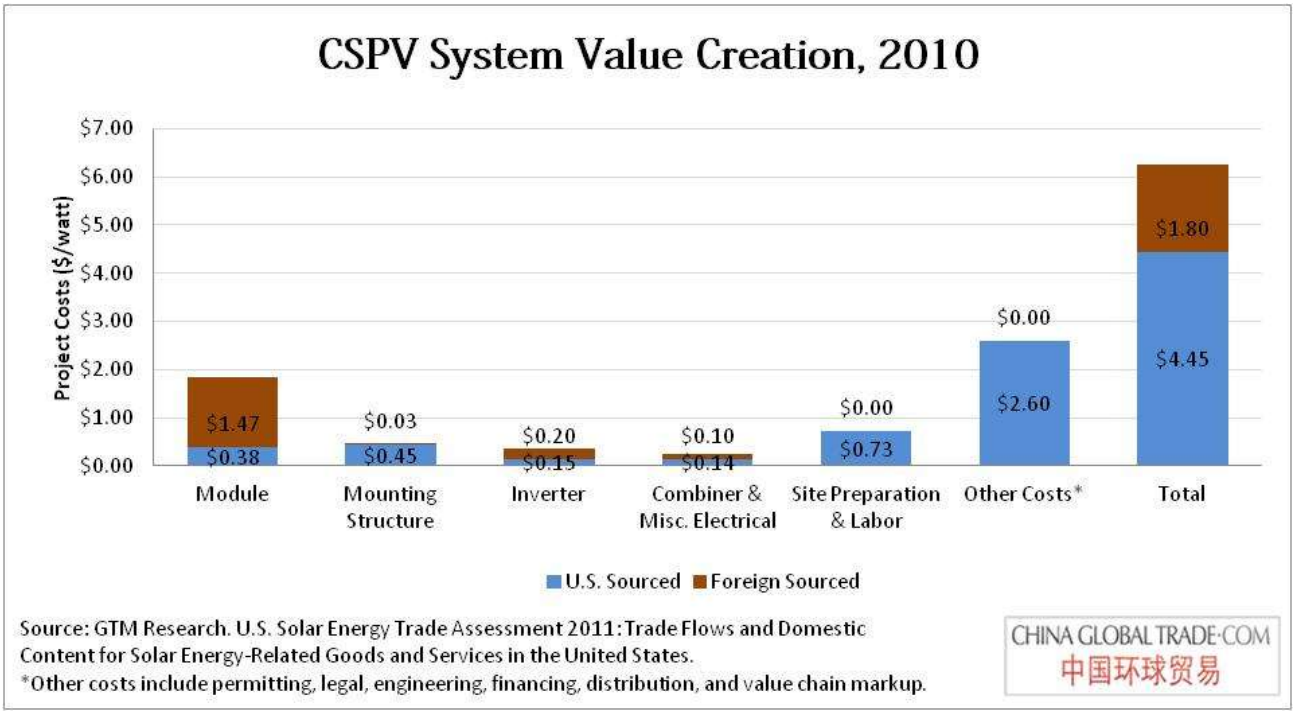
[141] Mark Berkman, Lisa Cameron and Judy Chang. *The Employment Impacts of Proposed Tariffs on Chinese Manufactured Photovoltaic Cells and Modules* (Washington: The Brattle Group, 2012) 1-26.

In response to The Brattle Group report, the Coalition for American Solar Manufacturing issued this statement: "Two years ago, the resellers of Chinese tires put out a very similar study, claiming that for every U.S. manufacturing job saved by the Section 421 trade action then being investigated, anywhere between 12 and 25 jobs at tire retailers would be lost. This never happened. There is no reason to believe that CASE's study on behalf of dumped subsidized Chinese imports will prove to be any more accurate."[142]

While it is true that there was no mass exodus from the U.S. tire industry after tariffs of 35 percent were imposed, it is also true that tire manufacturing employment continued its steady decline – falling 6 percent from 2009 (pre-tariff) to 2011, according to analysis by the US-China Business Council.[143] Furthermore, it is important to note that the tariffs imposed on imports of Chinese tires didn't bring those lost tire manufacturing jobs back to the U.S. – imports simply shifted to other countries.

