The Brattle Group

The Employment Impacts of Proposed Tariffs on Chinese Manufactured Photovoltaic Cells and Modules

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Executive Summary

At the request of the Coalition for Affordable Solar Energy (CASE), *The Brattle Group* has studied the employment impacts of a proposed trade restriction on Chinese-manufactured crystalline photovoltaic cells and modules. This topic is timely, because the U.S. Department of Commerce (DOC) is currently reviewing a petition that would lead to substantial tariffs on Chinese-produced photovoltaic cells and modules. Petitioners have requested tariffs up to 250% on Chinese-manufactured products in response to alleged government subsidies and below cost pricing.

In brief, we estimate that tariffs will slow the growth in domestic demand for photovoltaic systems by homeowners, commercial establishments and utilities, resulting in substantial job losses. We estimate jobs at risk under two tariff levels – 50% or 100%. We find that a 50% tariff will shut the vast majority of Chinese imports out of the U.S. market, and a 100% tariff will effectively block them altogether. We also estimate employment impacts accounting for two scenarios, a low scenario which assumes low demand elasticity and high supply elasticity, and a high scenario which reflects a high demand elasticity and a low supply elasticity.

- We expect that on average module prices would be higher than currently projected over the next three years by roughly 25-30%. Price increases of this magnitude may provide some assistance to domestic producers facing a highly competitive market, but at the same time will harm consumers, resulting in a drop in overall domestic demand.
- A tariff of 50% will result in between 14,877 and 43,178 fewer jobs in 2014, even accounting for production job increases.[1]
- A tariff of 100 % will result in between 16,917 and 49,589 fewer jobs in 2014, even accounting for production job increases.
- In addition, the Chinese government may retaliate if a tariff is imposed on its cells and modules by imposing a tariff on U.S. products, polysilicon a key photovoltaic (PV) material. In 2010 the U.S. exported approximately $863 million of polysilicon products to China. A reduction in demand of this magnitude could result in additional job losses of 10,881, bringing the total job losses up to as many as 60,000. Losses would be even greater if exports continue to grow as expected. Additionally, we have not accounted for retaliation on U.S. export of PV capital equipment, which could lead to even further job losses.
- These estimates reflect the assumption that PV costs will continue to fall as technologies improve, further efficiency gains are made in production and installation, and existing incentives and targets remain in place. Should the rate of these improvements slow or fail to materialize or existing incentives run out of funds, the negative impacts of the tariff on employment would be significantly greater.
- Finally, the economic basis for evaluating an import tariff is whether there is a gain to both consumers and producers. We estimate that consumers lose more than producers gain, resulting in a net revenue loss of between $621 million and $2.6 billion.

[1] Note that all employment impacts are given in terms of full-time equivalent (FTE) jobs. FTE employment is defined as total hours worked divided by average annual hours worked in full time jobs. An FTE is assumed to work 2,080 hours in a standard year.

Background

Driven by national and local subsidies in a variety of forms and rapidly falling production costs, the market for PV power systems has grown dramatically since the early 2000's, both domestically and abroad. The market for PV is highly complex. On the supply side, there are a large number of competitors, many with a multinational presence. The petitioner before the DOC, for example, is a German-based company with U.S. plants. There are also competing technologies in the marketplace. Crystalline silicon photovoltaic producers, for example, compete with thin film photovoltaic producers. Other renewable technologies including solar thermal, wind and geothermal also compete with PV, especially for utility customers.[2] Two other industries play an important role in the market. Polysilicon, the primary material of photovoltaic cells, is produced in the U.S. and exported to other countries including China. There are also numerous domestic PV distributors and installers.

On the demand side, residential, commercial, and utility customers are influenced by a wide range of incentives. Residential customers, depending on where they live, may have access to federal, state, and local subsidies. Utility customers, depending on where they operate, may have access to federal and state subsidies as well, but can also face regulatory obligations to invest in solar energy. Consequently, the exact magnitude of tariff impacts on producers, consumers, and total industry employment is difficult to determine. It is possible, however, to provide a plausible range for the impact of the tariff on demand and employment.

Findings

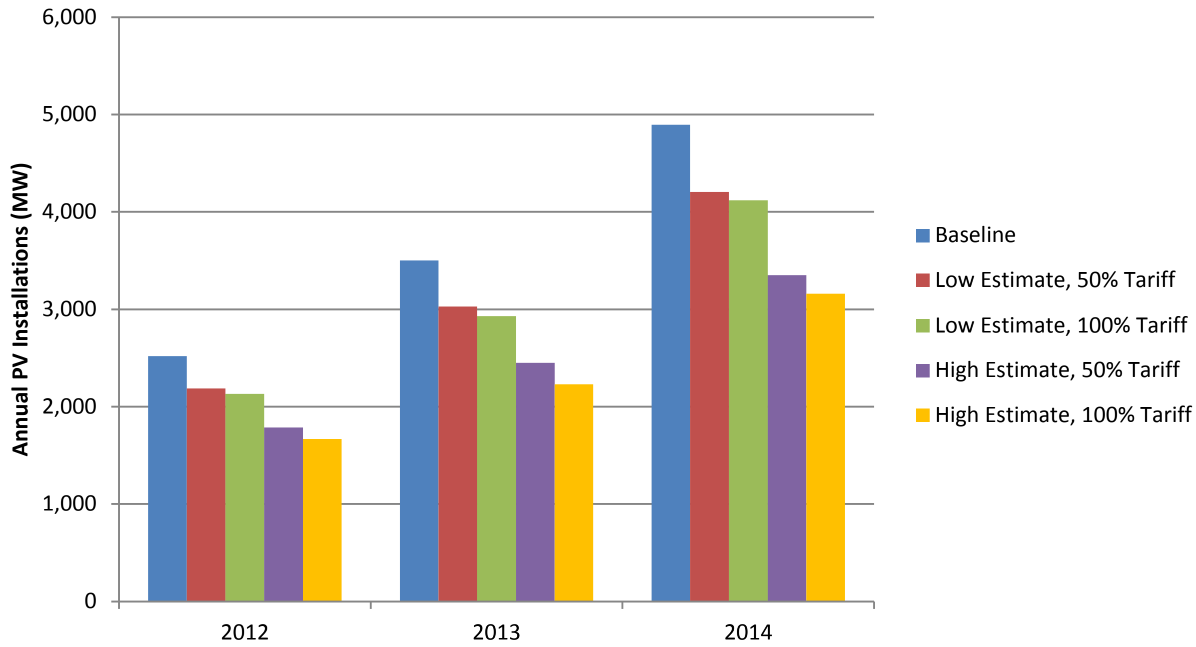
Based on our analyses, we have concluded that tariffs of the magnitude proposed by petitioners would result in substantial price increases for crystalline photovoltaic cells and modules. We expect that on average module prices would be higher than currently projected over the next three years by roughly 25-30% in all consumer sectors (homeowners, commercial establishments, and utilities). Price increases of this magnitude may provide some assistance to domestic crystalline PV producers facing a highly competitive market, but at the same time will harm consumers, resulting in a drop in overall domestic demand. We expect that U.S. demand for crystalline photovoltaic systems by residential, commercial, and utility customers will fall significantly in the face of the 25-30% average module price increase which would occur under a 50% or 100% tariff. As a result, any job gains from increased domestic PV module production will likely be offset by job losses from decreased total demand for PV.

Absent a tariff, the aggregate demand for photovoltaic systems is expected to grow from 1,678 MW in 2011 to 4,894 MW by 2014. A 50% tariff will delay this growth. As shown in Figure ES-1, the total MW demanded will fall to between 3,350 MW in our low case scenario and 4,206 MW in our high case scenario in 2014. A 100% tariff will delay this growth even more – MW demanded falls to between 3,159 MW in our low case scenario and 4,119 MW in our high case scenario in 2014. The range within tariff levels reflects differences in the assumed demand and supply elasticities (measures of price responsiveness by consumers and producers). The low values reflect a combination of low demand and high supply elasticities, while high values reflect a combination of high demand and low supply elasticities. The response of utility PV purchasers to tariff induced price increases is a critical variable in these results. Should the price increase greatly discourage utility PV demand, the most rapidly growing

[2] Utilities include investor and municipally-owned power companies, as well as independent power producers.

sector of the market could be slowed substantially.

Figure ES-1: Tariffs Slow U.S. PV Demand Growth



Reduced demand leads to fewer installations, which in turn reduces the number of solar-related jobs in the U.S. These include jobs from site preparation and labor, permitting, engineering, financing, distribution and other industry-supported positions. Aggregate jobs at risk from potential tariff impacts are depicted below in Figure ES-2 and
Table ES-1.

Estimated job impacts include direct, indirect, and induced effects. The *direct effect* captures the initial change in economic activity resulting from the new investment. For example, this category includes the direct employment of module manufacturing plants and the jobs of solar PV installers. The *indirect effect* reflects new economic activity that is stimulated by the direct investment in industries that supply inputs to the sector of initial change. For example, increased spending on engineering consulting services to support the construction of a production facility would be an indirect effect that arises during the construction phase of the plant. The *induced effect* captures the economic activity that results when the increased earnings generated by the direct and indirect economic activity is spent on local goods and services, for instance when construction workers hired to build a PV plant spend income on groceries, clothing, financial services, real estate, and healthcare. The economic impact of the tariff is the sum of these direct, indirect and induced effects.

