TESTIMONY OF
SHAYLE KANN
MANAGING DIRECTOR, SOLAR
GTM RESEARCH

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON NATURAL RESOURCES
Thursday, September 8, 2011
10:00 a.m.

Oversight Hearing on "Creating American Jobs by Harnessing our Resources: U.S. Offshore and Renewable Energy Production"

Chairman Hastings, Ranking Member Markey and members of the Committee, thank you for the opportunity to testify before you today. I am Shayle Kann, Managing Director of the solar program at GTM Research, a market analysis and consulting firm focused on renewable energy and smart grid technologies. Our team monitors and forecasts dynamics in the U.S. and global solar markets.

GTM Research formed a partnership with the Solar Energy Industries Association in 2010 to begin collecting, aggregating, and analyzing data on the U.S. solar market with greater detail than had previously been available. This partnership has spawned a series of quarterly reports tracking U.S. solar manufacturing and installations. We have also published two iterations of an annual report entitled *U.S. Solar Energy Trade Assessment*, which analyzes trade flows and value creation in the U.S. solar market.

Utilizing data from these reports, my testimony will address three topics. First, I will provide a framework to understand issues of trade, competitiveness, and job creation in the solar industry. When surveyed in its entirety, the U.S. solar industry shines as one of the few bright spots in a continuing difficult macroeconomic climate. Installations more than doubled last year, the U.S. ran a trade surplus both globally and specifically with China, and 73 cents out of every dollar spent on a U.S. solar installation stayed in the U.S. Second, I will discuss the future of domestic solar manufacturing, whose fortunes rest squarely on the shoulders of the continued development of innovative technologies that can compete with established, low-cost players in China and elsewhere. The intellectual property and research behind these technologies still largely resides within U.S. borders, and the U.S. can remain a leader in such early manufacturing. Continued innovation, however, requires significant investment in research and development. Finally, I will provide recommendations for how the federal government can sustain and build upon this momentum to make the U.S. the world's largest solar market by 2015 with a global market share of more than triple what it was in 2010.

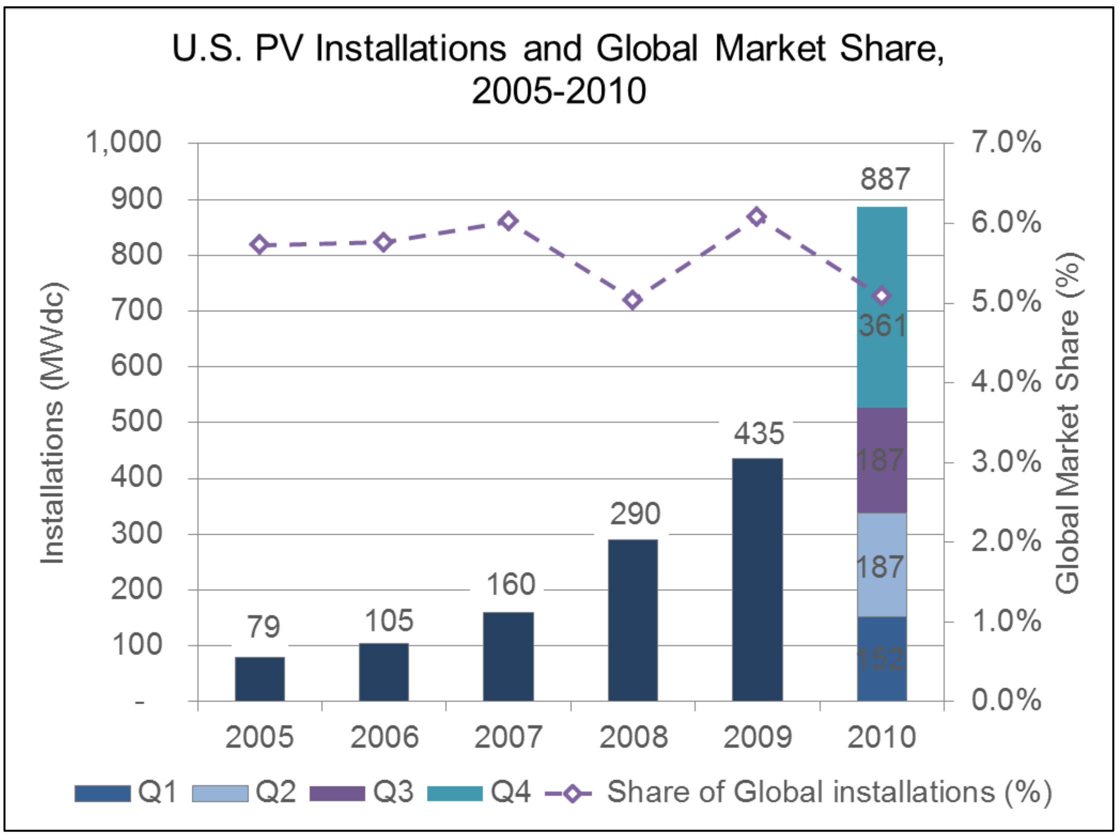
The U.S. solar industry is strong. Demand, private investment, and most importantly, employment are on the rise. A stable and reliable policy landscape will ensure that solar can serve as an engine of economic growth throughout the U.S.

The State of the U.S. Solar Market

Let me begin by providing an update on the state of solar in the U.S. I will focus my attention on solar photovoltaics, or PV, since this technology currently comprises approximately 82% of the total U.S. solar industry by economic value.

In 2010, the U.S. PV market grew 104% to install 887 megawatts (MW), the equivalent of 160,000 residential installations. The first half of 2011 saw the market on track to grow another 72% this year. GTM Research anticipates an even stronger second half and a near-doubling of installations again in 2011. Still, from a global perspective the U.S. has a long way to go to become a market leader. From 2005-2010, the U.S. market share of global PV installations hovered between 5% and 7%. In other words, the U.S. solar market grew in line with the rest of the world. In 2011 a slowdown in major European markets such as Germany and Italy, combined with continued rapid growth in the U.S., has meant that the U.S. is becoming an increasingly important end-market for solar power. **We anticipate that U.S. market share of global installations will more than triple to 17% by 2015.**

Figure 1 U.S. PV Installations and Global Market Share, 2005-2010



Source: SEIA®/GTM Research U.S. Solar Market Insight: 2010 Year-In-Review

The extraordinary market growth that we have seen in the U.S. has been driven by many factors, but two stand out. First, the Section 1603 Treasury Program, named after its section of the federal tax code, has been absolutely vital since its introduction in 2009. This program is an offshoot of the Investment

Tax Credit (ITC), the cornerstone of federal policy to support solar installations. The ITC, which was enacted as part of the Energy Policy Act of 2005, offers a 30% tax credit on solar installations and has been the primary driver of industry growth in the U.S. However, the program relies on the ability to monetize tax credits, which has historically been solved through tax equity investors in solar projects. In the wake of the financial crisis and recession, Congress introduced the Section 1603 program, which enabled commercial solar project owners to receive a grant in lieu of the ITC. That program was extended in late 2010 but is currently scheduled to expire at the end of this year. This leaves the industry facing a looming shortfall in available tax equity for solar projects that would otherwise move forward. Although Section 1603 is not the direct jurisdiction of the Natural Resources Committee, it is a critical program nonetheless.

The second factor enabling growth is that prices for PV panels have fallen substantially over the past three years, and even over the past six months. Since the end of 2008, average panel prices have fallen over 61%. Much of this price decline has taken place this year, with panel prices already falling 30% in 2011 alone. While this has created an exceedingly difficult landscape for panel manufacturers, which I will discuss later in this testimony, it has also created an increasingly attractive environment for solar installations.

Given the right market conditions, we forecast that the U.S. will become the world's leading PV market by 2015 with an annual installation rate of more than six gigawatts (GW), more than ten times the 2009 total.

Where Can Solar Create Economic Value for the U.S.?

There is a common misconception that stimulating demand for solar in the U.S. just adds to the revenues of foreign manufacturers. Generally, this assessment is determined solely by the location of the PV module (panel) assembly. That is, if the module itself comes from abroad, the solar array is said to be foreign-sourced. Given that module assembly increasingly takes place in lower-cost regions such as China, this has led many to believe that U.S. solar installations are largely channeling value to foreign manufacturers.

This faulty line of reasoning ignores two key points:

1) Most PV modules are manufactured through a multi-step process, and different stages often take place in different locations.