In addition to employing more people, those activities outside of cell and module manufacturing create more value for the U.S. economy as well. According to GTM Research, 71 percent of total CSPV system value in 2010 was created domestically.[144] Domestic value creation is particularly high in mounting structures, site preparation, labor, soft costs, and value chain markup for the module distributor and system installer. It is these activities that stand to lose the most if tariffs raise the price of solar panels in the U.S.

Figure 19: CSPV System Value Creation, 2010



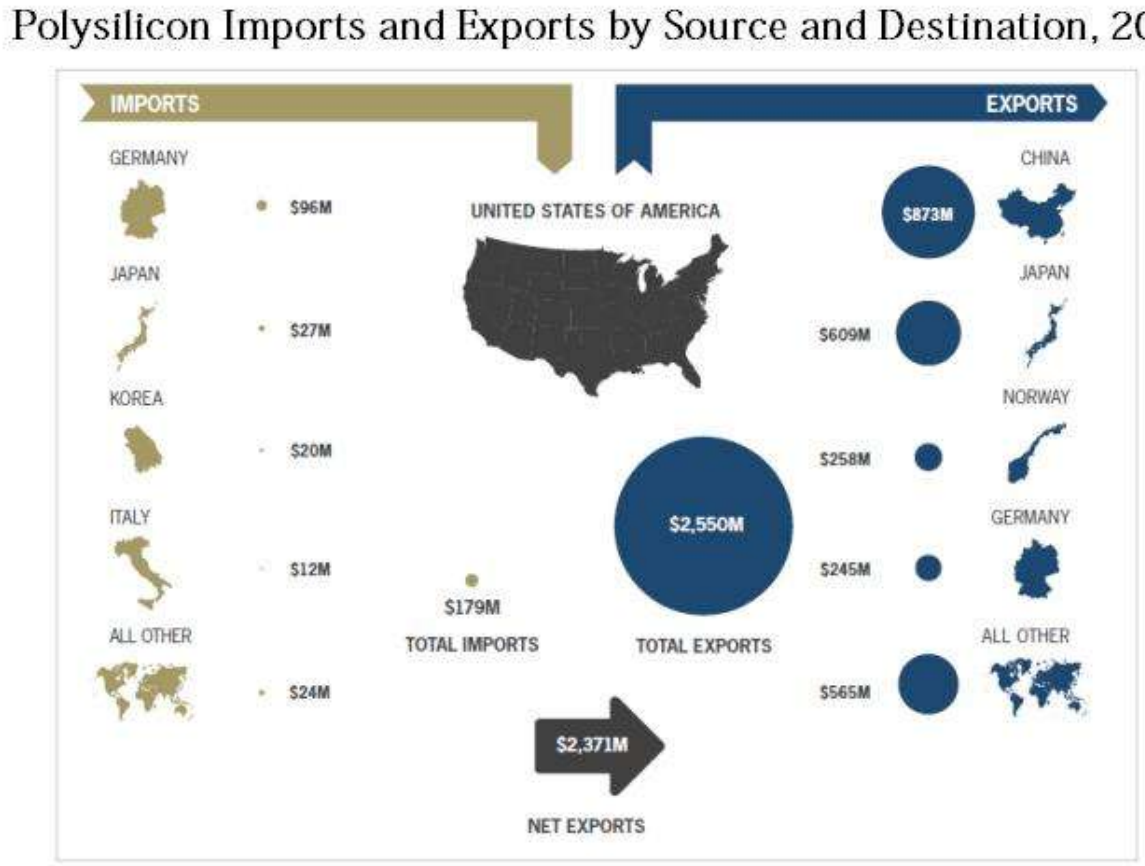
[142] "CASM Statement Response to New CASE Economic Report," *Coalition for American Solar Manufacturing*. Press release, 30 Jan. 2011.
[143] US-China Business Council, "Issues Brief: Tariffs on Chinese Tires Two Years Later – Right or Wrong Remedy?" Sep 2011.
[144] GTM. U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States. Washington: GTM, 2011. Web. 2012.