Figure ES-2: Solar-Related U.S. Employment Tariff Impacts

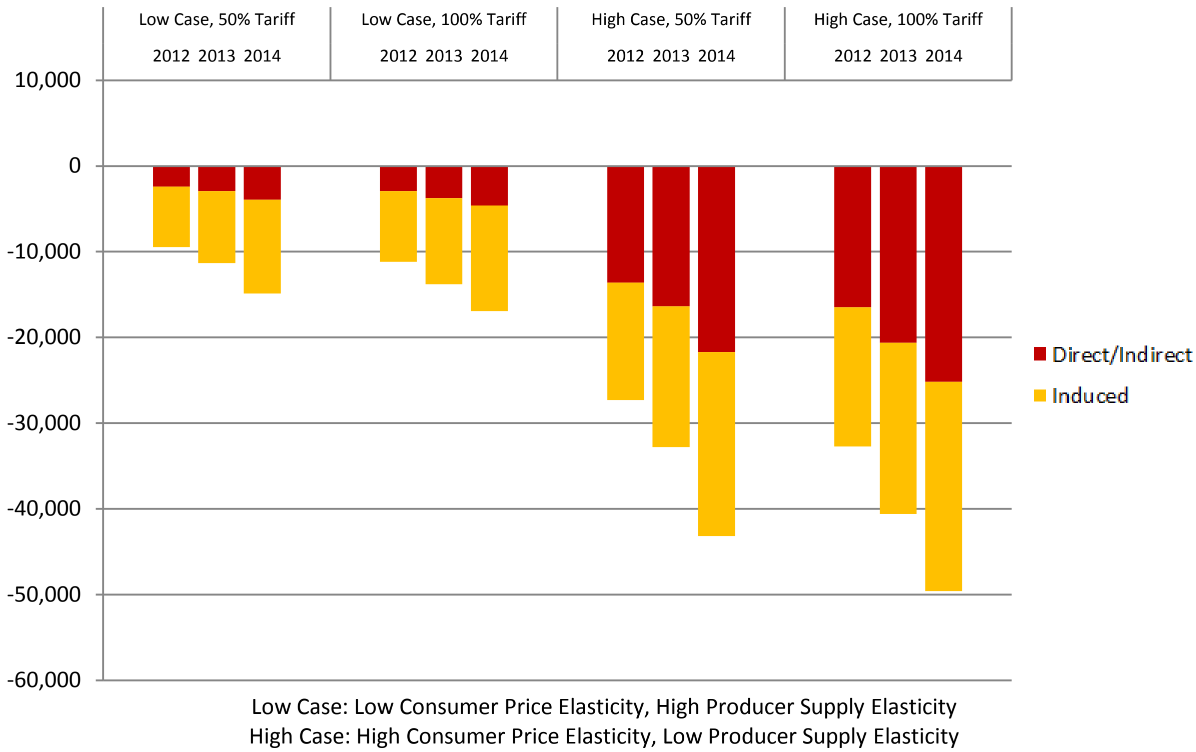
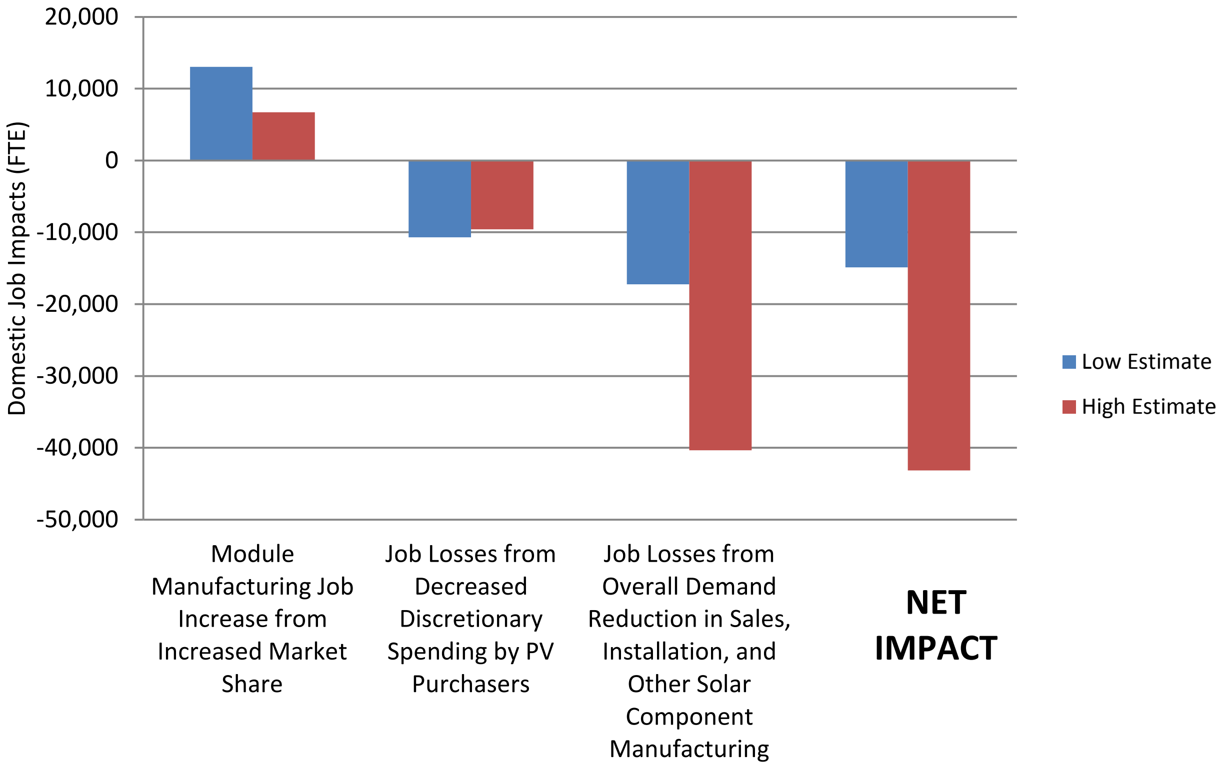


Table ES-1: Tariffs Result in U.S. Aggregate Job Losses (FTE)

Scenario	Year	Impact Type			Total
		Direct	*Indirect*	*Induced*	
Low Case, 50% Tariff	2012	-3,396	994	-7,059	**-9,461**
	2013	-4,084	1,161	-8,414	**-11,337**
	2014	-5,391	1,449	-10,935	**-14,877**
Low Case, 100% Tariff	2012	-4,125	1,198	-8,252	**-11,179**
	2013	-5,148	1,412	-10,065	**-13,801**
	2014	-6,260	1,668	-12,325	**-16,917**
High Case, 50% Tariff	2012	-10,185	-3,402	-13,733	**-27,320**
	2013	-12,262	-4,115	-16,422	**-32,798**
	2014	-16,221	-5,492	-21,466	**-43,178**
High Case, 100% Tariff	2012	-12,337	-4,133	-16,241	**-32,712**
	2013	-15,424	-5,216	-19,954	**-40,593**
	2014	-18,799	-6,381	-24,409	**-49,589**

These aggregate job losses are net of job gains in production. As shown in Figure ES-3, a 50% tariff would create around 6,712 to 13,032 new jobs from an increased module manufacturing market share by 2014. However, between 9,560 and 10,684 jobs would be lost because of decreased discretionary spending by PV purchasers as a consequence of higher prices for the PV systems they purchase. In addition, the largest losses in the economy would occur as a result of overall demand reduction from higher prices. This would impact jobs in sales, installation, and other solar component manufacturing. The gain in market share for module manufacturing is thus more than offset by the decline in jobs due to reduced demand for PV systems. Overall, this is predicted to result in a net loss of 14,877 to 43,178 jobs in 2014.

Figure ES-3: U.S. Employment Impacts of a 50% Tariff in 2014

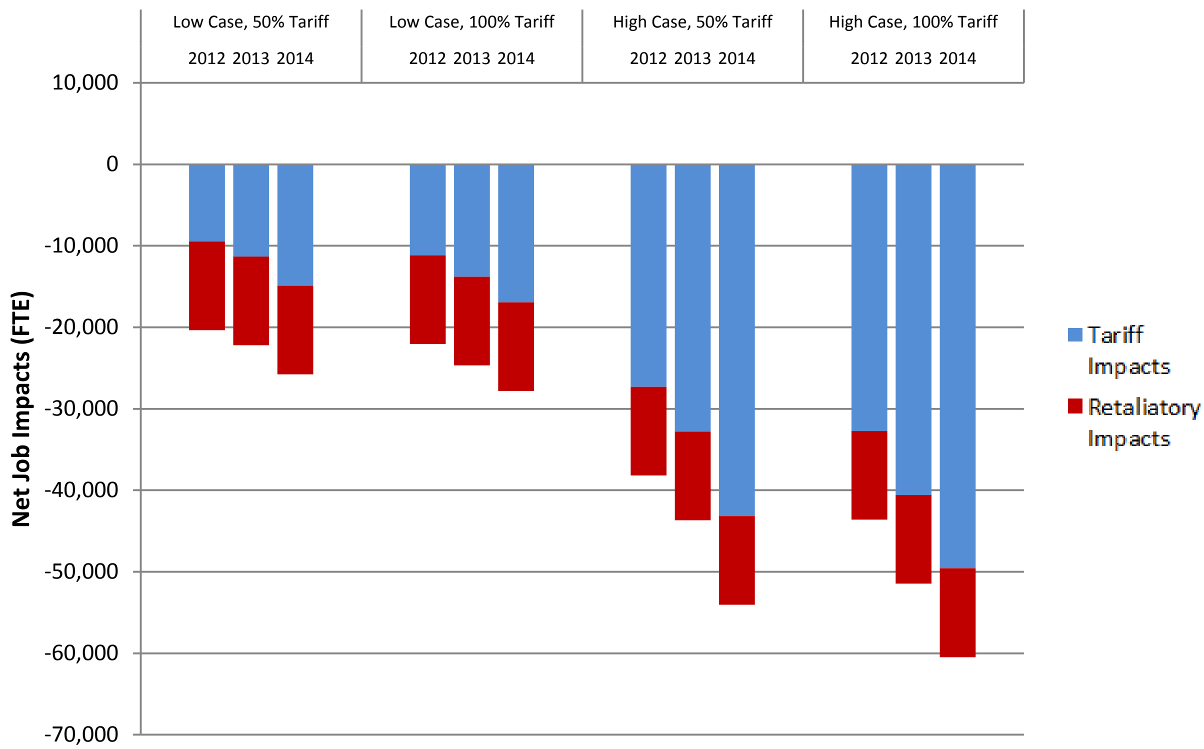


Finally, China could retaliate if a tariff is imposed. A retaliation policy from China would likely take the form of a tariff on U.S. polysilicon exports. The U.S. is a major supplier of polysilicon, a component of photovoltaic modules, and decreasing or completely eliminating Chinese demand for U.S.-manufactured polysilicon would result in around 10,881 U.S. job losses based on 2010 U.S. polysilicon export levels to China. Since exports are projected to grow absent a tariff, this is a conservative figure, and the losses could be greater by 2014. Retaliation is also possible with respect to PV capital equipment, and would lead to even greater job impacts. Table ES-2 and Figure ES-4 below depicts total job impacts of a 50% tariff, accounting for the effects of Chinese retaliation on U.S.-manufactured polysilicon.

Table ES-2: Chinese Retaliation Further Increases Expected Annual U.S. Jobs at Risk (FTE)

Direct	-1,645
Indirect	-4,061
Induced	-5,175
Annual Total	**-10,881**

Figure ES-4: Solar-Related U.S. Employment Tariff Impacts, including Chinese Retaliation



Overall, adding in the effects of a potential retaliatory tariff is expected to place possibly over 60,000 jobs at risk should the U.S. impose a tariff on Chinese imports. In sum, the imposition of a tariff on Chinese crystalline photovoltaic cells and modules will hurt consumers by increasing the price of solar PV and the power it produces, create a net job loss and delay the growth in solar energy production in the United States.

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Tables and Figures

Introduction

At the request of the Coalition for Affordable Solar Energy (CASE), *The Brattle Group* has estimated the employment impacts of a proposed trade restriction on Chinese-manufactured crystalline photovoltaic cells and modules.[3] This topic is timely, because the International Trade Commission (ITC) is currently reviewing a petition that would lead to substantial tariffs on Chinese produced photovoltaic cells and modules. Petitioners have requested tariffs up to 250% on Chinese manufactured products in response to alleged government subsidies and below cost pricing.

This paper presents our analysis. We first provide a brief summary of the petition currently before the ITC and a characterization of the solar energy market. We then describe the methods and assumptions used in our analysis. Our results are presented in the final section of the paper.

Background

In this section we provide background on the petition to impose tariffs on Chinese crystalline photovoltaic cell and module imports before the U.S International Trade Commission and on the solar photovoltaic power market that would be influenced by such a tariff.