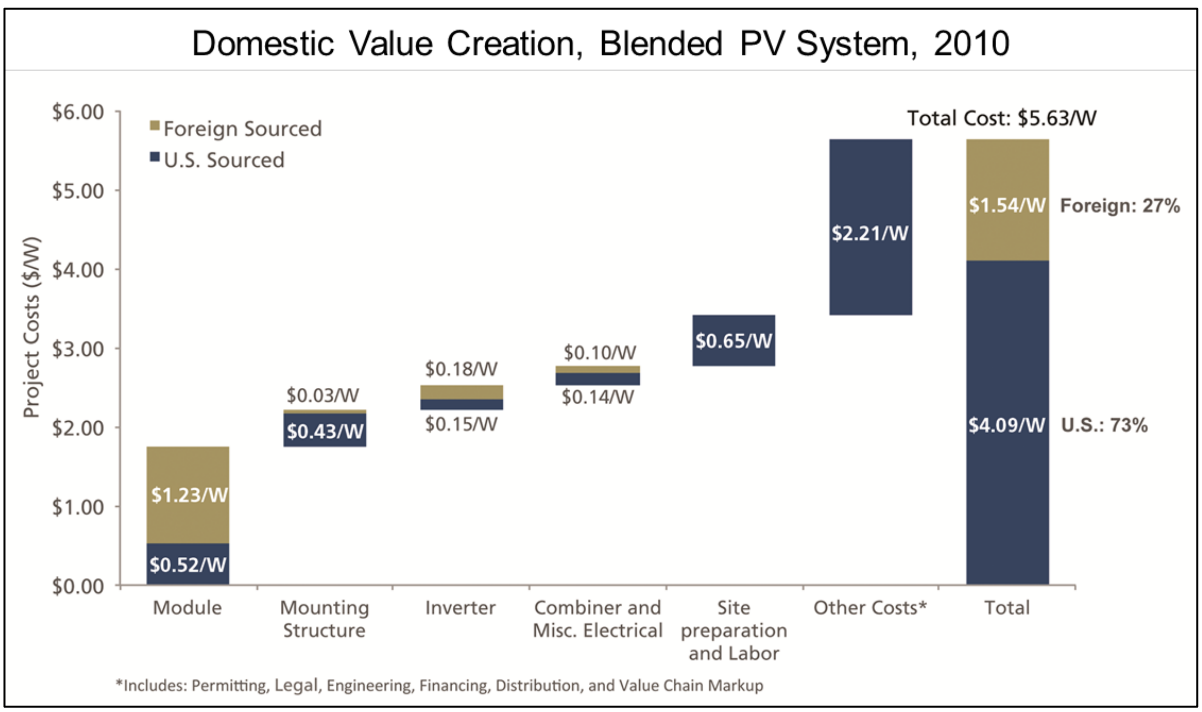
2) The module itself comprises less than 50% of the total PV system value. Other components such as mounting structures, as well as non-hardware costs, make up the majority of the investment in a PV installation.

Sources: Hemlock Semiconductor, Schott Solar, PV-Tech, Suntech Power Holdings, National Park Service

Our recent study, *U.S. Solar Energy Trade Assessment 2011*, examines the location of final module assembly as well as production locations for early steps in the value chain, including polysilicon (raw feedstock) and manufacturing equipment. It also accounts for elements of the solar value chain such as installation labor, site preparation, legal costs, and financing costs, the value of which accrues directly to the U.S. for domestic installations.

Our first major finding was that, on average, 73% of PV system value was created in the U.S. in 2010. This means that 73 cents out of every dollar spent on a PV installation in the U.S. in 2010 stayed in the U.S. This equates to a total of $3.6 billion in domestic value creation out of a total $5 billion market in 2010, and the numbers will undoubtedly be higher in 2011.

Figure 2 Domestic Value Creation, Blended PV System, 2010



Source: U.S. Solar Energy Trade Assessment 2011

Much of this value comes from outside the panel itself. The "soft costs" associated with a PV system, described above, contribute as much as 51% of total system value and are rarely, if ever, outsourced. To be clear, there is real economic value and real job creation in the installation portion of the industry. To provide a few concrete examples:

- SolarCity, a national provider of solar solutions and financing, has over 1,200 employees, of which nearly 500 were added in the past year. SolarCity plans to hire 200-300 more by the end of this year, including 16 new employees starting this week. The company operates in 25 physical locations across 11 states.

- Mainstream Energy, a company that includes a solar project developer and a solar product distributor, hired 245 permanent employees over the past 12 months and expects to hire an additional 280-300 over the next 12 months.

- Sungevity, a residential solar financing provider, has quadrupled its workforce in the past 12 months and now employs 300 people.

- SunRun, a residential solar service provider, tripled its staff to over 100 employees in 2010. The company provides financing solutions for a network of installers that support over 3,000 jobs.

In contrast to the early days of the solar industry when projects were sparse and many installation jobs were temporary, these are pure solar companies running at full steam and the jobs they create are permanent – as long as the market exists.

Do We Still Manufacture?

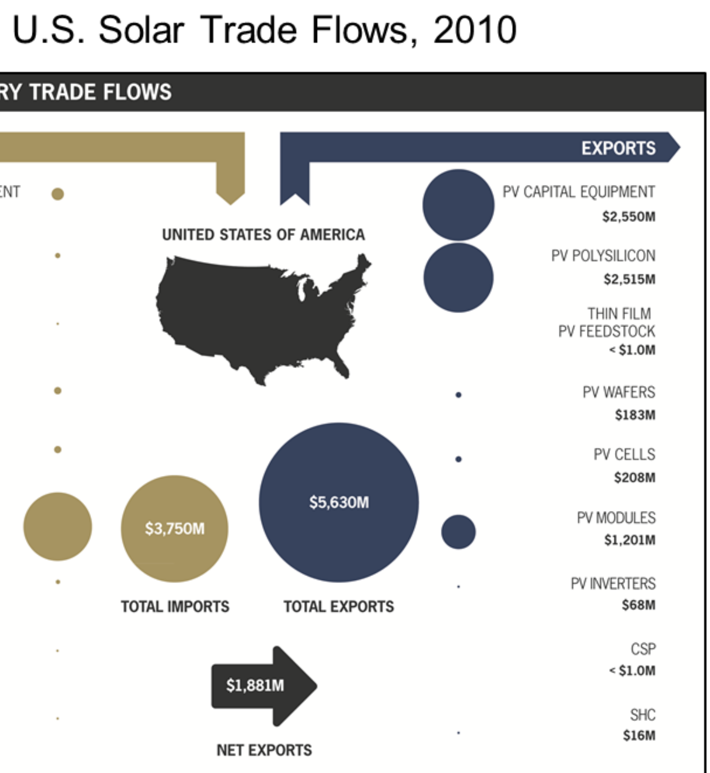
Solar manufacturing in the U.S. has become a highly contentious topic in light of three recent bankruptcy filings from U.S.-based panel manufacturers. Indeed, it has been a difficult period for PV manufacturers globally. The competition for share of the module market has been brutal; the industry is currently dominated by large, vertically-integrated Chinese firms that have received billions of dollars in low-cost loans from Chinese state banks and have access to a well-developed domestic supply chain for solar manufacturing.

Recent industry dynamics have strengthened these headwinds for manufacturers. Since early in the second quarter of 2011, solar manufacturers have been thrust into an environment of over-supply by an unexpected slowdown of end-demand in Germany and Italy, which together comprised 63% of the global PV market last year. As a result, panel prices have already fallen by 30% in 2011. These factors led to a number of announced factory closures in the U.S. over the past six months from manufacturers that could not compete with today's pricing.

Although some companies have folded, competitively positioned firms are still investing in domestic panel manufacturing facilities. First Solar, for example, has begun construction of a new 250 megawatt plant in Mesa, Arizona for which it expects to hire 600 people. Other companies such as General Electric are also planning new large manufacturing facilities in the U.S. In total, there are at least seven new module manufacturing facilities planned for the U.S. with a total capacity of over 500 megawatts. This also relates to the U.S. as a growing end-market. Suntech Power, a Chinese panel manufacturer, opened a 50 megawatt facility in Goodyear, Arizona last year in order to serve demand in the U.S. and has stated its intention to expand the facility to 120 megawatts if the market environment continues to thrive.