3.2.2 Effect on U.S.-based polysilicon producers

The U.S. produces about 25 percent of the world's polysilicon – a key photovoltaic material and the first step in the CSPV value chain.[145] In 2010, U.S. net exports (exports less imports) of polysilicon to the world was almost $2.4 billion, up 125 percent from 2009, and $869 million to China alone. In 2011, net exports of polysilicon to the world was just under $2.3 billion, $673 million to China alone.

Clearly, polysilicon is a key industry within which the U.S. has a comparative advantage. That's why Rob Wanless, Director of Business Development at SOLON Corporation, said that he's particularly nervous about China retaliating and imposing tariffs on polysilicon imports from the U.S. In The Battle Group Report, the analysts found that if China stopped importing polysilicon from the U.S., it would result in the loss of nearly 11,000 jobs.[146]

Figure 20: Polysilicon Imports and Exports by Source and Destination, 2010



Source: GTM. U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States.

[145] GTM. *U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States.* Washington: GTM, 2011. Web. 2012.
[146] Mark Berkman, Lisa Cameron and Judy Chang. *The Employment Impacts of Proposed Tariffs on Chinese Manufactured Photovoltaic Cells and Modules* (Washington: The Brattle Group, 2012) 1-26.

Figure 21: U.S. Net Exports to China 2010-11

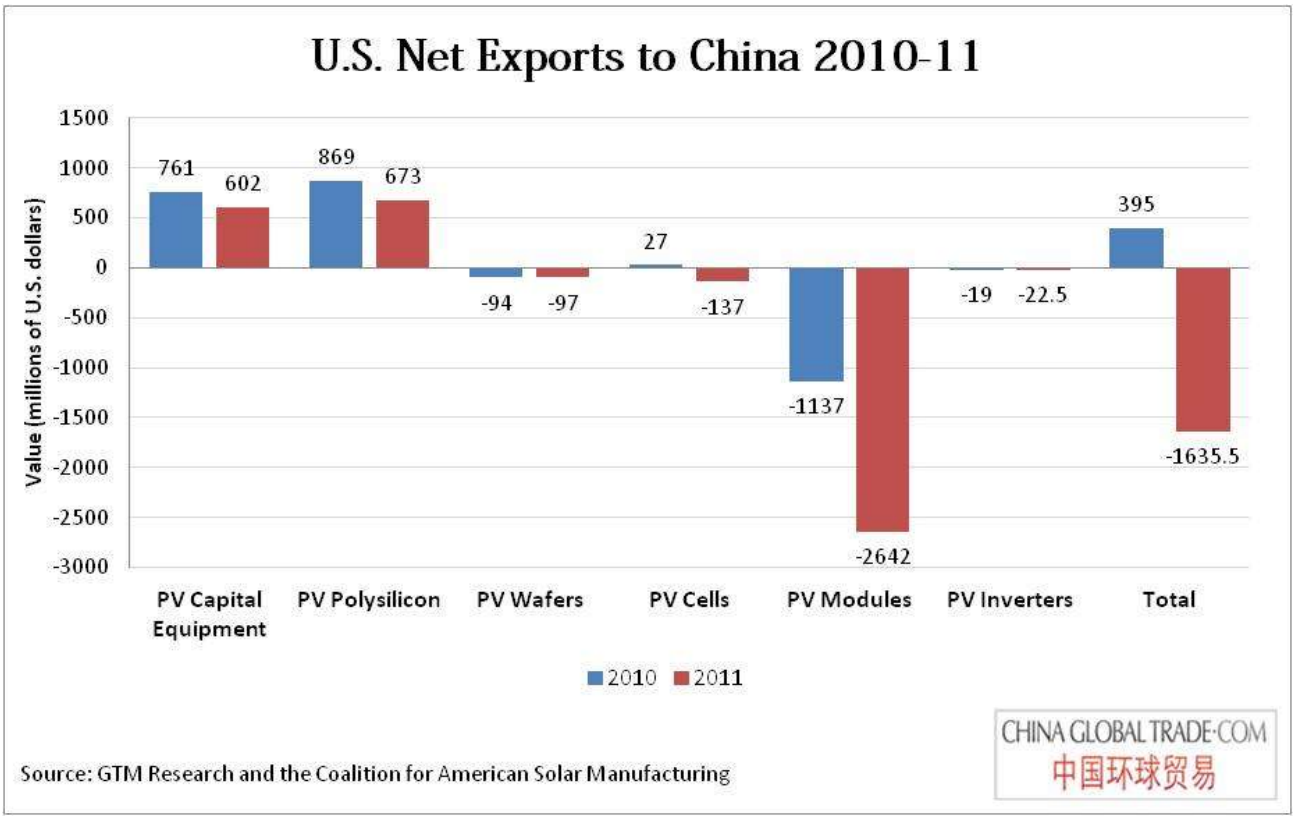
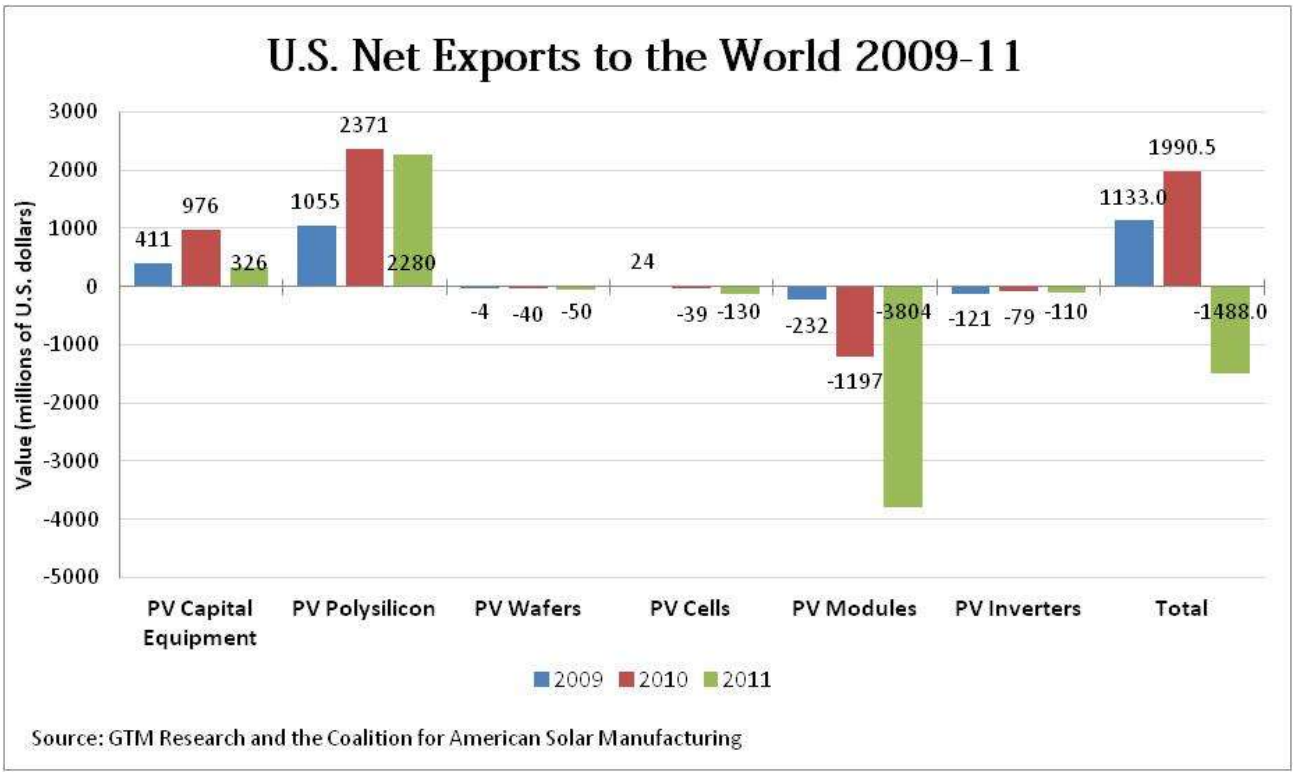