The SolarWorld Petition

On October 19, 2011, Bonn-based SolarWorld AG filed petitions with both the U.S. Department of Commerce ("DOC") and the U.S. International Trade Commission ("ITC") alleging that a domestic industry is materially injured or threatened with material injury by reason of less than fair value ("LTFV") and subsidized imports of crystalline silicon photovoltaic cells and modules from China.[4]

The overall process for antidumping and countervailing duty cases such as the one initiated by Solar World can be divided into five stages, each ending with a finding by either the DOC or the ITC. These stages are as follows: (i) initiation of the investigation by the DOC (20 days after filing the petition); (ii) the preliminary phase of the ITC's investigation (with a preliminary determination 45 days after filing of the petition); (iii) the preliminary phase of the DOC investigation (with a preliminary determination 115 days after the ITC's determination for antidumping cases or 40 days for countervailing duty cases); (iv) the final phase of the DOC investigation (with a final determination 75 days after the DOC's preliminary determination) and (v) the final phase of the ITC's investigation.[5]

In accordance with this schedule, the U.S. DOC decided to investigate the petition's claims on November 9, 2011. The U.S. ITC instituted countervailing duty investigation No. 710-TA-481 and antidumping

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3 CASE represents over 150 firms in the solar industry. www.coalition4affordablesolar.org.

4 Petitions are required to contain some evidence of dumping and injury to the domestic industry in order to initiate an investigation. However, the evidentiary requirements are quite modest. (Antidumping 101 The Devilish Details of Unfair Trade Law by Brink Lindsey and Dan Ikenson, www.freetrade.org.pubs/pas/tpa-020.pdf accessed on 1/17/12.)

5 Antidumping and Countervailing Duty Handbook, Thirteenth Edition, United States International Trade Commission pp. II-3 and II-4.

duty investigation No. 731-TA-1190 (Preliminary) on the day it received the petition.[6] On December 2, 2011, the ITC issued its affirmative preliminary determination.[7] On January 4, 2012, the U.S. DOC delayed its deadline for reaching a preliminary determination on whether China's solar sector has received countervailable subsidies. This move, which came at the request of SolarWorld Industries, only affects cases that involve countervailing duties but is not expected to delay DOC's parallel anti-dumping probe. The investigation at the DOC regarding countervailing duties is currently expected to produce a preliminary determination by March 2, 2012, but this deadline may be extended. If the DOC finds that imports are being dumped and/or subsidized and the ITC finds that the imports are causing or threatening injury to a domestic industry, the result could be a significant increase in tariffs on Chinese photovoltaic cells. The actual tariff levels will be set at the time of the determination. Tariff levels up to 250% have been requested.

Solar Market Characterization

Solar power has experienced substantial growth in the U.S. since the early 2000's. Installed capacity has grown from 435 MW in 2009 to an estimated 1,678 MW in 2011.[8]

This growth can be attributed to a combination of falling costs from technological gains and substantial public policy drivers and financial incentives provided by federal, state, and local governments in the U.S. and abroad. Because of technological advances and scale economies in PV cell manufacturing in recent years as well as falling polysilicon prices, the cost of crystalline silicon PV modules in the residential U.S. market has fallen to $1.24/W as of 2011 and is projected to fall to $0.74/W by 2014.[9]

With respect to public policy and incentives around renewable energy, twenty nine states and Washington D.C. have implemented Renewable Portfolio Standards (RPS) that require electric utilities to meet certain shares of electricity usage with renewable energy resources including solar power.[10] Several states have imposed specific solar power targets in addition to a more general RPS. Eight additional states have established goals for renewable energy without explicit penalties for non-compliance. Further, state and local governments have developed and implemented a variety of incentive programs to spur the adoption of solar and other renewable technologies. Thirty seven states offer loan programs for renewables, twenty eight states offer sales tax incentives, and twenty four states offer tax credits for renewables. Many programs provide specific financial subsidies in the form of grants and/or rebate programs for solar PV installations. Local programs exist as well. For example, San Francisco offers its own incentives for residential and commercial building solar investments.[11]

The combination of increasing PV cost efficiencies, public policy and financial incentives have successfully increased the growth of solar PV deployment in the U.S. Continued growth on a similar

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6 Countervailing duties—also known as anti-subsidy duties—are trade import duties imposed under World Trade Organization ("WTO") Rules to neutralize the negative effects of subsidies. Countervailing duties in the U.S. are assessed by the ITC, which, as noted above, is part of the DOC.

7 See Crystalline Silicon Photovoltaic Cells and Modules from China Investigation Nos. 710-TA-481 and 731-TA-1190 (Preliminary), Background.

8 GTM Research, U.S. Solar Market Insight Report, Q3 2011, pg. 54.

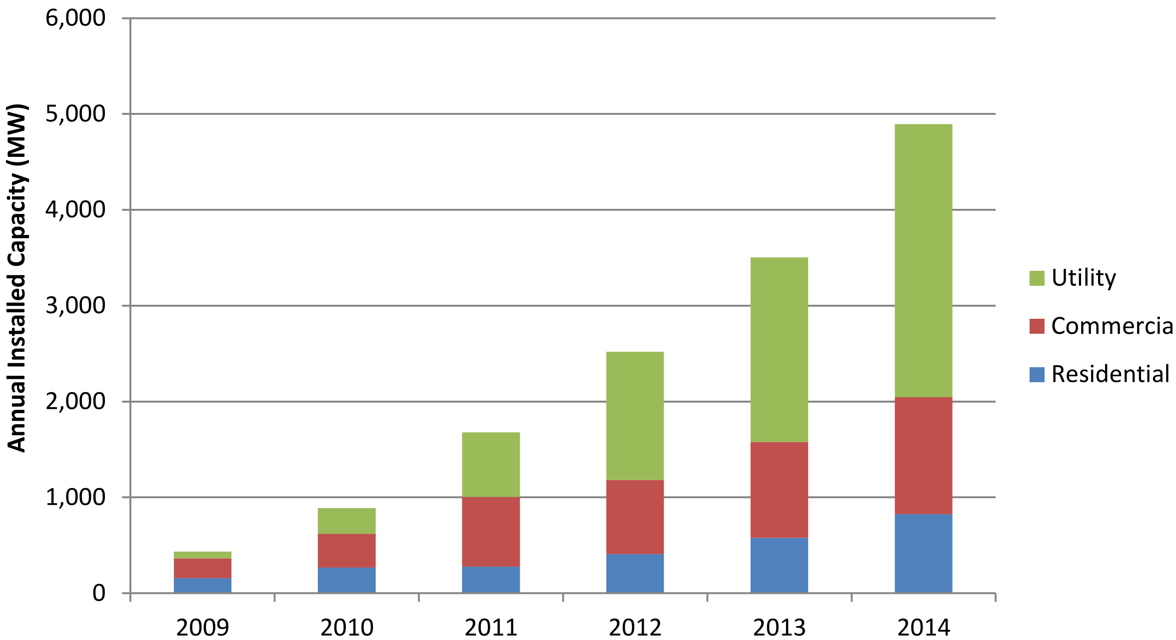
9 GTM Research Module Pricing Forecast.

10 DSIRE Database of State Incentives for Renewables and Efficiency. www.dsireusa.org/summarytables .

11 DSIRE, City of San Francisco – Solar Energy Incentive Program.

trajectory is expected to grow installed capacity to 4,894 MW in 2014.[12] While many early adapters were residential users, the most substantial growth is expected in the utility sector as utilities invest to meet RPS requirements and solar targets.[13]

Figure 1: U.S. PV Demand Projections by Sector



Source: GTM Research, U.S. Solar Market Insight Report, Q3 2011, pg. 54

There are over 57 active domestic and foreign owned facilities in the United States manufacturing photovoltaic components, including polysilicon, cells, wafers, modules, and inverters.[14] The typical PV system includes one or more modules, an inverter to convert DC to AC electricity, and associated electrical components and mounting structure. These facilities are located in 21 different states.[15] The market for these components, however, is international, and foreign plants also help meet U.S. photovoltaic demand. The U.S imports photovoltaic components from a number of foreign producers including plants located in China, Mexico, Japan, Taiwan and Germany.[16] Table 1 presents data on import revenues and expenditures on exports with major U.S. trading partners in the solar market.

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12 We reviewed several demand forecasts and chose a single forecast from GTM Research that most closely approximated an average growth rate. An overview of various industry demand forecasts is included in Appendix 1.

13 Utilities include investor and municipally-owned power companies, as well as independent power producers.

14 GTM Research, U.S. Solar Market Insight Report, Q3 2011 Full Report.

15 Ibid.

16 GTM Research, U.S. Solar Energy Trade Assessment 2011, pp. 10-11.

Table 1: U.S. Solar Trade Balance ($ millions)

Imports		Exports	
China	$1,431	China	$1,817
Mexico	$480	Germany	$865
Japan	$322	Japan	$609
Taiwan	$264	Norway	$258
Germany	$215	Canada	$223
Austria	$24	Italy	$126
Canada	$22	France	$74
Korea	$20	Spain	$23
Italy	$12	Other	$912
Other	$194	Undisclosed	$712
Undisclosed	$695		
Total	*$3,679*		*$5,614*
NET EXPORTS			**$1,934**

As shown in the table above, domestic PV-related plants export principally to China, Germany, Japan, Norway and Canada. In 2010, the U.S. was a net exporter, with a trade balance of $1.934 billion. China is by far the U.S.'s largest trade partner, importing significant quantities of PV capital equipment and polysilicon. In 2010, the U.S. exported $873 million in polysilicon to China, and there are fears that any tariffs placed on Chinese-manufactured modules would lead to retaliatory action against U.S. manufactured polysilicon currently being shipped to China. Retaliation is also possible with respect to capital equipment, and would lead to even greater job impacts.

Overall, the solar energy market appears highly competitive as evidenced by the continued decline in price and the level of entry and exit. A slowdown in demand at the international level in 2011, which was caused by a number of factors including reduced incentives and economic conditions in Europe, has forced six domestic module manufacturing plants into closure or idling.[17] Four of these plants manufactured crystalline silicon modules. At the same time, nine new plants are expected to open in 2012 and 2013.[18] Five of these plants will manufacture thin film rather than crystalline silicon modules.

The rise of domestic solar power adoption accounted for 100,237 manufacturing, installation, and sales jobs in 2011 according to the National Solar Jobs Census.[19] A breakdown by job category is presented in Table 2 below.

17 GTM Research, U.S. Solar Market Insight Report Q3 2011, p. 37.
18 Ibid, p. 41.
19 National Solar Jobs Census 2011, The Solar Foundation (October 2011), p. 13.

Table 2: Domestic Solar Industry Jobs by Employment Sector in 2011

Sector	Jobs	%
Manufacturing	24,064	24%
Sales and Distribution	17,722	18%
Installation	52,503	52%
Other	5,948	6%
Total	*100,237*	*100%*

Source: National Solar Jobs Census 2011

The Census expected the number of jobs to grow to 123,951 in 2012, a 24% growth rate. This total includes direct and indirect jobs at establishments that report 50% or more of their jobs are supported by the solar PV industry. This is a somewhat different definition than captured by the employment model used in this analysis, which also includes the impacts of induced solar-related jobs. These jobs, which reflect the impact of spending by employees, are discussed in greater detail below on page 13.

Methodology and Assumptions

We estimate employment and revenue impacts of proposed tariffs in two steps. The first step relies on a standard economic model of tariffs and quotas that can be found in many economics textbooks.[20] This model provides us with estimates of changes in domestic and foreign producer revenues, consumer spending, and government revenue from tariffs (if any) based on information regarding producer and consumer price sensitivity (elasticity), production costs, product prices, and tariff levels. The second step relies on an input-output model of the U.S. economy. This model provides employment impact estimates based on changes in producer revenues and consumer spending.