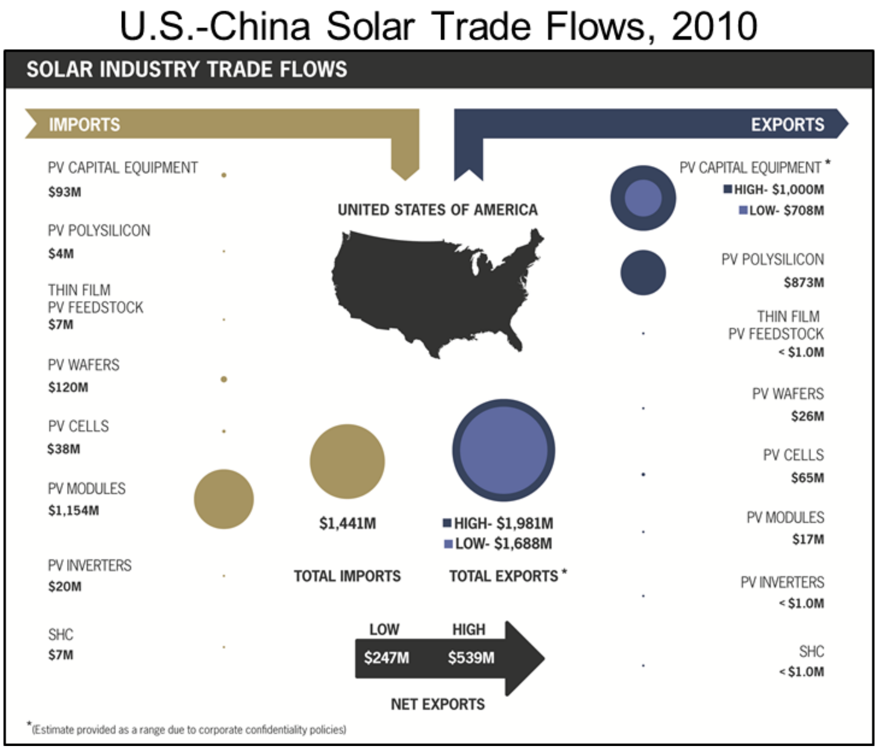
Moreover, the U.S. continues to be a world leader in PV research and development, polysilicon feedstock manufacturing, and capital equipment for PV manufacturing. In *U.S. Solar Energy Trade Assessment 2011*, we found that the U.S. was a net exporter of solar products by $1.9 billion in 2010. Even more notably, the U.S. ran a trade surplus with China by at least $247 million. Figure 3 displays overall U.S. solar trade flows, while Figure 4 isolates those trade flows that occurred with China. In essence, the U.S. sold a great deal of manufacturing equipment and polysilicon feedstock to China, while China primarily shipped finished PV modules back to the U.S. To the extent that the U.S. remains a world leader in these elements of the value chain, it will benefit from every expansion of the global PV industry.

Figure 3 U.S. Solar Trade Flows, 2010



Source: U.S. Solar Energy Trade Assessment 2011

Figure 4 U.S.-China Solar Trade Flows, 2010



Source: U.S. Solar Energy Trade Assessment 2011

It will be difficult for the U.S. to compete with China at its own game – namely, high-volume manufacturing of a commoditized product – given the cost advantages available for Chinese manufacturing. However, the U.S. can and should continue to develop and commercialize innovative technologies that offer lower costs than traditional panels. These new technologies are generally proprietary, require a more skilled labor force, and are difficult to duplicate. First Solar is an example of this; the company's Perrysburg, Ohio manufacturing facility is cost competitive with any foreign supplier, and no other company has been able to successfully copy First Solar's technique with any degree of success.

The future of domestic solar manufacturing lies squarely on the shoulders of innovative technologies that can compete with Chinese players on a cost basis. The intellectual property and research behind these new technologies still largely resides within U.S. borders, and the U.S. can remain a leader in such early manufacturing. However, this necessitates continued heavy investment in research and development. Programs such as the Department of Energy's SunShot Initiative provide enormous value in this regard. Just last week the DOE awarded more than $145 million to 69 PV research and development projects in 24 states. Many of these technologies have the potential to bring PV costs down even further.

Many of the most innovative solar companies in the world have been spun out of U.S. universities and are building manufacturing facilities in the U.S. Suniva, a Georgia Tech spin-out, manufactures its cells and modules in Norcross, Georgia. Meanwhile, 1366 Technologies is building a 20 MW facility in

Massachusetts to drastically lower silicon wafer costs with technology developed at MIT. National laboratories also play a role; the National Renewable Energy Laboratory (NREL) has spawned more technological innovations in PV than any other single source.

What Policies Will Enable the Solar Industry to Remain an Engine of Economic Growth?

The first action that the federal government can take to enable the continued growth of the U.S. solar industry is to support market demand with a clear, stable policy landscape. Most immediately, Congress can extend the 1603 Treasury program to allow the market to expand without creating a tax equity bottleneck. There are over 10 gigawatts of large PV projects that have power purchase agreements signed by U.S. utilities, many of which are just awaiting financing to begin construction. Given slow overall economic growth, tax equity availability will unnecessarily constrain these projects.

Ultimately, policymakers should disentangle solar incentives from taxes all together. Ideally, this would be achieved through an extension of the Section 1603 program through 2016 to match the tenure of the ITC. However, even a one-year extension would enable continued strong growth of the domestic solar market. Even though the Section 1603 program is not the direct purview of the Natural Resources Committee, I urge Committee members to support the program's extension this year.

Financing is the primary barrier remaining for solar deployment in the U.S. Apart from extension of the 1063 Treasury Program, creation of the Clean Energy Deployment Administration, or CEDA, would enable technologies to bridge the so-called Valley of Death between proof-of-concept and mass production. CEDA passed out of the Senate's Environment and Natural Resources Committee in 2009 with bipartisan support, and a very similar version of this program passed in the House this year.

Congress should also continue to support R&D investment in solar technology. Programs like the SunShot initiative will maintain the U.S. lead in technological innovation and early-stage manufacturing.

Conclusion

We stand at a critical juncture in the development of the solar power market in the U.S. Many companies, both manufacturers and installers, are just beginning to invest in the U.S. market to gain a foothold in case it truly reaches a tipping point. The U.S. has spent the last few years building up the early infrastructure and business models that will support this level of growth. Now we need continued private investment and a stable, reliable policy landscape in order to realize the market's potential.

At the same time, solar manufacturing in the U.S. is growing overall but being outpaced by expansion abroad. Still, the U.S. remains a breeding ground of technological innovation in solar manufacturing. By continuing to invest in research and development and supporting promising technologies through commercialization, we can place the U.S. in the driver's seat as solar travels down the cost curve.

On behalf of GTM Research and its parent company, Greentech Media, I'd like to thank Chairman Hastings, Ranking Member Markey and members of the Committee for the opportunity to testify today.

U.S. Solar Energy Trade Assessment 2011:

Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States

A GTM Research Study

Prepared for Solar Energy Industries Association® August 2011

TABLE OF CONTENTS

LIST OF FIGURES

Solar Energy Industries Association:

Tom Kimbis, Vice President, Strategy & External Affairs
Justin Baca, Senior Research Manager
John Smirnow, Vice President, Trade & Competitiveness
Will Lent, Research & Policy Analyst
RESEARCH@SEIA.ORG

GTM Research:

Shayle Kann, Managing Director
Shyam Mehta, Senior Analyst
Brett Prior, Senior Analyst
MJ Shiao, Solar Analyst
Andrew Krulewitz, Research Associate
SOLARANALYSTS@GTMRESEARCH.COM

1 EXECUTIVE SUMMARY

Trade

This is the second annual edition of a study first published in November 2010. It is a comprehensive analysis of trade flows and domestic value creation in the U.S. solar energy industry for the calendar year 2010. The primary intent of this study is to go beyond the relatively simplistic analysis of solar trade issues often provided in both industry and political circles. Specifically, most prior analyses have focused on estimating domestic production versus imports of individual components of a solar system, particularly the solar module (also known as the panel). However, a complete assessment of solar trade flows needs to be both broader and deeper.

In contrast to other research, this study:

- Captures critical elements of the solar value chain such as installation labor, legal costs, and other "soft costs", the value of which accrues directly to the U.S. for domestic installations;
- Analyzes trade flows of components of a solar installation, such as polysilicon, that are omitted in other analyses;
- Examines, in the case of photovoltaic (PV) modules, not just the location of final assembly but also production locations for earlier steps in the value chain; and
- Examines all mainstream solar technologies types individually and aggregated – photovoltaics, concentrating solar power (CSP), and solar heating and cooling (SHC).

In addition, this updated version of the report considers two important elements that were not included in last year's report: capital equipment and thin film PV feedstock.

Domestic Value Creation

A significant portion of the revenue generated by solar projects resides beyond the physical components, as site preparation, installation labor, permitting, financing and other soft costs comprise nearly 50% of the total cost of a typical project. Accordingly, when evaluating solar installations this study focuses on the proportion of "total value created" in the U.S. rather than just the components that would figure into a "domestic content" calculation.