Figure 22: U.S. Net Exports to the World 2010-11

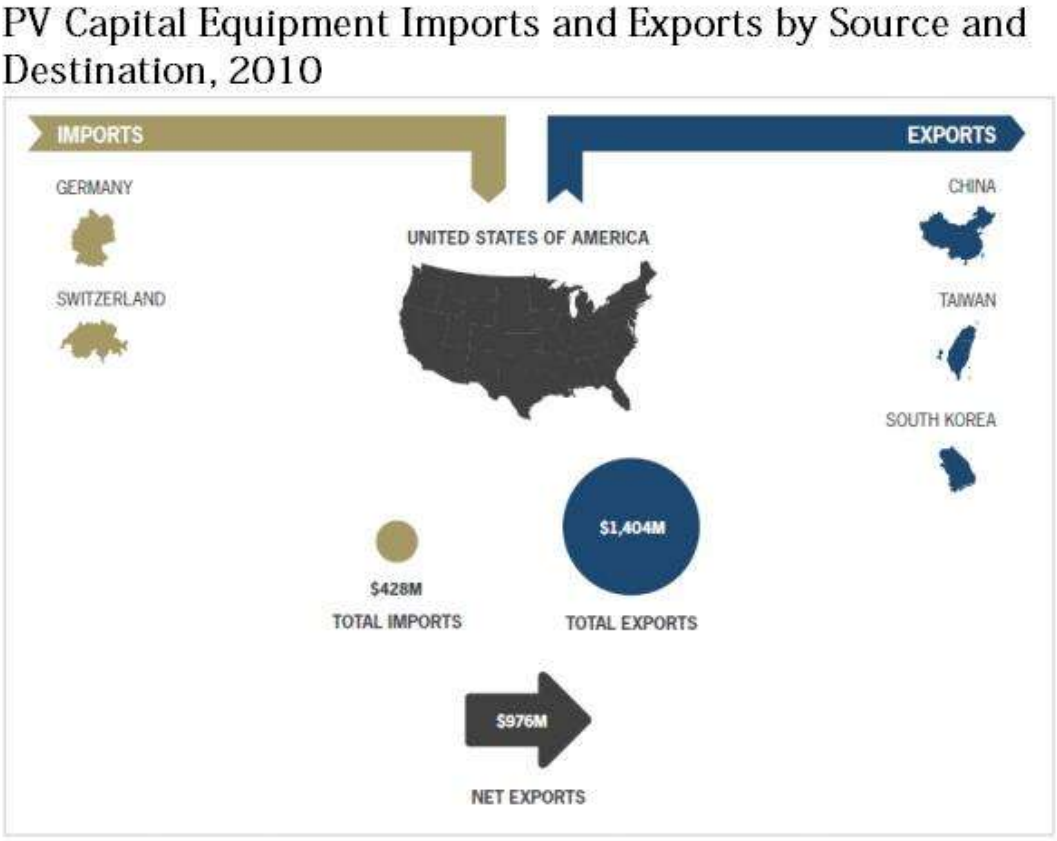


3.2.3 Effect on U.S.-based solar equipment manufacturers

The same story is true for manufacturers of PV capital equipment. In 2010, U.S. net exports (exports less imports) of PV capital equipment to the world was just over $975 million, up 137 percent from 2009, and $761 million to China alone. In 2011, net exports of capital equipment to China was $602 million.[147]

[147] GTM. *U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States.* Washington: GTM, 2011. Web. 2012.