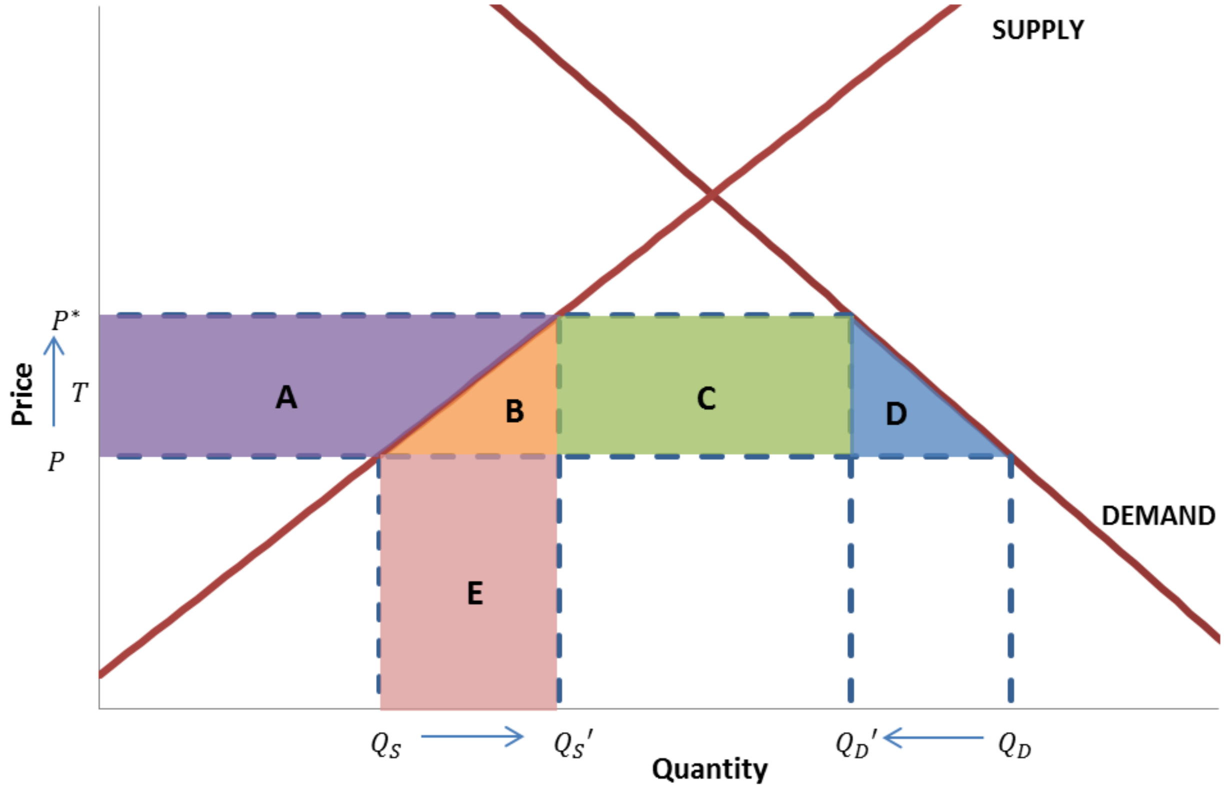
Tariff Model

The intuition behind the first model is as follows. The increase in price resulting from the tariff causes total demand for the product to decrease. Consumers that still purchase the product at the higher price lose money that they would have saved or used for other purposes if they had been able to purchase the product at the pre-tariff price. Some of consumers' increased spending is distributed to new and existing domestic producers, who increase production due to the higher price. A portion of increased consumer spending also flows to other non-domestic producers. To the extent those foreign producers are subject to the tariff, the government collects revenues equal to the amount of the tariff. The remainder of increased consumer spending flows out of the domestic economy. Figure 2 provides a graphic representation of these results.[21]

[20] See for example, Robert S. Pindyck and Daniel C. Rubinfeld, *Microeconomics*, 6th Edition, Pearson Prentice Hall: New Jersey, 2005.

[21] Ibid., Section 9.5, pp. 321-326.

Figure 2: Economic Model for Estimating Tariff Impacts



In Figure 2, the upward sloping line represents the supply curve of domestic producers and the downward sloping line represents the demand of domestic consumers for the good. The slope of the supply curve reflects the elasticity of supply, a measure of the degree to which producers respond to price changes. It also reflects the marginal cost of producing another unit. Similarly, the slope of the demand curve reflects the price elasticity of domestic consumers, which reveals how consumers respond to price changes.

In the absence of a tariff, the world price is P and output purchased by domestic consumers is Q_D. Of these domestic purchases, Q_S is provided by domestic producers and the rest (Q_D less Q_S) is imported. Introducing a tariff T raises price from P to P* and results in a corresponding drop in demand from Q_D to Q_D'. Domestic producers benefit from this in the form of greater revenues due to higher prices, as well as an increase in total output equal to the difference between Q_S and Q_S'. Domestic producers reap gains from two sources as a result of this price increase. The first source of gain is depicted by Trapezoid A, which represents the increased revenue to domestic producers associated with the tariff-induced price increase. The second source of gain, equal to areas B plus E, arises from increased domestic production at the higher price.

With the tariff, the total imports have now shrunk from the distance between Q_S and Q_D to the distance between Q_S' and Q_D'. While the U.S. government may gain taxes represented by area C in tariff revenues, consumers face higher prices and therefore cut back their purchases (from Q_D to Q_D'). The overall loss to consumers is equal to the sum of areas A+B+C+D.

The net benefit of the tariff can be judged by comparing changes in consumer and producer gains arising from the tariff. For example, are the producer surplus gains larger than the consumer surplus losses? There will also be a government gain in the form of tariff revenues to consider.

This model can be parameterized with real world data to evaluate the impacts of proposed tariffs on photovoltaic cells and modules produced in China.[22] For example, given data on the equilibrium world and domestic prices for PV modules, the market share of foreign and U.S. module manufacturers, and estimates of the elasticity of supply and demand for PV, we can calculate expected market movement along the supply and demand curves from an increase in module price. These movements along the curves represent the change in module production among U.S. manufacturers, and the change in total solar installations purchased by U.S. consumers. The amounts of these changes are then used to quantitatively analyze the job impacts of the potential tariff.

The model inputs data and assumptions required to implement the model are summarized below:

1. World prices and domestic prices for PV modules
2. World market share and domestic market share for PV modules
3. The price elasticity of domestic demand for these products
4. The price elasticity of domestic supply for these products
5. Domestic value component of non-module PV installation costs

Much of the above data differs significantly across consumer sectors (residential, commercial, and utility), and our analysis takes into account the different market forces acting upon each type of consumer. Due to a constantly evolving marketplace for PV, much of this data is subject to significant uncertainty and cannot be predicted with precision. However, we believe we have accounted for the likely range of marketplace characteristics, which enables us to estimate realistic outcomes. We have consulted a variety of sources including industry reports and experts, government studies, and academic research.

World and Domestic Prices

Our analysis requires projections of module price changes over the next three years. Based on a review of literature and industry reports, we selected projections of module prices in the three U.S. consumer sectors as well as average global prices out to 2014.[23] While the imposition of a tariff on Chinese imports is expected to substantially raise average prices within the U.S., technological advancement is still expected to lead to steady declines in module pricing.

In addition to these pricing forecasts, in order to establish the effect of a tariff on the price of modules and installed system prices we gathered information on:

1. The average annual domestic thin film market share
2. The percent of modules consumed that will be affected by the tariff
3. The cost of various components in the overall installed solar PV system

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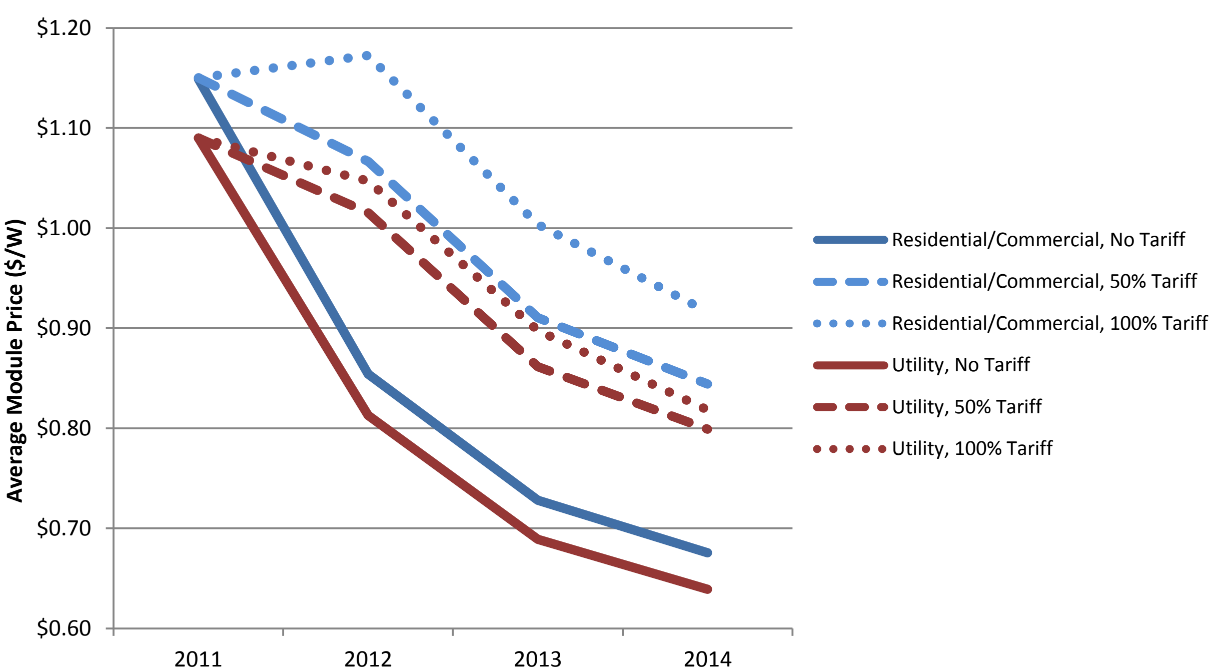
[22] We focus our analysis on modules. This is the case for two reasons. First, cells are commonly sold already installed in modules. Second, modules account for most of the affected sales.

[23] The most complete projections we found were GTM Research's module pricing forecasts.

The pricing forecasts separate price by sector and module type. The market penetration of thin-film modules in the U.S. is significant and needs to be accounted for in calculating average domestic prices of all installed modules. We use blended averages of predicted module prices to account for the sale of lower-priced thin film modules currently occupying significant market share in the U.S. Based on discussions with industry analysts and data from the Solar Energy Industries Association, we assume thin film modules are used in 5% of residential and commercial installations and 30% of all utility installations.[24]

Average module prices in the U.S. are largely determined by Chinese imports. A major industry report predicted that 41% of all PV installations in the U.S. used panels subject to a tariff in the third quarter of 2011.[25] Based on current market trends that percentage is increasing, and our analysis assumes an average of 50% of U.S. installations would use panels subject to the tariff over the next three years. We assume that with the downward price pressure from Chinese imports removed, average module prices will increase to the average world price if the tariff is set at a rate high enough to block Chinese imports. A 50% tariff will raise prices to within 5% of the current world average, while a 100% tariff will raise the price to the world average. This represents a 25-30% increase over module prices in absence of a tariff. For example, in 2012 residential module prices would be expected to rise from $0.85/W without a tariff to $1.07 under a 50% tariff, and $1.17 under a 100% tariff. Tariff rates above 100% would have little further impact, as China is already effectively priced out of the U.S. market at the 100% tariff level. Figure 3 below depicts predicted blended module prices over the next three years in each consumer sector with and without the imposition of a 50% or 100% tariff on Chinese imports.