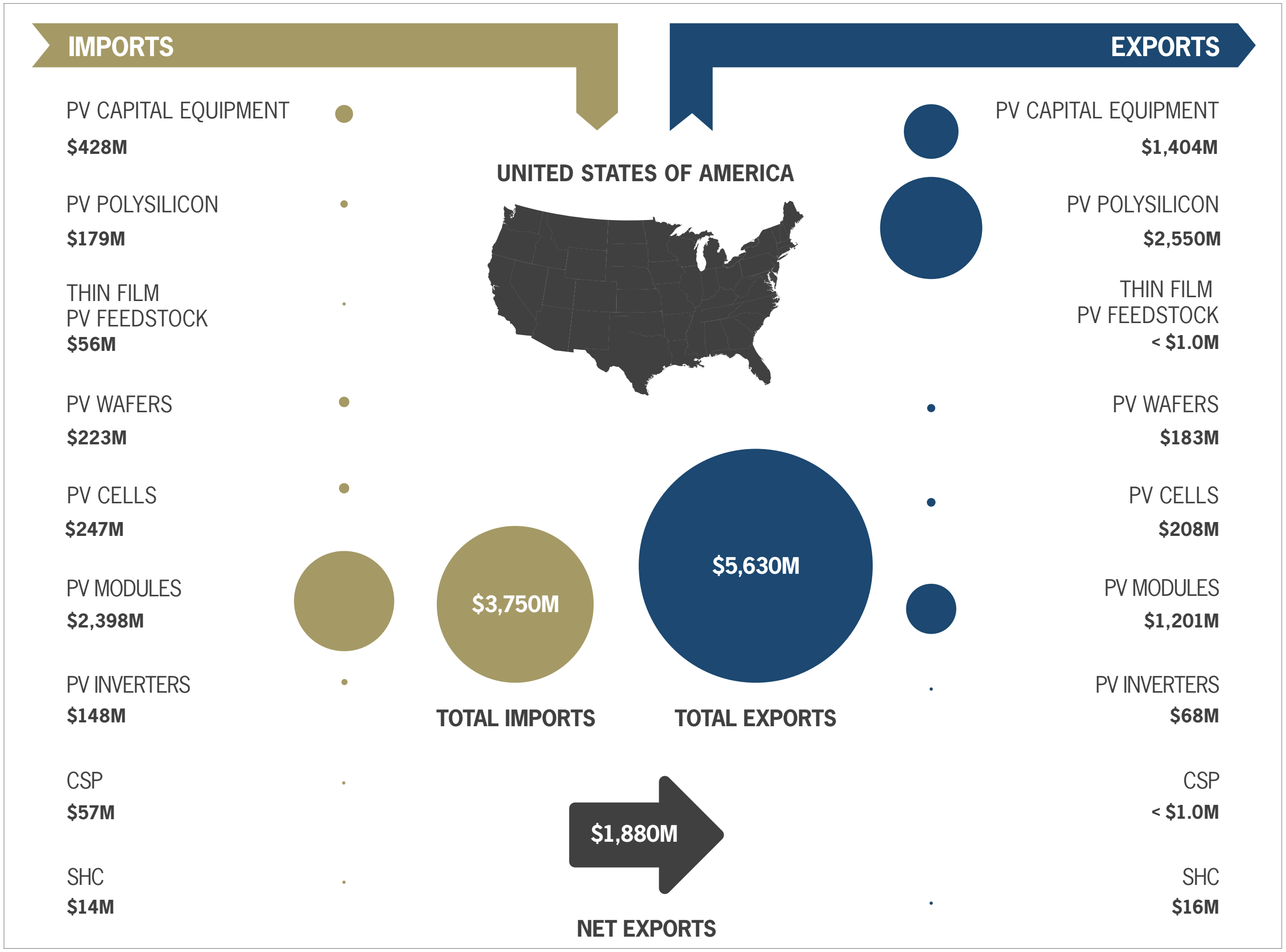
This study seeks to answer two fundamental questions:

- What percentage of the value in U.S. solar installations was created domestically in 2010?
- What was the value of solar products that were imported into, and exported from, the United States in 2010?

1.1 Key Findings: Solar Energy

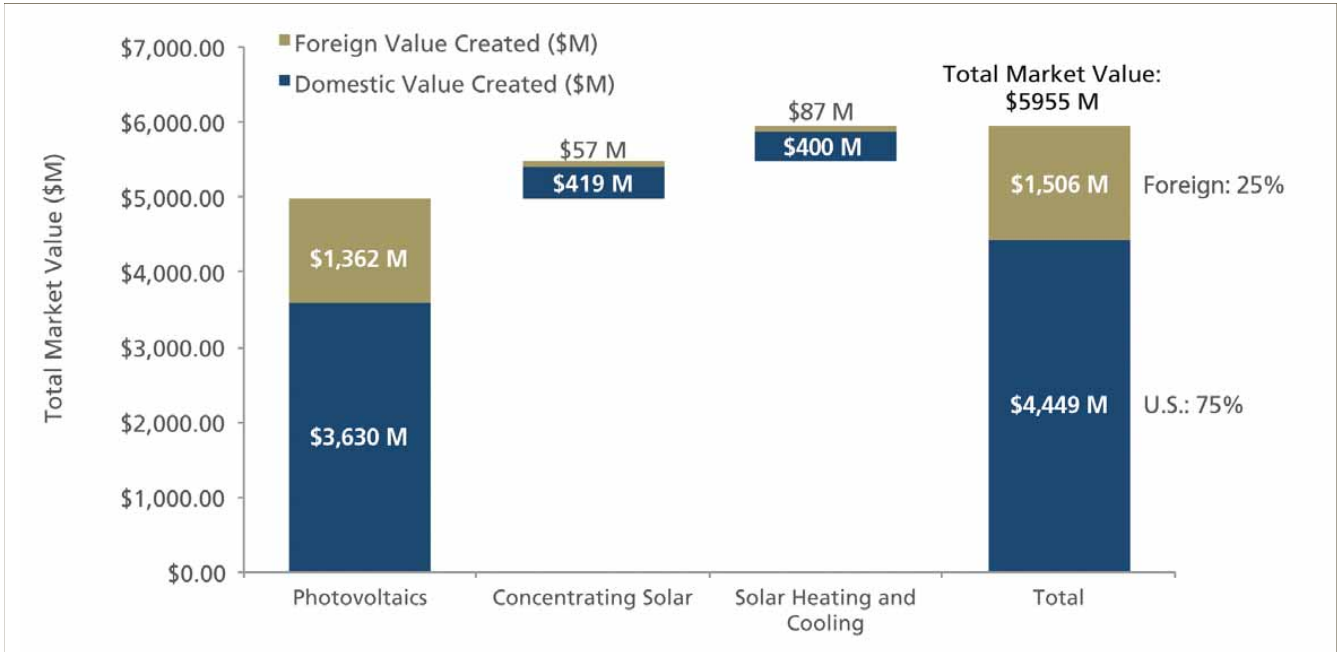
- The U.S. was a significant net exporter of solar energy products with total **net exports of $1.9 billion** in 2010.
- The U.S. solar industry had a positive trade balance with China with **net exports of $247 million - $540 million**.
- The largest solar energy export product is **polysilicon**, the feedstock for crystalline silicon photovoltaics, of which the **U.S. exported $2.5 billion** in 2010.
- The second largest solar energy export product is **PV capital equipment**, the manufacturing equipment for PV products, of which the **U.S. exported $1.4 billion** in 2010.
- The largest solar energy import product is **PV modules**, of which the **U.S. imported $2.4 billion** in 2010.
- **2010 U.S. solar energy installations created a combined $6.0 billion in direct value, of which $4.4 billion (75%) accrued to the U.S.**
    - 82% ($3.6 billion) of the domestic value created by solar in the U.S. came from the photovoltaics sector
    - 9% ($419 million) came from the concentrating solar sector
    - 9% ($400 million) came from the solar heating and cooling sector

Figure 1-1: Solar Industry Trade Flows, 2010



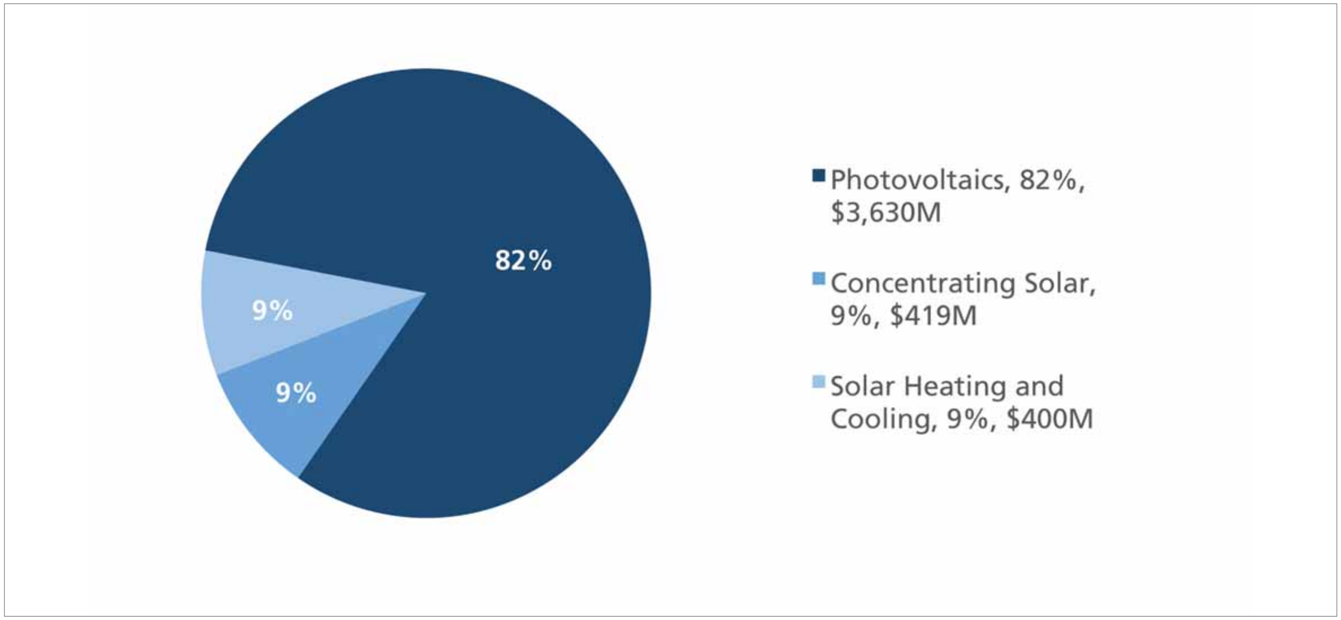
Source: GTM Research, International Trade Commission