Figure 23: PV Capital Equipment Imports and Exports by Source and Destination, 2010



Source: GTM Research. U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States.

Yet there are some who argue that refraining from assessing tariffs on subsidized and (allegedly) dumped Chinese imports just because China might retaliate and cause losses in the U.S. polysilicon and PV capital equipment industries would be short-sighted. They argue that China will seek to dominate the polysilicon and capital equipment industries just as they have cell and module manufacturing.

Indeed, China has already rapidly increased its share of world polysilicon production – now at 17 percent. And the 12th Five Year Plan requires China's leading polysilicon manufacturers to reach a 50,000-ton annual production capacity (per company) by 2015. A number of those leading polysilicon producers are at least partially state-owned or state-controlled. For example, Yichang CSG Polysilicon Co., Ltd is a subsidiary of the China Southern Power Grid Company Limited ("CSG"), a state-owned enterprise, or SOE (see here). The China Investment Corporation, a wholly state-owned company, holds an interest in CGL-Poly Energy Holdings Limited (see here).

There are, broadly, two problems with China's rise in the polysilicon industry. If China's rise takes away production from the U.S. (which is not inevitable) that would represent a further deterioration of the solar manufacturing industry in the U.S. And that would send ripple effects across the economy. "Many economists believe there is a strong link between manufacturing and R&D: lose manufacturing and you lose the high-paying jobs in R&D, design and other areas. Lose manufacturing and you lose the entire industry to foreign companies. This is particularly true for process engineering dependent industries like solar PV where continuous improvements in manufacturing processes play a major role in cost reduction

and product improvement. In the *Harvard Business Review*, Harvard professors Pisano and Shih wrote, 'the decline of manufacturing in a region sets off a chain reaction. Once manufacturing is outsourced, process-engineering expertise can't be maintained, since it depends on daily interactions with manufacturing. Without process-engineering capabilities, companies find it increasingly difficult to conduct advanced research on next-generation process technologies. Without the ability to develop such new processes, they find they can no longer develop new products. In the long term, then, an economy that lacks an infrastructure for advanced process engineering and manufacturing will lose its ability to innovate.'"[148] And it is innovation that drives productivity – which drives growth – in the American economy.

And that's the second potential problem with China's rise in the polysilicon industry. Today, China's leading solar cell and module manufacturers are equally as innovative as U.S. manufacturers. But if China develops a monopoly across the solar supply chain, that could drive out innovation. According to Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, "Governments don't subsidize forever. Once the foreign competitors are driven out of the industry, then the Chinese government will stop subsidizing Chinese manufacturers and the price will increase. But the supply will be limited. And when you limit the number of suppliers, then there's less competitions, and it is competition that drives innovation."

That is essentially what happened in the rare-earth market; Chinese producers of rare-earth drove costs so low that producers in the U.S. and elsewhere couldn't compete, and were forced to close up shop. That gave Chinese producers a virtual monopoly over rare-earth production, which they have recently leveraged to withhold supply and drive prices back up. (Now, U.S. producers are getting back into the market.)[149]

Jigar Shah, President of the Coalition for Affordable Solar Energy, agrees that innovativeness is important, but rejects the notion that America must manufacture solar cells and modules in order for the industry to continue innovating. "Because the U.S. has no industrial policy, if you're an entrepreneur who has come up with a new innovation for solar, or a new innovation for batteries, guess what you do? You go to China to manufacture it. The Chinese are not innovating new solar, but they're licensing technologies from companies in the U.S. that have come up with great new strategies and they're paying them handsomely for the technologies, and they're manufacturing them in China."

In addition to its clear move to develop a domestic polysilicon industry, there is evidence that China is already moving into other areas of the solar value chain as well. According to one executive at a Chinese solar manufacturer, "a lot of companies" are moving in the direction of building and running utility-scale power plants – using the panels they produce, of course. "In another two years," she said, "modules won't be the most important part [of our business]; it will be utility-scale solar parks."