Figure 3: Forecasted U.S. Module Prices through 2014



24 SEIA Major Solar Installations, http://www.seia.org/galleries/pdf/Major%20Solar%20Projects.pdf.
25 GTM Research U.S. Solar Market Insight Report Q3 2011, pg. 8.

Increases in the average price of solar modules will increase the price of installed solar systems. The overall solar PV's installed system prices are expected to decline in the future due to technological and efficiency gains. We assume system prices will continue to fall at a rate proportional to module prices in a competitive market. Module prices are thus predicted to maintain a constant share of total installed system price over time. Using data from a solar market research firm and discussions with industry analysts, we assume a 25% module share of total system price for residential and commercial systems, and a 40% share of utility system costs.[26] The difference in the proportion between residential/commercial and utility systems is accounted for by greater installation and permitting efficiency in larger-scale utility installations (and therefore lower "rest-of-the-plant" costs associated with installed costs) than for residential/commercial systems. Overall, while increasing module prices will increase system prices across all sectors, they are expected to have a larger relative impact on the price of utility systems.

Price Elasticity of Supply

The price elasticity of supply refers to how suppliers (in this case PV manufacturers) respond to price increases. Economists ask the question: "How much more product will they make if market prices rise?" (Recall that the price elasticity explains the slope of the supply curve in the economic model described on page 5. It represents the marginal cost of production. Producers will increase production so long as the marginal cost of production does not exceed the market price.) We found no formal estimate of this value in our literature review and discussions with industry experts. However, for the purpose of this study, we selected a value of 1, indicating that we assume that a one percent increase in price will result in manufacturers producing one percent more PV modules. A supply elasticity assumption of less than 1 would indicate that the supply is inelastic. Inelastic supply could be expected when an industry is running at peak production capacity (at least in a relatively short-term period). An elasticity assumption of greater than 1 indicates that supply is elastic, which will typically be the case when there is excess production capacity as manufacturers can quickly respond to higher prices because there is either capacity or the cost of increased production is low. As of early 2012, some excess production capacity exists globally as PV demand softens due to reduced subsidies and a weak European economy. In the U.S., inventories appear high even as some manufacturers have closed facilities. On the other hand, several new manufacturing facilities are scheduled to start up in the U.S. in the 2012-2013 timeframe. Consequently, a price elasticity of 1 seems relatively neutral and a reasonable assumption. We have also conducted sensitivity analyses accounting for a potentially much higher price elasticity of 2.7. This is the elasticity of renewable energy generation estimated by an economist at Georgia Institute of Technology.[27] Assuming this higher supply elasticity would lead to greater job creation from increased U.S. manufacturing in response to a tariff. We thus incorporate the higher elasticity value in our lower bound estimate of total job impacts from the proposed tariff.

To estimate how U.S. market share in module manufacturing would change in the face of a tariff on Chinese imports, we used available information to estimate a baseline domestic market share of U.S.-manufactured modules. Data collected from California Solar Initiative (CSI) installations shows that on

[26] GTM Research, U.S. Solar Energy Trade Assessment 2011.

[27] Erik Johnson, "The Price Elasticity of Supply of Renewable Electricity Generation: Evidence from State Renewable Portfolio Standard," Georgia Tech School of Economics, Working Paper #WP2011-001, October 2011. www.econ.gtech.edu/research/workingpapers.

average, approximately 30% of all installations associated with the CSI program over the last three years have used U.S.-manufactured modules.[28] This number has remained fairly constant in California over 2010 and 2011, even as the module imports from China have steadily increased during the same time period. We use the 30% as a proxy baseline market share percentage and apply it to the U.S. market in general, in the absence of more complete data.

Price Elasticity of Demand

The price elasticity of demand reflects how consumers (residential, commercial, and utility) respond to price changes. Our review of the literature and discussions with industry experts did not yield formal elasticities for any of the consumer categories. As a result we assumed values for each category based on relevant information.

To set a boundary on potential price sensitivity in the utility sector, we use scenarios in which the price increases resultant of a 50% tariff would cause utilities to cancel 20% and 50% of their total planned PV investment that has not yet begun construction. These scenarios are equivalent to assumed price elasticities of -2 and -5, respectively. Our industry demand forecast estimates 3.5 GW of PV currently in the pipeline over the next three years for which construction has not started. A 20% and 50% cancellation assumption represents a reduction of 0.7 GW and 1.75 GW of utility investment in solar power by 2014.[29] We understand that the planned utility-based solar PV capacity could be very sensitive to price changes. For instance, many of these utility-scale solar PV project developers have obtained approval at a fixed power price, and those investors have anticipated that PV prices would continue to fall as their projects move toward construction. Consequently, higher than expected prices could cause renegotiation of previously signed and approved power purchase contracts and would likely compromise many utility-scale projects. Relatedly, obtaining approvals from regulatory bodies for cost increases would be problematic because regulators are adverse to unexpected higher electricity prices. Higher PV prices will more rapidly drain funds allocated to incentives. Thus, incentives could be made more restrictive or eliminated.

To independently gauge the price sensitivity, we conducted investment discounted cash flow studies with and without the influence of a tariff. We found that the expected price impact of a 50% tariff resulted in a negative net present value at a typical 20MW PV plant.[30] In addition, some recent studies continue to show that the cost of solar PV for use at the utility level must continue to fall to be a viable competitor for renewable energy capacity.[31]

For the residential and commercial solar PV consumers, we use price elasticities of demand of -1 for our lower bound estimate and -2 for the high estimate. We based this assumption on the information

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[28] Average calculated based on quarterly CSI installation data from GTM Research, U.S. Solar Market Insight Report Q3 2011, pg. 38.

[29] Discussion with industry expert, 1/17/12.

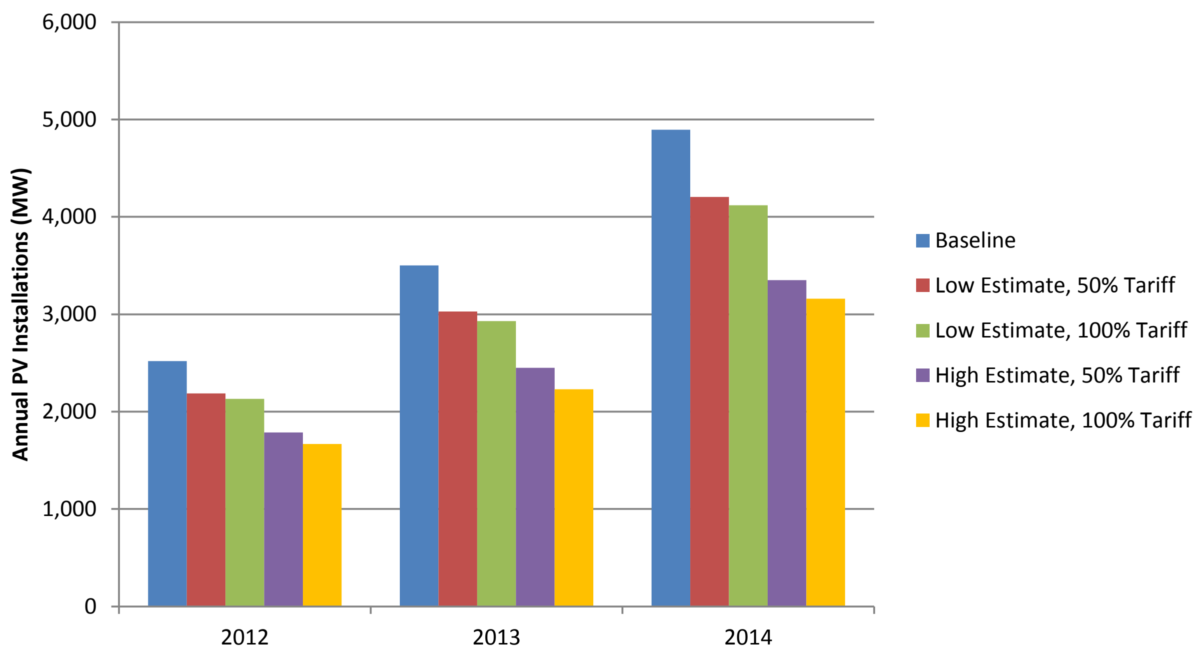
[30] This reflects an increase in the cost of capital of $270 per kW, and a 12% discount rate. This is not surprising since a 100% tariff would increase a 20MW plant's total capital cost by an average of $5.4 million. Further details are provided in Appendix 2.

[31] Paul Joskow, "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies, September 27, 2010 (revised February 9, 2011). Severin Borenstien "The Market Value and Cost of Solar Photovoltaic Electricity Production," Center for the Study of Energy Markets, University of California Energy Institute, UC Berkeley, CSEM WP 176, January 8, 2008.

provided by the National Renewable Energy Laboratory (NREL), which quantified expected changes in PV demand based on average system price changes due to a federal solar incentive program.[32] The data from the NREL report suggests an average price elasticity of -2 for the residential sector and -1.5 for the commercial sector over the period from 2008-2015.

Our lower bound and upper bound estimates of price elasticity yield different demand losses when tariff-induced module price increases are applied. Figure 4 shows the total predicted change in demand across all sectors for each scenario under a 50% and 100% tariff.

Figure 4: Tariff Impacts on Projected U.S. Demand



Revenue Impacts of Decreased Demand

Given the information outlined above, we were able to estimate revenue losses in the U.S. economy from decreased PV demand. While the change in production for U.S.-manufactured modules has already been calculated, there is a significant amount of domestic value created from all other areas in the PV industry. For each decreased MW of demand, there are significant losses to manufacturers of other PV hardware components, as well as the many affiliated companies which provide services related to permitting, engineering, financing, distribution, and installation. A breakdown of associated costs for a blended PV system is shown in Table 3.

32 J. Paidipati, et al. "Rooftop Photovoltaics Market Penetration Scenarios." (2008)

Table 3: Non-Module System Costs and Domestic Value Generation in 2010

Category	% of Total System Cost	% Domestic Value
Mounting Structure	8%	94%
Inverter	6%	45%
Combiner Box and Misc. Electrical	4%	59%
Site Preparation and Labor	11%	100%
Other Costs	39%	100%
TOTAL	**68%**	**92%**

Note: Other costs include permitting, legal, engineering, financing, and distribution costs.