Figure 1-2: U.S. Solar Installations Domestic Value Creation, 2010



Source: GTM Research

Figure 1-3: Solar Industry Domestic Value Creation by Technology, 2010

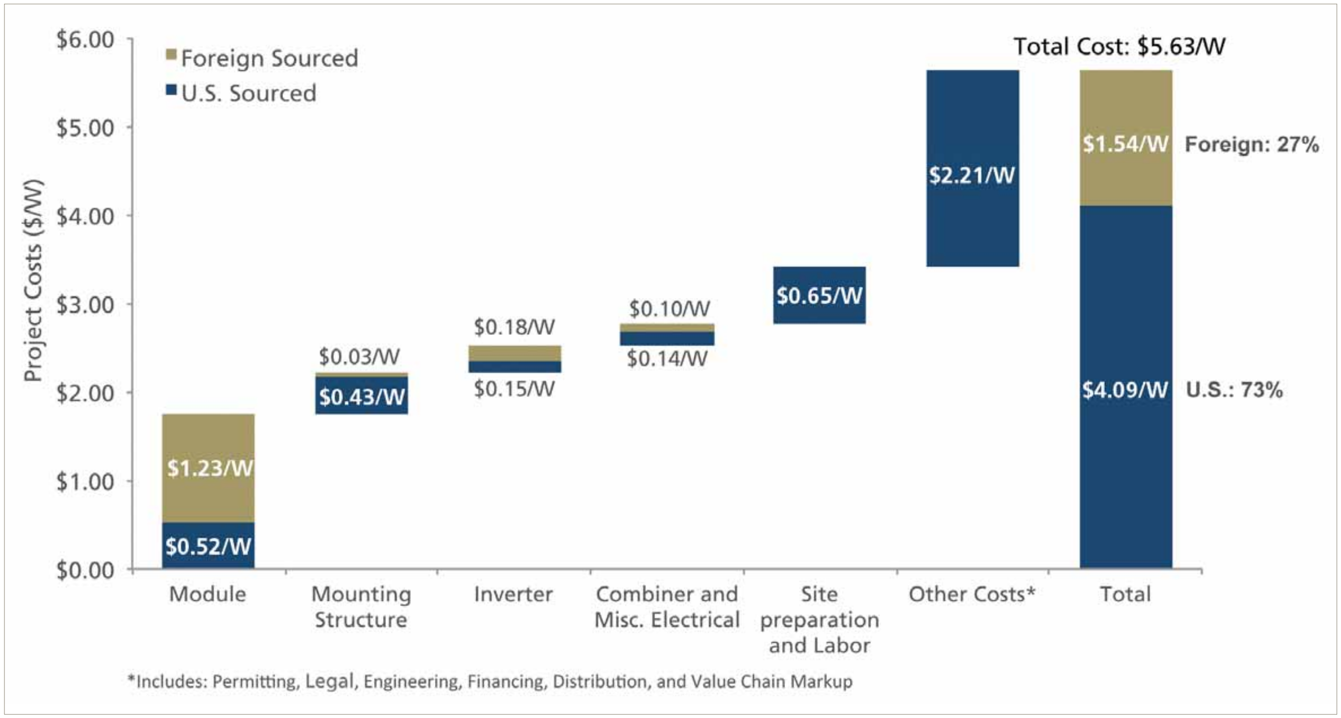


Source: GTM Research

1.2 Photovoltaics (PV)

- **73%** of total PV system value was created domestically in 2010. The domestic value was primarily created in the areas of module manufacturing, site preparation, labor, soft costs, and value chain markup for the module distributor and system installer. This is relatively even with 2009, when 71% of total PV system value was created domestically. At the same time, blended average system prices fell 18% from $6.90/W to $5.63/W from 2009 to 2010.
- **30%** of the value of PV modules deployed in U.S. installations in 2010 was created domestically, while the remaining **70%** came from foreign sources. This is roughly equal to 2009, when 31% of the value of PV modules was created domestically. The domestic value was primarily created in the areas of polysilicon production, module assembly for crystalline silicon modules, capital equipment, glass manufacturing, labor, and value chain markup for thin film modules. On a technology and application-blended basis, modules accounted for **31%** of the total representative system cost.

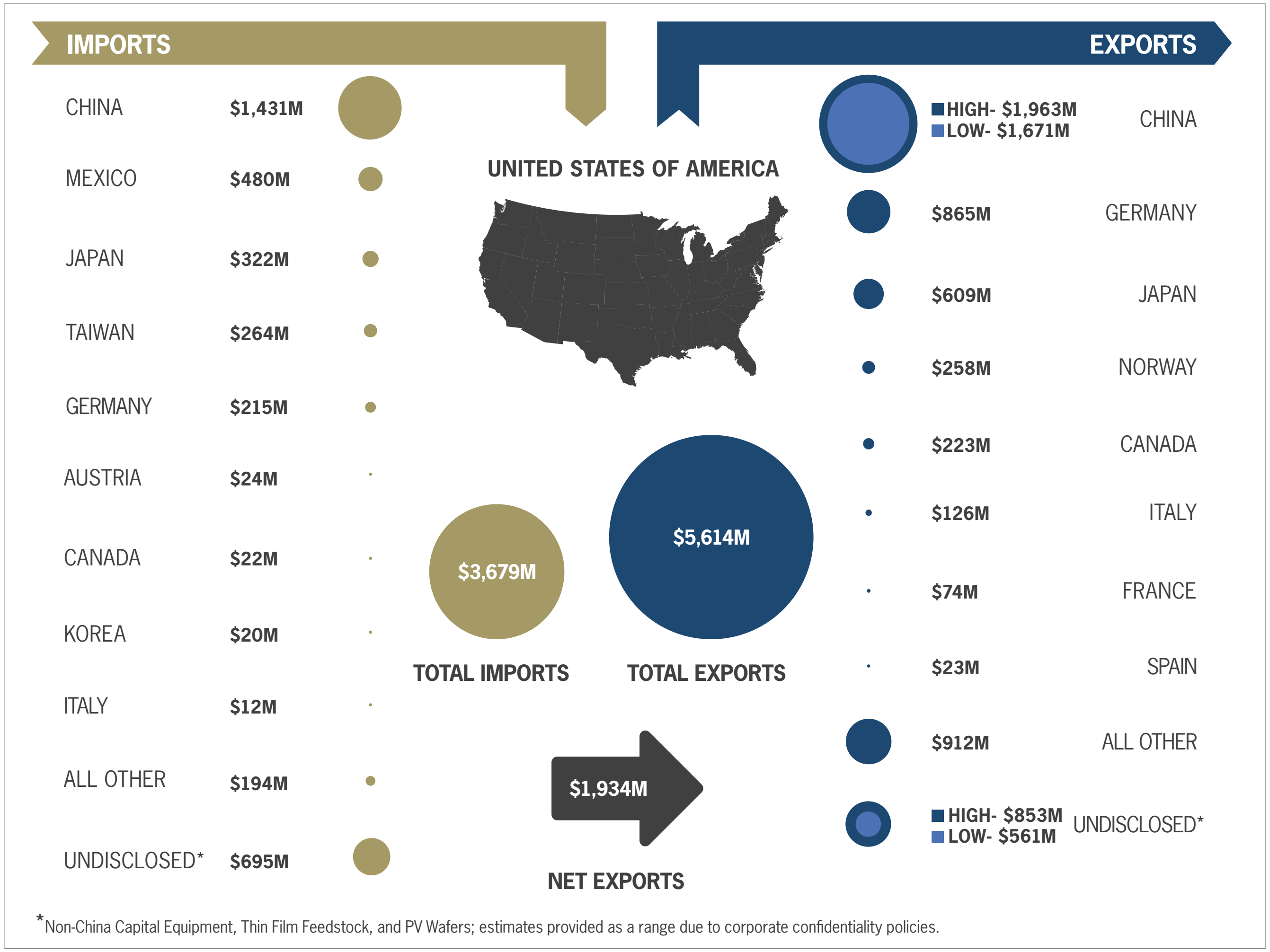
Figure 1-4: PV System Domestic Value Creation, 2010



Source: GTM Research

- U.S. PV-related imports in 2010 totaled **$3.7 billion** while exports totaled **$5.6 billion**, making the U.S. a net exporter of PV goods by **$1.9 billion**. Key export goods included polysilicon ($2.5 billion), capital equipment ($1.4 billion) and modules ($1.2 billion), while modules ($2.4 billion) were the most prominent imported goods. Imports came predominantly from China ($1.4 billion) and Mexico ($480 million). 2010 imports from China grew significantly from $430 million in 2009. Much of this growth came from PV modules, as Chinese producers gained a stronger foothold in the U.S. market in 2010. For U.S. exports, China ($1.7 billion - $2.0 billion), Germany ($865 million), and Japan ($609 million) were the most prominent destinations.