Where are these Chinese companies looking to build and run these parks? All over the world. And the reason, said the executive at the Chinese solar module manufacturer, is that the price of cells and modules continues to fall, and the profit margin continues to shrink. "A large-scale project like a solar park will be run by us and power sold to utility companies. We'll do EPC [Engineering, Procurement and Construction] and finance of the project, and we'll still use our products."

[148] SEMI North American PV Advisory Committee, *Manufacturing Solar Photovoltaic Products in the United States* (Washington: SEMI North American PV Advisory Committee, 2012)
[149] "Of metals and market forces," *The Economist*, 4 Feb 2012.

3.2.4 Effect on the growth of solar power as an alternative energy source

Adam Hersh, Economist at the Center for American Progress, argued that if Chinese producers have an unfair advantage, it will undermine the world's transition to renewable energy as a source of power. "If the producers are being given unfair advantages in China it's going to undermine innovation in the sector of renewable energy infrastructure and will set back the pace of our transition to using sources of renewable energy. That's why it's so important to have a level playing field in this…There are some who argue that we should let in these subsidized, dumped products from China because it makes it cheaper to install and build out renewable energy here in the U.S. But that's a very short-sighted view of the dynamics of the industry. We need to have the innovation competition which will allow us to scale up and produce the most efficient and next generation of solar and other renewable energy sources going forward."

Others argue that imposing tariffs on China's low-cost solar products will raise the price of solar systems dramatically enough to curb demand for them. Low total system cost is critical to the growth of the solar industry given that solar power is still not, in many cases, cost competitive with traditional power sources. So if the imposition of tariffs causes costs to increase, that could cause demand for solar products to decline – and slow the transition to solar energy as an alternative power source.

How much might prices rise? According to Jigar Shah, President of the Coalition for Affordable Solar Energy, "Stock analysts have said that module prices will probably go up by between 10 and 15 percent. That's what they think it will cost to abandon China's supply chain and buy from Taiwan and Malaysia and other places instead." But according to Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress, it's hard to say how tariffs would impact prices. "There's a lot of oversupply right now," she said, "and that will blunt the price impact of tariffs."

4 Moving forward

By the U.S. Department of Commerce's preliminary estimation, anyway, Chinese solar cell and module producers have received countervailable (i.e., illegal) subsidies of about 2.90-4.73 percent. We will find out on May 17 whether Commerce found evidence of dumping and, if so, what the extent of it was (the petitioners in the trade case allege dumping margins of 49.88 to 249.96 percent).

If we assume, for the sake of argument, that the Department of Commerce does not find evidence of dumping, or finds relatively low dumping margins and, thus, tariffs against Chinese manufacturer remain relatively small and not particularly punitive, then we still likely have a problem. U.S. solar manufacturers will still struggle with the difficulties that have plagued them the past several years. Chinese manufacturers will still have the scale, the vertical integration, the discounted materials and equipment, and the low labor costs that allow them to sell cells for 20 percent less than their American competitors. And they will still have the significant support of the Chinese government's industrial policy.

If we imagine a scenario like that, are there actions the U.S. – or U.S. manufacturers – could take that would help improve their competitiveness in the global solar industry?

According to Shyam Mehta, Senior Analyst at GTM Research, Western and Japanese crystalline silicon manufacturers will never beat China at the CSPV game because China has such lower costs. For non-Chinese companies, he said, the future lies in either differentiated technology or a new business model. They must either:

1) Commercialize a revolutionary technology at high scale that lowers the PV cost curve. China has had no success developing non-crystalline silicon PV technology. Elsewhere, there is only one notable semi-success, and that is First Solar thin-film technology; or
2) Find a different business model. For example, First Solar and SunPower build and operate solar farms, and have done so successfully in the U.S. The advantage of building and operating solar power plants is that then the company has a dedicated sales channel that insulates its profit margins against China's low-cost panels. Though as the Chinese module manufacturing executive pointed out, Chinese firms are moving toward this business model, too (see here).