Source: GTM Research, U.S. Solar Energy Trade Assessment 2011, pg. 42

The numbers shown in Table 3 are for a blended system in which module costs compose 32% of total system price and non-module costs make up approximately 68% of total system costs. We adjust the above costs proportionally to account for our module cost share assumptions of 25% in the residential and commercial sectors and 40% in the utility sector. Of the non-module costs, we assume a total domestic value component of 92% for an average system. Thus, each MW of reduction in demand for solar PV resulting from higher prices will decrease domestic revenues for all PV-related components and services depicted in the table above. Of those PV-related revenues, 92% will relate to direct spending losses in the U.S. economy.

Below in Table 4, we present the full set of assumptions used in our analyses.

Table 4: Modeling Assumptions

Parameter	Residential/Commercial	Utility
Average Annual U.S. Thin Film Market Share	5%	30%
% Modules Affected by Tariff	50%	50%
Module Share of Installed System Cost	25%	40%
Price Elasticity of Supply	2.7 (Low), 1 (High)	2.7 (Low), 1 (High)
% US-installed Modules Manufactured Domestically	30%	30%
Price Elasticity of Demand	-1 (Low), -2 (High)	-2 (Low), -5 (High)
Domestic Value Creation of Non-Module System Costs	92%	92%

Employment Model

Estimating changes in output and demand enable us to also estimate related changes in employment using IMPLAN. The IMPLAN model is used for economic impact analysis by over 2,000 public and private institutions, including the U.S. Department of Commerce, the Bureau of Economic Analysis, the U.S. Department of Interior, the Bureau of Land Management, and the Federal Reserve System member banks.[33] The IMPLAN modeling system relies on a matrix representation of the economy that describes the relationships among industries, consumers, government and foreign suppliers in order to derive the economy-wide impacts of changes in a specific industry. This matrix representation is the so-called Leontief matrix, which contains average input (purchase) coefficients that describe the mix of goods, services and labor that are required to produce a unit of output; that is, how the output of one industry is used as an input in other related industries. The resulting input-output coefficients represent what economists refer to as production functions.[34] The basic input-output model can be expressed in a straightforward equation: $X= (I-A)^{-1} *dY$ where (I-A) is the inverse of the Leontief matrix, dY is a change in final demand and X is output.

The IMPLAN model refines the U.S. economy into 440 unique sectors and allows for regional disaggregation down to the county level. IMPLAN can address national, state, regional and county level impacts. It accounts for interstate and county interdependencies through a set of domestic trade coefficients.

The model can be used to estimate the direct, indirect and induced impacts on employment, earnings and output as a result of final demand changes that result from a new investment in a particular industry or compilation of industries.[35] Alternatively, it can be used to estimate impacts on employment, earnings, and final demand as a result of output changes.[36] The *direct effect* captures the initial change in economic activity resulting from the new investment. For example, a direct employment effect of photovoltaic module production. The *indirect effect* reflects new economic activity that is stimulated by the direct investment in industries that supply inputs to the sector of initial change. For example, increased spending on engineering consulting services to support the construction of a production facility would be an indirect effect that arises during the construction phase of the plant. The *induced effect* captures the economic activity that results when the increased earnings generated by the direct and indirect economic activity is spent on local goods and services, for instance when construction workers hired to build the plant spend income on groceries, clothing, financial services, real estate, and healthcare. The economic impact of the project is the sum of these direct, indirect and induced effects.

Our IMPLAN analysis consists of three components: the increase in revenues to U.S. producers of modules, the consumer surplus loss due to the increase in the domestic price of PV cells and modules, and the loss in revenues from decreased installations of PV systems. The increase in revenues to U.S. producers of modules is simulated using an industry change activity type for the IMPLAN sector that encompasses solar cells manufacturing. The industry change activity type is the most fundamental and

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33 http://implan.com/V4/index.php?option=com_content&view=article&id=282:what-is-implan&catid=152:implan-appliance-&Itemid=2.

34 The production functions used in IMPLAN are based on the US Bureau of Economic Analysis' (BEA's) Benchmark Input-Output Accounts.

35 *Final Demand* is the demand of units external to the industrial sectors that constitute the producers in the economy, *e.g.*, households, government and foreign trade. (Miller and Blair, 1985) Output represents the value of industry production.

36 The general equation is solved with respect to X rather than Y.

commonly used method of modeling impacts in IMPLAN. The consumer surplus loss is treated as a negative institutional spending pattern for households earning $100,000 to $150,000 a year.[37]

Institutional spending patterns are another IMPLAN activity type that can be used to model the impact of spending by households or governments.[38] This spending is assumed to be induced by some other activity, such as a change in the output of a particular sector, and hence results only in induced effects. For the purpose of analysis, we interpret the consumer surplus loss due to the increase in the price of modules as the difference between income consumers would have spent and the income that they actually spent. In using the institutional spending pattern method, we treat the consumer surplus loss as an actual loss of income that would have been spent on the mix of commodities a household in the $100,000 to $150,000 income bracket typically demands. The total loss in revenues from decreased installations is simulated as a collection of changes in the demand for various related components and services, using the allocation scheme shown below in Table 5. Note that totals are directly proportional to the breakdown of non-module PV costs presented previously in Table 3.

Table 5: Non-Module System Costs IMPLAN Breakdown

Category	%
Mounting Structure	11.7
Inverter	8.8
Miscellaneous Electrical	5.9
Site Prep and Labor	16.2
Other Costs	57.4
Total	**100**

We have assumed that "Other Costs" include Engineering, Permitting/Environmental Services and Legal/Business Support such that each category is allocated 19.13% of the total loss in revenues. Each of these categories is mapped to a proper industry (NAICS) code and in turn, an IMPLAN industry code. Note that we explicitly model the materials expenditures for the Mounting Structure, Inverter and Miscellaneous Electrical. All other materials and equipment required in the construction of a solar PV system are purchased indirectly through spending on Site Prep and Labor when we run a final demand change through the construction sector. The IMPLAN sectors used in our analysis and their NAICS equivalents are shown in Table 6.

37 A recent study finds that customer-owned PV adoption is positively correlated to the fraction of household incomes above $150,000 per year, while third-party owned PV adoption is positively correlated to the fraction of household incomes above $100,000 per year. Eason, Drury et al. "The Transformation of Southern California's Residential Photovoltaic Market Through Third Party Ownership". *Energy Policy,* 2012.

38 http://implan.com/V4/index.php?option=com_multicategories&view=categories&layout=blog&cid=251:institutionalspendingpatterns&Itemid=14.

Table 6: NAICS to IMPLAN Sectors

Category	NAICS	NAICS Description	IMPLAN	IMPLAN Description
PV Module	334413	Solar cells manufacturing	243	Semiconductor and related device manufacturing
Mounting Structure	332322	Sheet metal work manufacturing	187	Ornamental and architectural metal products manufacturing
Inverter	335999	Inverters, solid-state, manufacturing	275	Other miscellaneous electrical equipment and component manufacturing
Miscellaneous Electrical	335313	Switchgear and switchboard apparatus manufacturing	268	Switchgear and switchboard apparatus manufacturing
Site Prep and Labor	237130	Alternative energy structure construction	36	Construction of other new nonresidential structures
Other Costs - Engineering	541330	Engineering services	369	Architectural, engineering, and related services
Other Costs - Permitting & Environmental	541620	Environmental consulting services	375	Environmental and other technical consulting services
Other Costs - Legal & Business Support	5614	Business support services	386	Business support services

The employment results are converted into full-time equivalent jobs using national averages from the Bureau of Economic Analysis.[39] [40]

Results

Employment Impacts

PV system price increases resulting from a tariff are expected to lead to decreased total demand across all consumer groups in the U.S. market, which would adversely impact the myriad jobs outside of module manufacturing which depend on domestic PV sales.[41] Our analysis indicates that tariffs on the order of 50 to 100% will substantially delay the growth of domestic demand for PV systems by homeowners, commercial establishments, and utilities. This delay results in notably fewer jobs than would otherwise be the case. For example, a 50% tariff is expected to put between 14,877 and 43,178 jobs at risk by 2014. Aggregate jobs at risk rise even higher under a 100% tariff, up to a maximum of almost 50,000 jobs in 2014. Chinese retaliation would result in even greater jobs at risk, as it is anticipated to come in the form of tariffs on U.S.-manufactured polysilicon. Chinese PV facilities are a major consumer of U.S. polysilicon, comprising $873 million in demand in 2010.[42] Potential retaliation and the removal of Chinese demand for polysilicon are expected to place almost 11,000 additional jobs at risk. Overall, possibly over 60,000 jobs are expected to be placed at risk as a result of a U.S. tariff.

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39 http://implan.com/V4/index.php?option=com_multicategories&view=article&id=628:628&Itemid=10.

40 Full-time equivalent (FTE) employment is defined as total hours worked divided by average annual hours worked in full time jobs. An FTE is assumed to work 2,080 hours in a standard year.

41 The National Solar Jobs Census forecasts total employment in the solar industry over the next year will grow by 24%, to a total of 123,951. It is important to note that the Census employment figures are not exactly equivalent to the direct, indirect, and induced jobs we estimate using IMPLAN. IMPLAN captures all jobs connected to PV production and installation, as well as jobs created by employee spending, while the Census accounts for jobs in those establishments that report they are involved in solar-related activities 50% of the time.

42 GTM, U.S. Solar Energy Trade Assessment 2011, pg. 16.

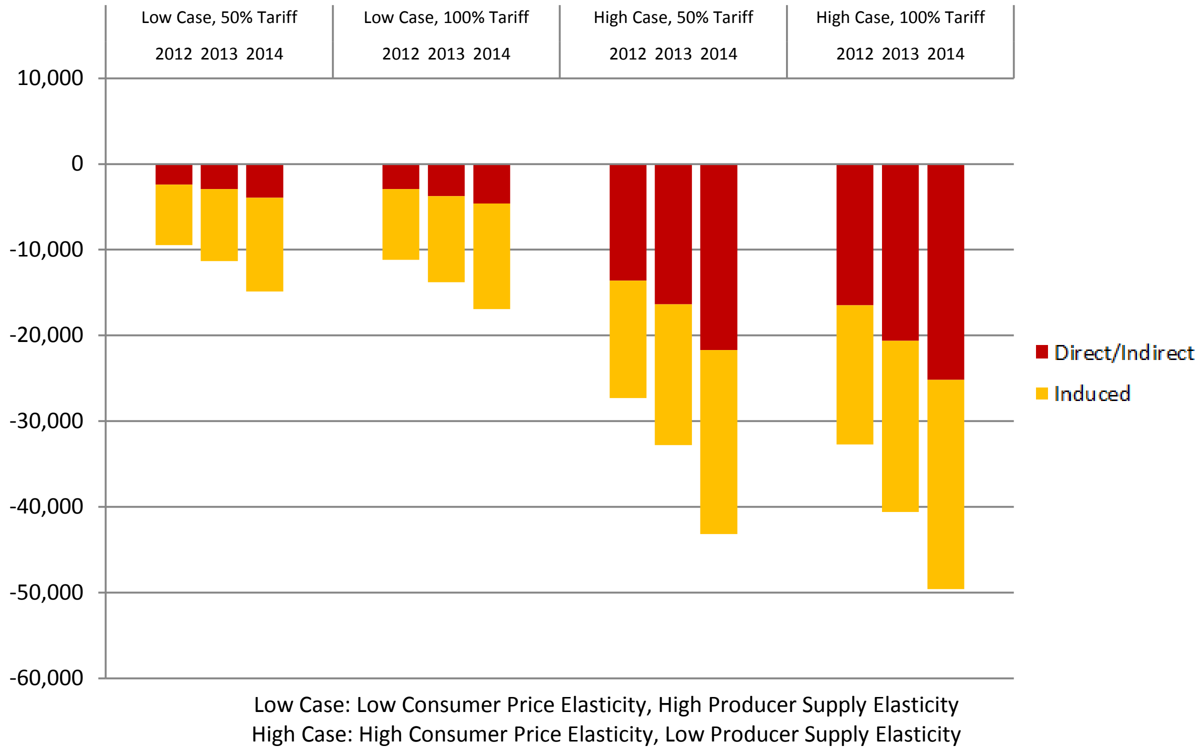
These estimates reflect the assumption that PV costs absent a tariff will continue to fall as technologies improve and further efficiency gains are made in production and installation. Should the rate of these improvements slow or fail to materialize, the impacts of the tariff would be significantly greater.