Figure 1-5: PV Imports and Exports by Source/ Destination, 2010

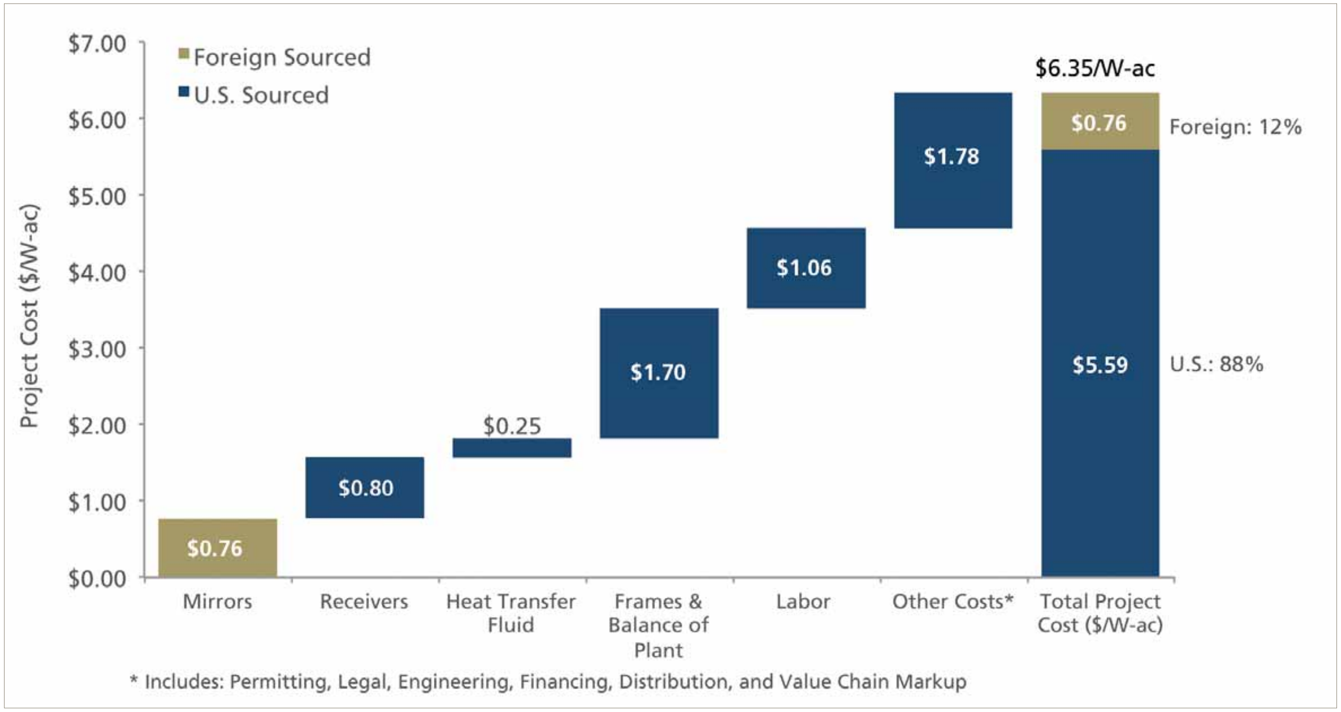


Source: GTM Research

1.3 Concentrating Solar Power (CSP)

- **88%** of the total value of 2010 CSP installations was created domestically. The only components sourced internationally were mirrors, which were imported from Spain.
- U.S. imports of CSP-related goods totaled **$57 million**, all of which came from Spain. The U.S. did not export any CSP–related goods in 2010 in significant quantities. Looking forward, trade flows for CSP should remain relatively small, as many of the components are low value per pound commodities, where the economics favor domestic sourcing to avoid transport costs.
- Note that data for CSP installations in 2010 is limited as there was only one large installation in the U.S. during the year.