Others suggest that the U.S. develop an industrial policy (see also here). "U.S. incentives can level the playing field. The scale of Chinese incentives dwarf U.S. efforts. Access to capital is a critical compliment to the United States' capacity to innovate."[150] To that end, the SEMI PV Group recommends:[151]

- Large, long-term, stable, market-side support policies, including a national Renewable Clean Energy Standard (RES), state Renewable Portfolio Standards, buyer incentive programs, and sales and property tax credits;
- Maintain the Investment Tax Credit (ITC) through 2016;
- Extend the Section 1603 Treasury Grant Program that has provided a grant in lieu of the advanced energy investment tax credit (ITC);

[150] Alan Goodrich, Ted James and Michael Woodhouse. *Solar PV Manufacturing Cost Analysis: U.S. Competitiveness in a Global Industry*, Power Point Presentation, Stanford University: Precourt Institute for Energy, 10 Oct. 2011.
[151] SEMI North American PV Advisory Committee, *Manufacturing Solar Photovoltaic Products in the United States* (Washington: SEMI North American PV Advisory Committee, 2012)

- Increase Department of Energy funding for both R&D and manufacturing infrastructure development of the U.S. solar industry;
- Establish the R&D tax credit on a long-term basis to assure solar manufacturers greater consistency in tax and investment planning;
- Revive the Advanced Energy Manufacturing Tax Credit (MTC), and creation of a federal Green Bank to supplement PV and other green energy projects, particularly for manufacturing; and
- Work with foreign counterparts and the WTO to develop a strong, effective and enforceable rules-based international trading system that promotes free and open trade.

"We need to make sure we are investing in the foundations of innovation here in the United States to give our companies the policy environment they need to remain competitive against a rising China," argues Melanie Hart, Policy Analyst for Chinese Energy and Climate Policy at the Center for American Progress. "It is inevitable that there will be some global economic reshuffling as China moves up the economic ladder, but we can gain a lot of benefits from that process if handled well. China's growing domestic market, for example, can be a major new source of consumers for U.S. products, but we have to make sure that we do not cede critical American jobs to the Chinese – in solar manufacturing as in other U.S. industries – just because we were lax on the policy side."[152]

Speaking at the Conference on the Renaissance of American Manufacturing, Gordon Brinser, President of SolarWorld Industries America, said that the U.S. must respond more quickly when there is evidence that China is violating international or domestic trade laws. "Because at this point reactively, a lot of the damage is pretty deep. There have been 12 manufacturers that have laid off workers, shut down, one last week just sold their equipment. There are bankruptcies. What about those 12 companies? There is no remedy for those workers who have lost their jobs. These remedies that go forward aren't going to help them at this point. So in some respect, we're too late, the industry has already been damaged." Brinser recommended some specific policy improvements:

1. The administration's new trade unit should closely monitor import data for early signs of market distortions spurred by foreign governments;
2. Our trade agencies must look hard at ways to preserve an open, transparent process for trade cases but in fewer steps and less time;
3. They also must, in conjunction with U.S. Customs, aggressively find ways to anticipate and stop circumvention of trade remedies and theft of intellectual property;
4. The government should bring legitimate cases for industries that are too small or injured to afford them; and
5. The government must shed light on foreign companies that raise capital on U.S. exchanges and then withhold audit information from securities regulators.

These are all steps that could help – the U.S. should help its manufacturers and enforce international and domestic trade laws. But it's important to realize, as this report and the preliminary countervailing duty from the Department of Commerce have made clear, that China's top tier solar cell and module manufacturers are highly competitive for many more reasons than having received subsidies on the order of 3-5 percent.

[152] Melanie Hart. *Shining a Light on U.S.-China Clean Energy Cooperation*. Center for American Progress, Feb. 2011: Print.

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