The aggregate job losses predicted for a low and high scenario under a 50% and 100% tariff are presented in Table 7 and Figure 5. As discussed previously, the low and high scenarios reflect different assumptions of demand and supply elasticity. These job impacts are also disaggregated into direct, indirect, and induced components. In the low case scenarios, indirect job impacts from a tariff are expected to be positive, while the direct and induced impacts are predicted to be significantly negative, for a net negative effect. This is explained by the difference in the number of indirect jobs created by module production compared to solar PV installation. IMPLAN shows that module production creates notably more indirect jobs than do solar installations. However, the net impact on direct and indirect jobs is negative in all cases. For example, in the low case scenario under a 50% tariff in 2014, the decrease of 5,391 direct jobs overwhelms the predicted 1,449 indirect job increase.

Table 7: Aggregate U.S. Jobs at Risk as Result of Tariff (FTE)

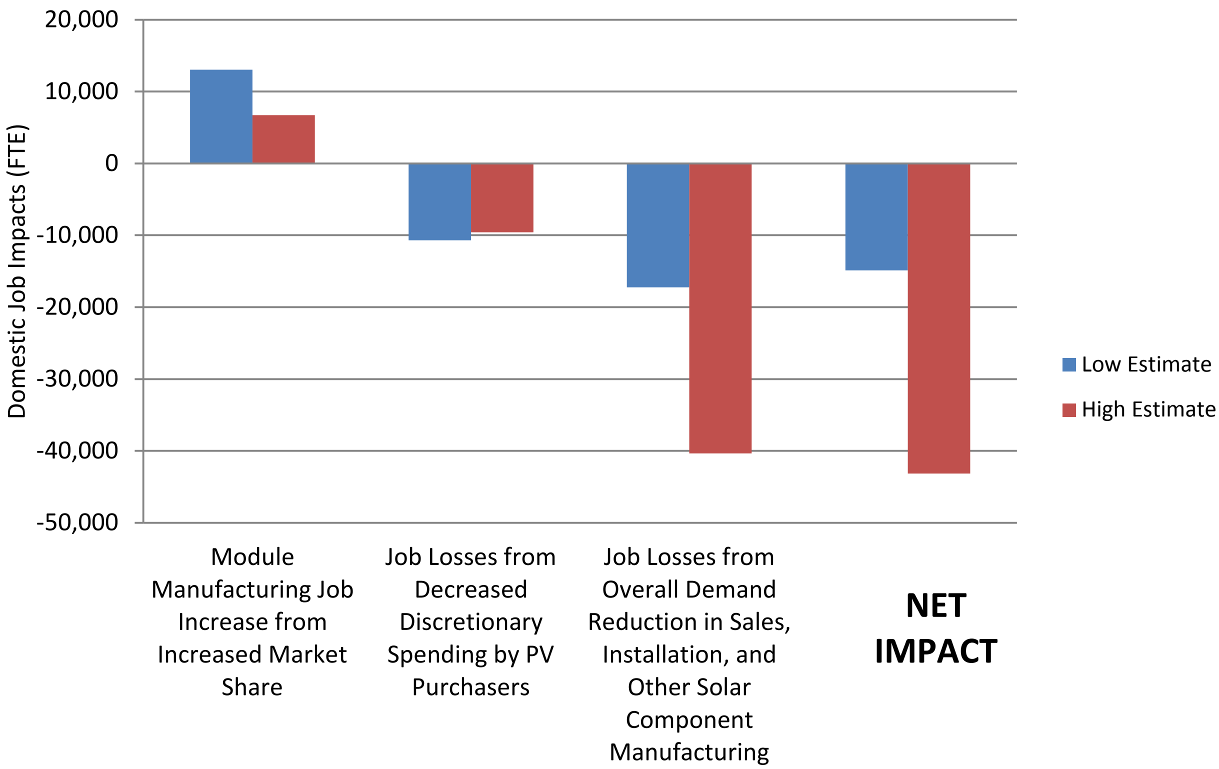
Scenario	**Year**	**Impact Type**			**Total**
		Direct	*Indirect*	*Induced*	
Low Case, 50% Tariff	2012	-3,396	994	-7,059	**-9,461**
	2013	-4,084	1,161	-8,414	**-11,337**
	2014	-5,391	1,449	-10,935	**-14,877**
Low Case, 100% Tariff	2012	-4,125	1,198	-8,252	**-11,179**
	2013	-5,148	1,412	-10,065	**-13,801**
	2014	-6,260	1,668	-12,325	**-16,917**
High Case, 50% Tariff	2012	-10,185	-3,402	-13,733	**-27,320**
	2013	-12,262	-4,115	-16,422	**-32,798**
	2014	-16,221	-5,492	-21,466	**-43,178**
High Case, 100% Tariff	2012	-12,337	-4,133	-16,241	**-32,712**
	2013	-15,424	-5,216	-19,954	**-40,593**
	2014	-18,799	-6,381	-24,409	**-49,589**

Figure 5: Solar-Related U.S. Employment Tariff Impacts



These aggregate job losses are net of job gains in production. As shown in Figure 6, a 50% tariff would create around 6,712 to 13,032 new jobs from an increased module manufacturing market share by 2014. However, between 9,560 and 10,684 jobs would be lost because of decreased discretionary spending by PV purchasers as a consequence of higher prices for the PV systems they purchase. In addition, the largest losses in the economy would occur as a result of overall demand reduction from higher prices. This would impact jobs in sales, installation, and other solar component manufacturing. The gain in market share for module manufacturing is thus more than offset by the decline in jobs due to reduced demand for PV systems. Overall, this is predicted to result in a net loss of 14,877 to 43,178 jobs in 2014.

Figure 6: U.S. Employment Impacts of a 50% Tariff in 2014



Note that as shown in Figure 6, jobs at risk from decreased discretionary spending by PV purchasers are actually lower under the high estimate than the low estimate. This is the result of the difference in demand elasticity assumptions between the cases. The high case reflects a higher price elasticity. Consequently, consumers are more sensitive to price changes, and will purchase fewer PV systems when faced with a higher price. These consumers then have more to spend on other goods and services, thereby reducing the induced employment impact. At the same time, since they purchase fewer PV systems their purchase decision reduces demand for PV systems thereby increasing the direct and indirect employment impacts. As shown in Figure 6, the net result is a substantially greater net job loss under the high case.

Predicted job impacts would be felt differently at the state level based on the location of module manufacturing facilities and the total installation demand in each state. Our analysis uses the relative state shares of domestic PV demand and the capacity of module production facilities in each state to estimate the relative share of jobs at risk across a number of states.[43] States which have high module production capacity but less installation-supported jobs are expected to have relatively fewer jobs at risk as a result of a tariff or possibly add jobs, whereas states such as California with a major share of total domestic PV demand and large numbers of installation-supported jobs will be much more sensitive to tariff impacts. Predicted aggregate jobs at risk for selected states are presented below in Table 8.

[43] Relative state share of domestic PV demand and module production obtained from GTM Research, U.S. Solar Market Insight Report Q3 2011, pg. 44 and 54.

Table 8: State-Level Jobs at Risk as a Result of a 100% Tariff in 2014

State	Year	Impact Type			Total
		Direct	*Indirect*	*Induced*	
Arizona	2012	-840	-251	-709	**-1,800**
	2013	-1,050	-314	-869	**-2,232**
	2014	-1,279	-383	-1,061	**-2,723**
California	2012	-5,269	-1,677	-4,651	**-11,597**
	2013	-6,580	-2,100	-5,701	**-14,381**
	2014	-8,017	-2,561	-6,967	**-17,544**
Colorado	2012	-552	-89	-371	**-1,012**
	2013	-691	-114	-454	**-1,259**
	2014	-843	-139	-556	**-1,538**
New Jersey	2012	-1,626	-451	-1,273	**-3,351**
	2013	-2,031	-565	-1,560	**-4,156**
	2014	-2,475	-689	-1,906	**-5,070**

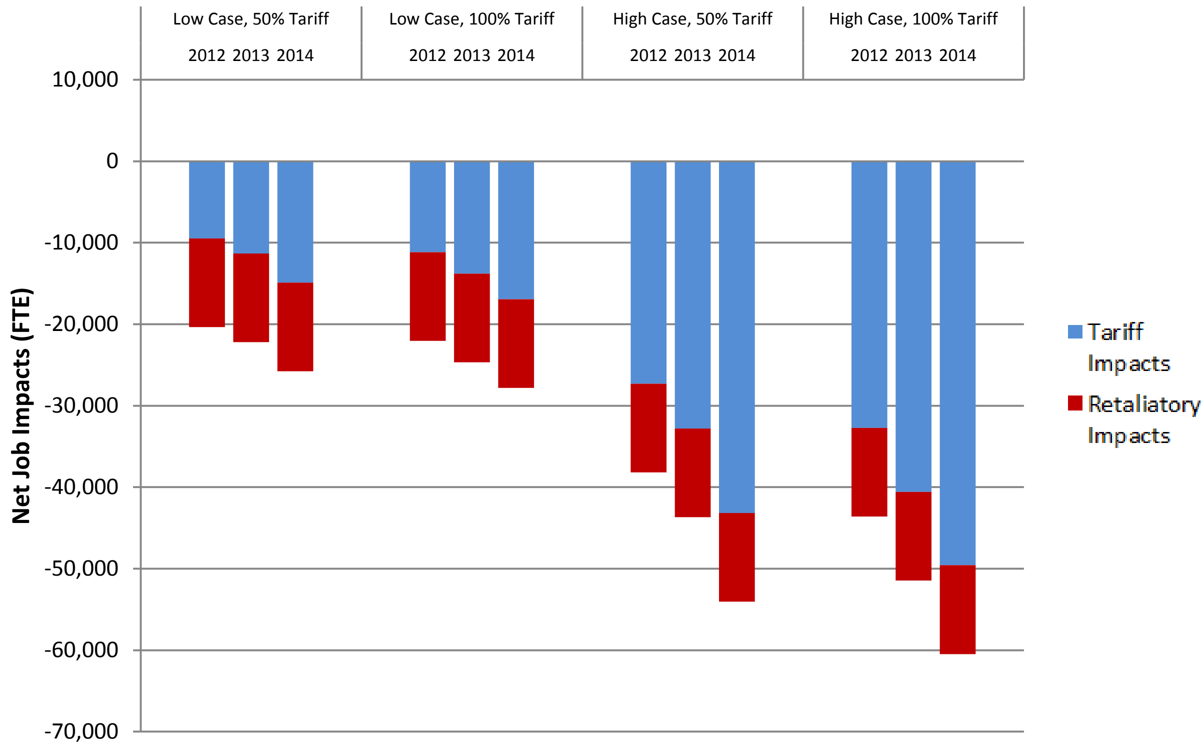
In addition to the impacts of a tariff on the U.S. industry, should China retaliate by imposing a tariff of its own an even greater number of jobs would be placed at risk. Our analysis assumes Chinese imposition of a retaliatory tariff on U.S.-manufactured polysilicon, effectively pricing U.S. exports out of the Chinese market. These exports totaled $873 million in 2010. Even without expected further growth in U.S. polysilicon production, removing the value of those exports from the domestic economy is forecasted to place almost 11,000 additional jobs at risk. Table 9 and Figure 7 display revised totals for jobs at risk under each scenario, assuming the burden of a Chinese retaliatory tariff. The totals below reflect jobs at risk under 2010 polysilicon production levels. Expansion of U.S. polysilicon production capacity is underway and Chinese demand is expected to increase significantly in the future.[44] Should this occur, the job impacts of a retaliatory tariff would be even larger.