Figure 1-6: CSP Project Domestic Value Creation, 2010

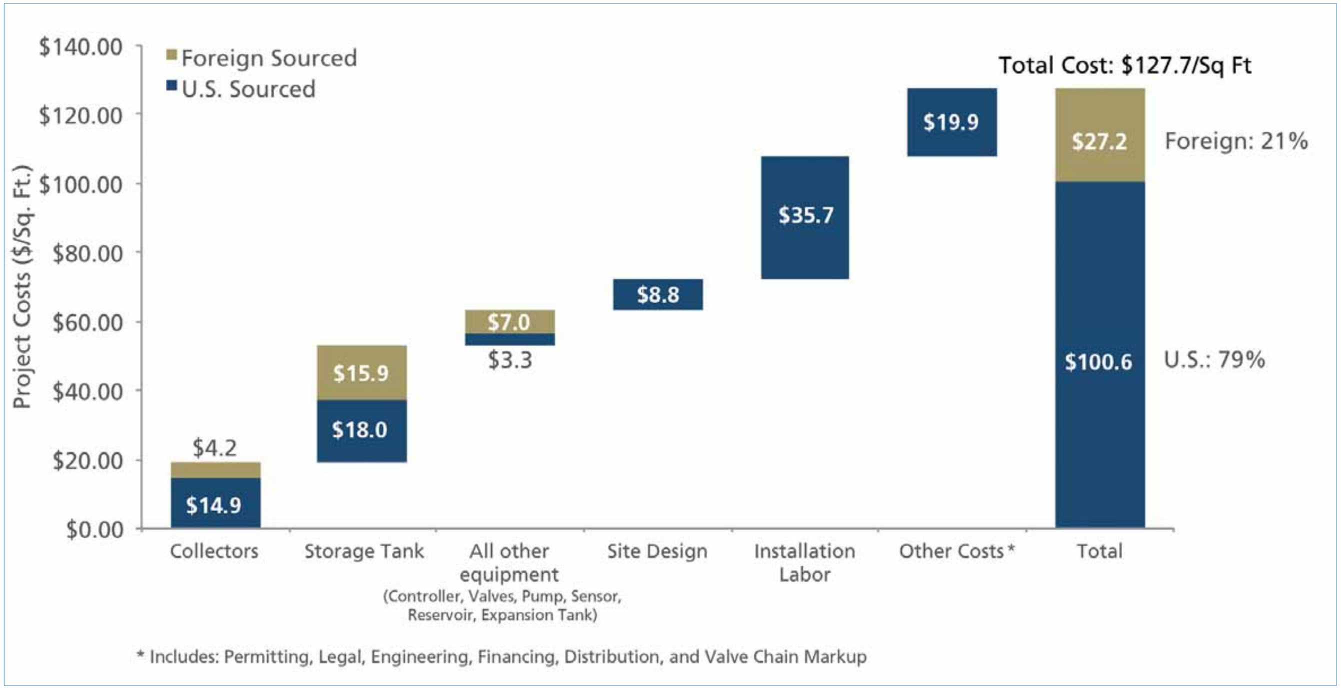


Source: GTM Research

1.4 Solar Heating and Cooling (SHC)

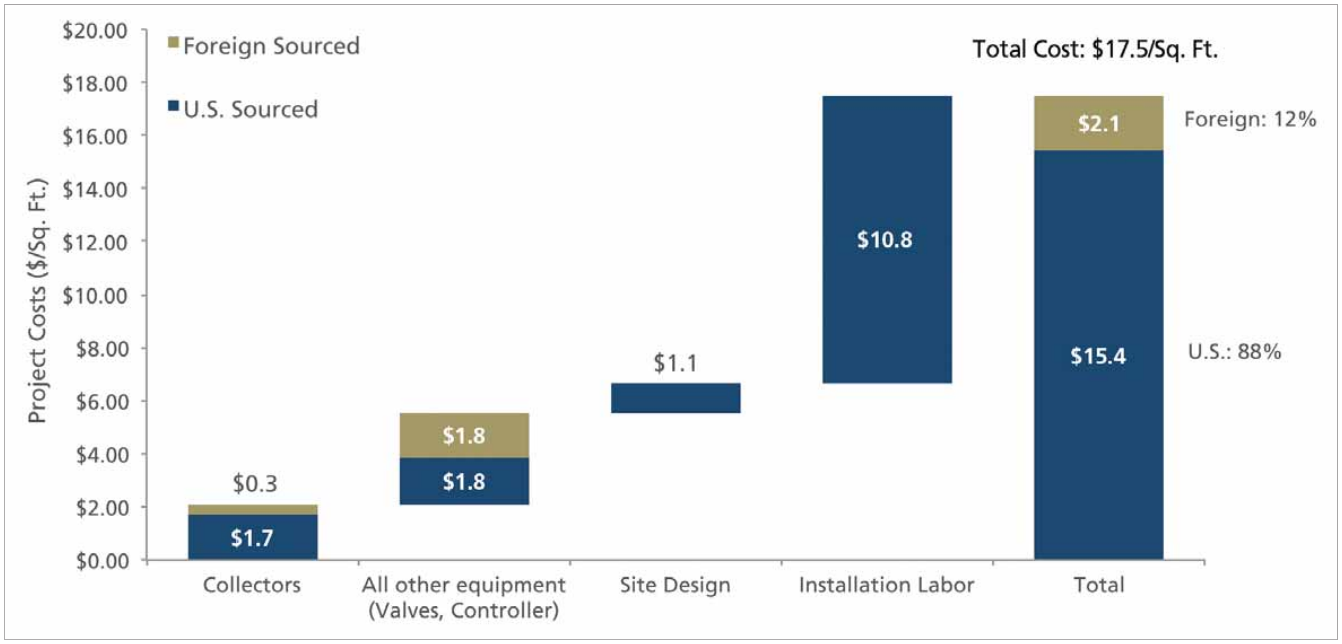
- For solar water heating (SWH) systems, **79%** of the total value of 2010 installations was sourced domestically. Storage tanks represented the largest portion of equipment obtained from foreign sources.
- For solar pool heating (SPH) systems, **88%** of the total value of 2010 installations was sourced domestically. The **12%** of value sourced from abroad was primarily due to Israeli-made collectors.
- Imports of SWH and SPH collectors in 2010 totaled **$13.6 million**, compared to exports of **$16.3 million**; this made the U.S. a net exporter of SWH and SPH products by **$2.7 million**. China was the most prominent import location, while Mexico contributed the most to SWH and SPH exports.

Figure 1-7: SWH System Domestic Value Creation, 2010



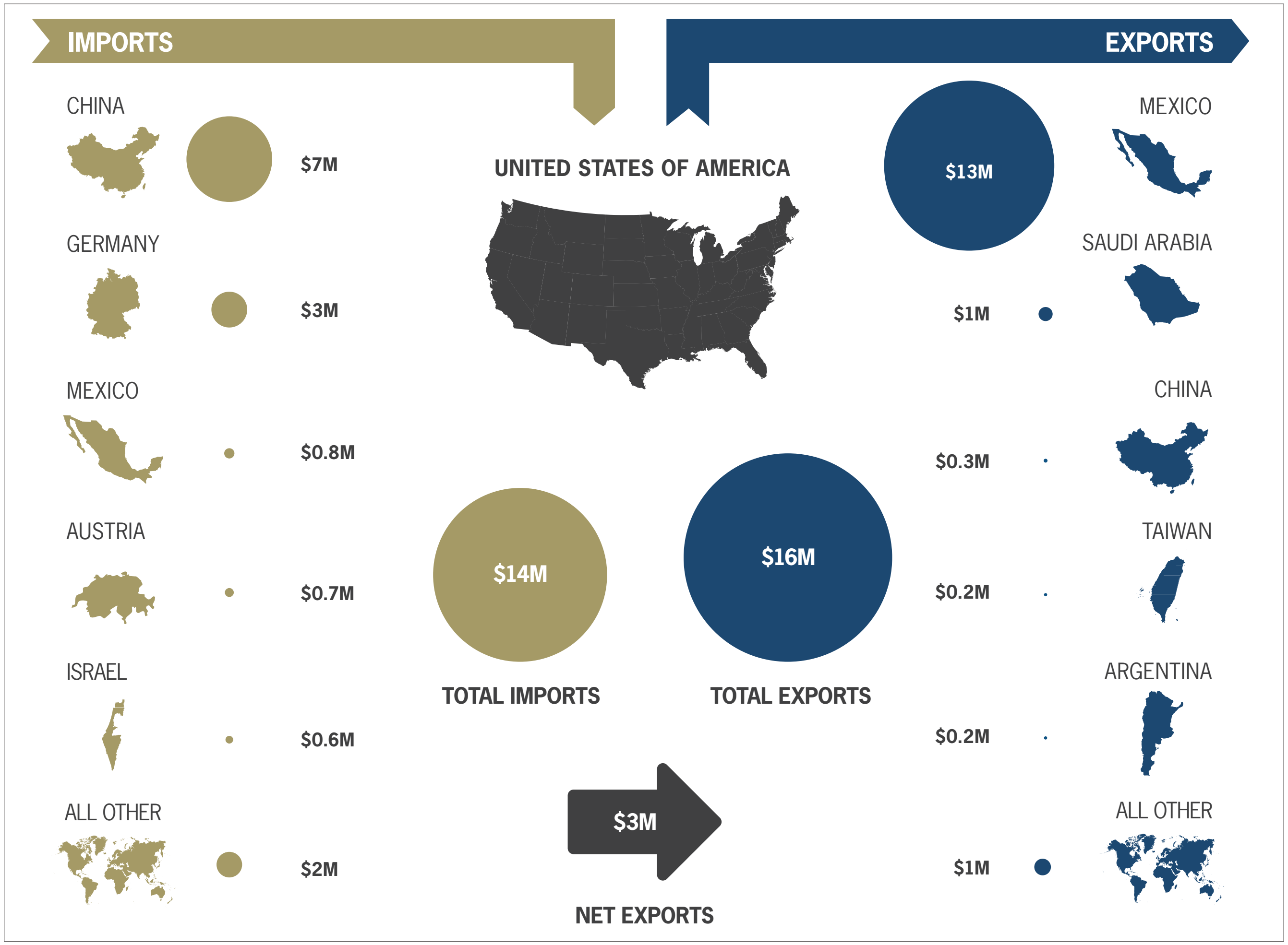
Source: GTM Research

Figure 1-8: SPH System Domestic Value Creation, 2010



Source: GTM Research

Figure 1-9: SWH and SPH Collectors: Imports and Exports by Source/ Destination, 2010