Table 9: Chinese Retaliation Further Increases Expected Annual U.S. Jobs at Risk (FTE)

Direct	-1,645
Indirect	-4,061
Induced	-5,175
Annual Total	**-10,881**

[44] Discussion with industry representatives.

Figure 7: Solar-Related U.S. Employment Tariff Impacts, including Chinese Retaliation



Economic Impact

Recall that the economic model we rely on provides the basis to determine whether producer revenue gains (and government tariff revenues) exceed the loss to consumers. This is a key metric to establishing whether the tariff is economically efficient. As shown in Table 10 and Table 11 below, a 50% or higher tariff is decidedly inefficient. Consumer losses from increased price and lower demand exceed module manufacturer gains by at least $621 million under a 50% tariff and $698 million under a 100% tariff. There are no government tariff revenues because the tariff will price Chinese imports out of the domestic market.

Table 10: Domestic Revenue Impacts of a 50% Tariff in 2014 ($ millions)

Category	Low Impact Estimate	High Impact Estimate
Module Manufacturing Revenue Gains	$1,046	$539
Increased Consumer Costs	-$745	-$667
Decreased Demand Losses	-$922	-$2,159
Total	*-$621*	*-$2,287*

Table 11: Domestic Revenue Impacts of a 100% Tariff in 2014 ($ millions)

Category	Low Impact Estimate	High Impact Estimate
Module Manufacturing Revenue Gains	$1,210	$620
Increased Consumer Costs	-$838	-$739
Decreased Demand Losses	-$1,070	-$2,501
Total	*-$698*	*-$2,620*

References

Baldwin, John and Wulong Gu, "The Impact of Trade on Plant Scale, Production-Run Length and Diversification," Producer Dynamics: New Evidence from Micro Data, NBER Books, National Bureau of Economic Research, Inc., number dunn05-1, pp. 557-592, January 2009.

Bernstein, M.A. and J. Griffin, "Regional Differences in the Price-Elasticity of Demand for Energy," Subcontract Report, NREL/SR-620-39512, February 2006.

Bird, L., D. Hurlbut, P. Donohoo, K. Cory, and C. Kreycik, "Examination of the regional supply and demand balance for renewable electricity in the United States through 2015," *Publications (E),* Paper 23, 2009.

Black, Andy, "Economics of Solar Electric Systems for Consumers: Payback and other financial tests," Economics of Solar Electric Systems, July 2009.

Bollinger, Bryan and Kenneth Gillingham, "Peer Effects in the Diffusion of Solar Photovoltaic Panels," Draft Version, March 2010.

Borenstein, Severin, "The Market Value and Cost of Solar Photovoltaic Electricity Production," Center for the Study of Energy Markets, University of California Energy Institute, UC Berkeley, CSEM WP 176, January 8, 2008.

Connor, Sean, "The Growth of Solar Concentrator Photovoltaic Markets in the Southwest U.S.," April 2008.

Drury, Easan, Mackay Miller, Charles M. Macal, Diane J. Graziano, Donna Heimiller, Jonathan Ozik, and Thomas D. Perry IV, "The Transformation of Southern California's Residential Photovoltaics Market through Third-Party Ownership," *Energy Policy*, January 2012.

EuPD Research, "Economic Impact of Extending the Section 1603 Treasury Program," Prepared for the Solar Energy Industries Association, October 12, 2011.

European Photovoltaic Industry Association, "Global Market Outlook for Photovoltaics until 2014," May 2010 update.

Holt, Ed and Lori Bird, "Emerging Markets for Renewable Energy Certificates: Opportunities and Challenges," Technical Report, NREL/TP-620-37388, January 2005.

James, Ted, Alan Goodrich, Michael Woodhouse, Robert Margolis, and Sean Ong, "Building - Integrated Photovoltaics (BIPV) in the Residential Sector: An Analysis of Installed Rooftop System Prices," Technical Report, NREL/TP-6A20-53103, November 2011.

Johnson, Erik, "The Price Elasticity of Supply of Renewable Electricity Generation: Evidence from State Renewable Portfolio Standards," School of Economics, Georgia Institute of Technology, Work Paper # WP2011-001, October 2011.

Joskow, Paul L., "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies, September 27, 2010 (revised February 9, 2011).

Klein, Joel and Anitha Rednam, “Comparative Costs of California Central Station Electricity Generation Technologies,” California Energy Commission, Electricity Supply Analysis Division, CEC-200-2007-011.

Luque, Antonio, “Photovoltaic Market and Costs Forecast Based on a Demand Elasticity Model,” *Progress in Photovoltaics: Research and Applications*, 2001; **9**:303-312.

Miller, Ronald E. and Peter D. Blair, *Input-Output Analysis Foundations and Extensions*, Prentice Hall, Englewood New Jersey, 1985.

Milstein, Irena and Asher Tishler, “Intermittently renewable energy, optimal capacity mix and prices in a deregulated electricity market,” *Energy Policy*, 2011, vol. 39, issue 7.

Navigant Consulting, Inc., “Economic Impacts of Extending Federal Solar Tax Credits,” Prepared for the Solar Energy Research and Education Foundation (SEREF), Final Report, September 15, 2008.

Paidipati, J., L. Frantzis, H. Sawyer, and A. Kurrasch, “Rooftop Photovoltaics Market Penetration Scenarios,” Subcontract Report, NREL/SR-581-42306, February 2008.

Pindyck, Robert S. and Daniel L. Rubinfeld, “Microceconomics,” Sixth Edition,

Renewable Energy Transmission Initiative Phase 1B Final Report, prepared for the RETI Coordinating Committee and RETI Stakeholder Steering Committee, January 2009.

Rubini, Loris, “Innovation and the Elasticity of Trade Volumes to Tariff Reductions,” Arizona State University, 2010.

Sarzynski, Andrea, “The Impact of Solar Incentive Programs in Ten States,” George Washington University Institute of Public Policy, Technical Report, Revised March 2010.

Sawhney, Aparna and Matthew E. Kahn, “Understanding Cross-National Trends in High-Tech Renewable Power Equipment Exports to the United States,” National Bureau of Economic Research, Working Paper 17217, July 2011.

Swan, Lukas G. and V. Ismet Ugursal, “Modeling of end-use energy consumption in the residential sector: A review of modeling techniques,” *Renewable and Sustainable Energy Reviews*, Volume 13, Issue 8, October 2009, pp. 1819-1835.

The Solar Foundation, “National Solar Jobs Census 2010: A review of the U.S. solar workforce,” October 2010.

The Solar Foundation, “National Solar Jobs Census 2011: A review of the U.S. solar workforce,” October 2011.

U.S. Department of Energy, “2008 Solar Technologies Market Report,” January 2010.

U.S. International Trade Commission, “Crystalline Silicon Photovoltaic Cells and Modules from China,” Investigation Nos. 701-TA-481 and 731-TA-1190 (Preliminary), Publication 4295, December 2011.

Wei, Max, Shana Patadia, and Daniel M. Kammen, “Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the U.S.?” *Energy Policy*, Volume 38, Issue 2, February 2010.

Appendix 1

Table 12: U.S. Photovoltaic Demand Forecasts

No.	Source Details
1	Solarbuzz Quarterly; Third Quarter 2011; Sept. 21, 2011; p.11 (Q3 2011 Forecast)
2	Solarbuzz Quarterly; Q4'11 PV Industry and Market Analysis; p.11 (Q4 2011 Forecast)
3	Bloomberg New Energy Finance; Solar-Quarterly Outlook Q1 2011; Mar. 23, 2011; p.19 (Conservative Forecast)
4	Bloomberg New Energy Finance; Solar-Quarterly Outlook Q1 2011; Mar. 23, 2011; p.19 (Optimistic Forecast)
5	PHOTON Consulting - Demand by Country, 2009-2015; Jan. 2011; p.S521 & S770
6	European Photovoltaic Industry Association; Global Market Outlook for Photovoltaics Until 2014; May 2010; p.20 (Moderate Scenario)
7	European Photovoltaic Industry Association; Global Market Outlook for Photovoltaics Until 2014; May 2010; p.20 (Policy-Driven Scenario)
8	GTM Research - Solar Energy Industries Association; US Solar Market Insight Report; Q3 2011; p.53 (Downside Case)
9	GTM Research - Solar Energy Industries Association; US Solar Market Insight Report; Q3 2011; p.53 (Base Case)
10	GTM Research - Solar Energy Industries Association; US Solar Market Insight Report; Q3 2011; p.53 (Upside Case)
11	EIA - AEO 2011; Apr. 26,2011; Table 120; http://www.eia.gov/forecasts/aeo/tables_ref.cfm

Appendix 2

Table 13: 50% Tariff Impacts on Typical PV Plant Discounted Cash Flow

	Units	Base Scenario	Increased Module Price Impacts	Additional Cost Scenario
Assumptions				
Project Size	MW	20	-	20
Project Life	Years	20	-	20
Net Capacity Factor	%	20%	-	20%
PPA Rate (including SRECs)	$ / MWh	185	-	185
Operating Expenses	$/ kW - Year	27	-	27
Debt Terms:				
Interest Rate	%	6.50%	-	6.50%
Term	Years	10	-	10
Investment Tax Credit	%	30%	-	30%
Bonus Depreciation		Y		Y
Projected Constructed Cost	$ / kW	3,130	270	3,400
Source & Uses				
Sources:				
Debt	$M	23.2	0	23.2
Equity	$M	20.7	3.8	24.4
ITC	$M	18.8	1.6	20.4
Uses:				
Project Cost	$M	62.6	5.4	68
Average Cash Flows (First 10 Years)				
Revenue	$M	5.7	-	5.7
Operating Expenses	$M	0.6	-	0.6
EBITDA	$M	5.1	-	5.1
Debt Service	$M	3.2	-	3.2
Calculated DSCR	Cash/Debt Service	1.62	-	1.62
Post-Tax Returns (5 Year MACRS on eligible capital)				
Equity IRR	**%**	**13.00%**	**-4.20%**	**8.80%**
Equity - NPV 12	**$M**	**0.5**	**(2.2)**	**(1.8)**