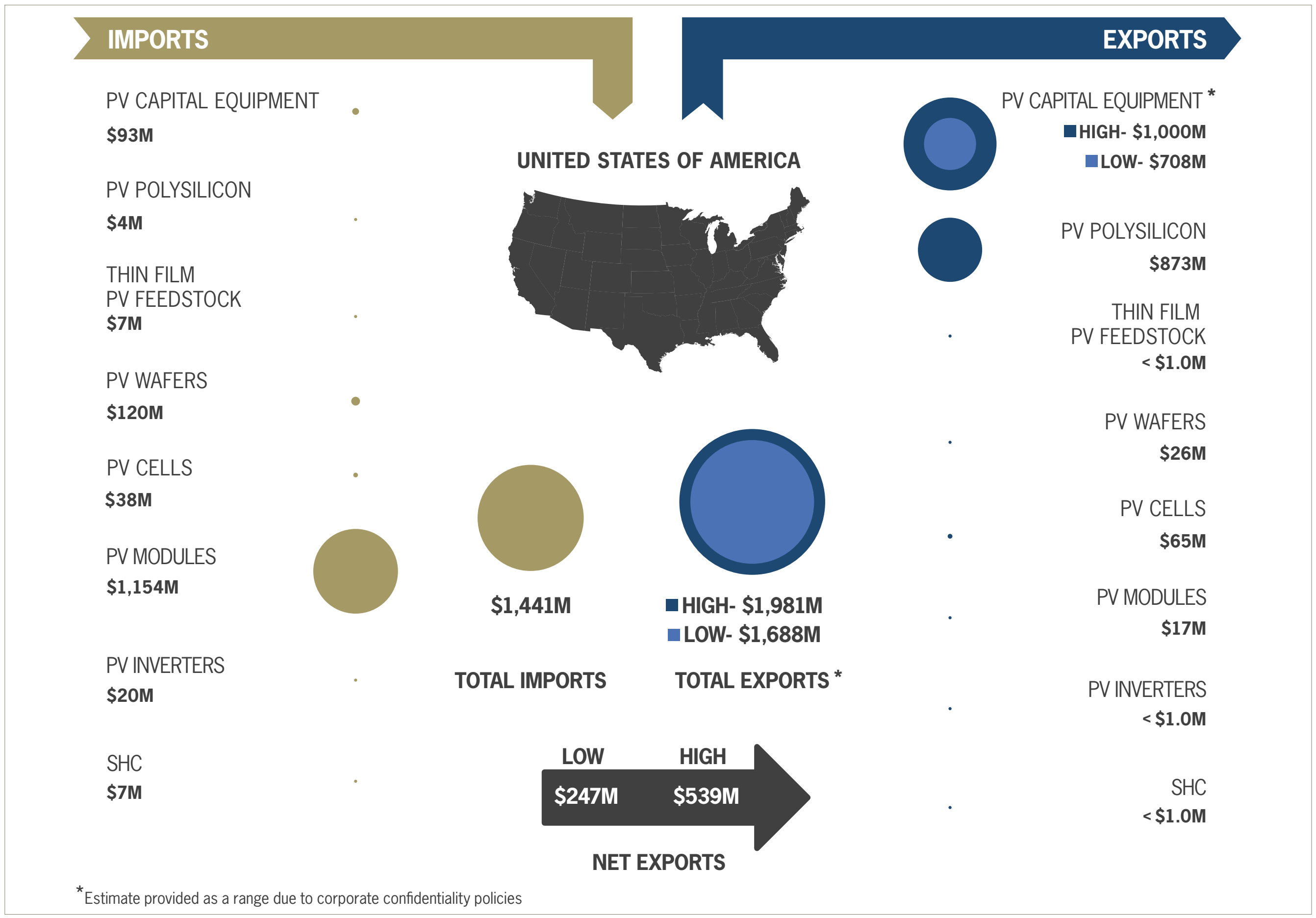


Source: GTM Research

1.5 U.S.-China Trade Flows

With respect to solar energy-related trade flows to China, U.S. imports in 2010 were estimated at $1.4 billion, while exports were estimated to be between $1.7 billion - $2.0 billion based on the availability of data for capital equipment sales. This made the U.S. a net exporter of solar goods to China by $247 million to $539 million. Imports came predominantly from modules ($1.2 billion), while exports were driven by capital equipment ($708 million to $1 billion) and polysilicon ($873 million).

Figure 1-10: U.S.-China Solar Energy - Related Trade Flows, 2010



Source: GTM Research

2 PHOTOVOLTAICS (PV)

The term photovoltaic (PV) refers to those materials that convert light energy into electrical energy; the operation of these devices is based on the photoelectric effect, wherein light (in the form of photons) striking the surface of a suitable semiconducting material is absorbed by electrons in its atoms. The electrons can then be harnessed to produce electric current. PV technologies are primarily differentiated based on the nature of the absorber material that is responsible for converting light into electricity. The existing technology options can be classified into the following categories:

a. Crystalline silicon

b. Thin films

c. Emerging materials, or next-generation PV

2.1 Domestic Value Created

A total of 887 megawatts (MW) of PV systems were installed in the U.S. in 2010 at a capacity-weighted average price of $5.63/W, indicating a total value of $5.0 billion for the U.S. solar PV market. Driven by the Federal Investment Tax Credit (ITC), the 1603 Treasury program and a variety of new state-level incentives, 2010 installations grew by 104% over 2009. One key question is how much of this value was created domestically versus sourced from abroad.

To determine this, GTM Research estimated the cost structure of a PV system that is representative of installed systems in the U.S. in 2010. Since the two prominent PV technologies (i.e. crystalline silicon and thin film) have markedly different system cost structures, these were estimated separately and then blended together based on the market share of these two technologies in 2010. The primary cost structure elements for a finished system are the following:

- Module
- Inverter
- Mounting Structure
- Combiner Box and Misc. Electrical Materials
- Site Preparation, Labor, Soft Costs and Value Chain Markup

2.2 Crystalline Silicon PV Modules

Crystalline silicon, or c-Si, is the most commonly used PV technology in the world today, owing to a mature process technology that utilizes the accumulated knowledge base of the semiconductor industry. As shown below, the crystalline silicon PV value chain consists of the following steps:

a. Polysilicon production
b. Ingot/Wafer production
c. Cell production
d. Module assembly

An illustration of the value chain for crystalline silicon PV is provided below.

Source: Hemlock Semiconductor, Schott Solar, PV-Tech, Suntech Power Holdings, National Park Service

Each of these steps is a separate manufacturing process and requires a different set of manufacturing equipment, and individual manufacturing facilities can exist for each. Hence, they are considered independently in terms of their contribution to the overall cost of the PV system and the percentage of value created domestically.

2.2.1 Polysilicon Production

Polycrystalline silicon, commonly known as polysilicon, is the primary raw material for the manufacturing of crystalline silicon PV modules, since it is silicon (with impurities introduced into it) that converts sunlight into electricity. Polysilicon is also used as feedstock for the production of wafers in the semiconductor industry, which are used in the fabrication of integrated circuits and other microdevices.

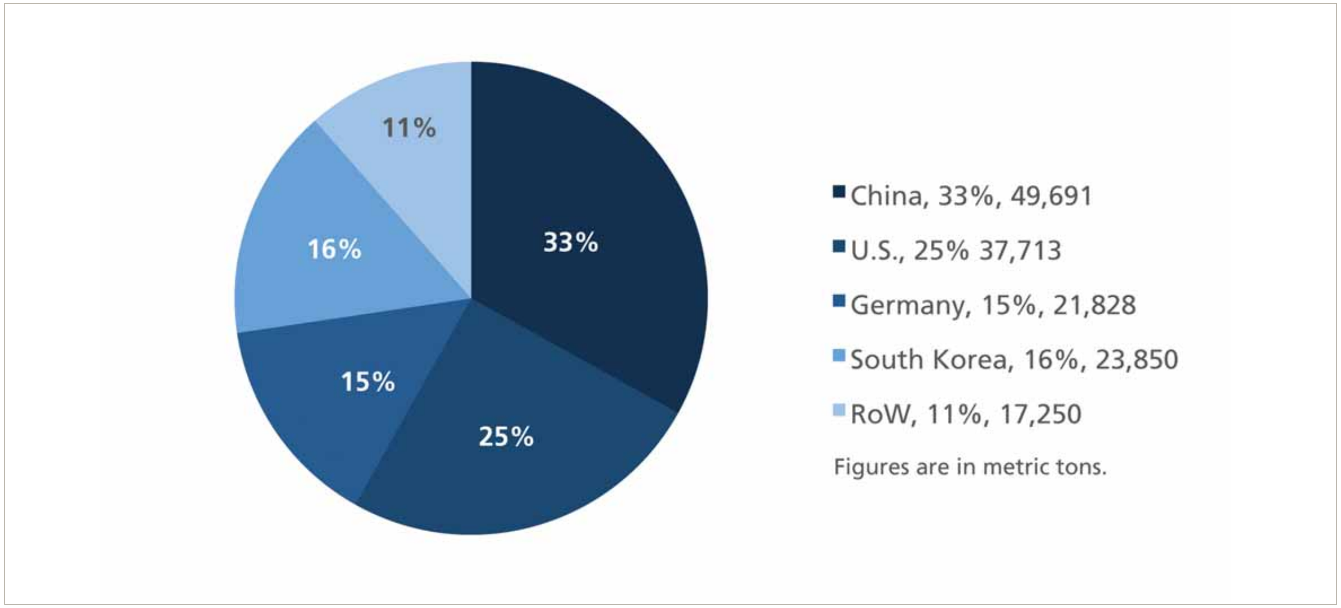
Generally, polysilicon production begins with the conversion of metallurgical-grade silicon (already 99 percent pure) to Trichlorosilane (TCS) or silane in gaseous form. This is then either passed over polycrystalline silicon rods of high purity at 1150 °C (the Siemens process), or passed at extremely high velocities through a chamber containing polysilicon granules (known as the fluidized bed reactor, or FBR process). The end result is extremely high purity polysilicon (at least 99.9999%, or “6N” purity), suitable for use in the PV industry.

Source: Hemlock Semiconductor

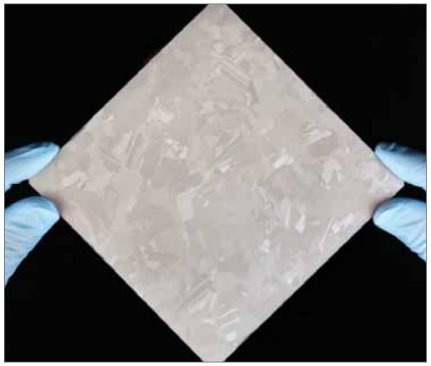
Roughly 90% of the polysilicon produced prior to 2000 was used for semiconductor wafers, and the PV industry obtained its polysilicon from the small amount of feedstock not consumed by the semiconductor industry. However, as global PV cell production (specifically crystalline silicon PV) exploded in the 2000s (from only 360 MW in 2001 to 3,369 MW in 2007), cell manufacturers began to consume as much polysilicon as chip manufacturers. By 2006, PV consumed more than 50% of polysilicon produced, and this figure is estimated to have increased to 79% in 2010.

The percentage of value created domestically by polysilicon in a U.S.-installed system was estimated based on U.S. share of global polysilicon production. Global PV polysilicon production in 2010 amounted to 150,332 metric tons (MT), where 1 metric ton equals 1,000 kilograms. Of this quantity, 37,713 MT, or 25%, came from the U.S. Three facilities were primarily responsible for this production volume, namely REC's two plants in Washington and Hemlock Semiconductor's facility in Michigan.

Figure 2-1: Solar Polysilicon Production by Country, 2010



Source: GTM Research

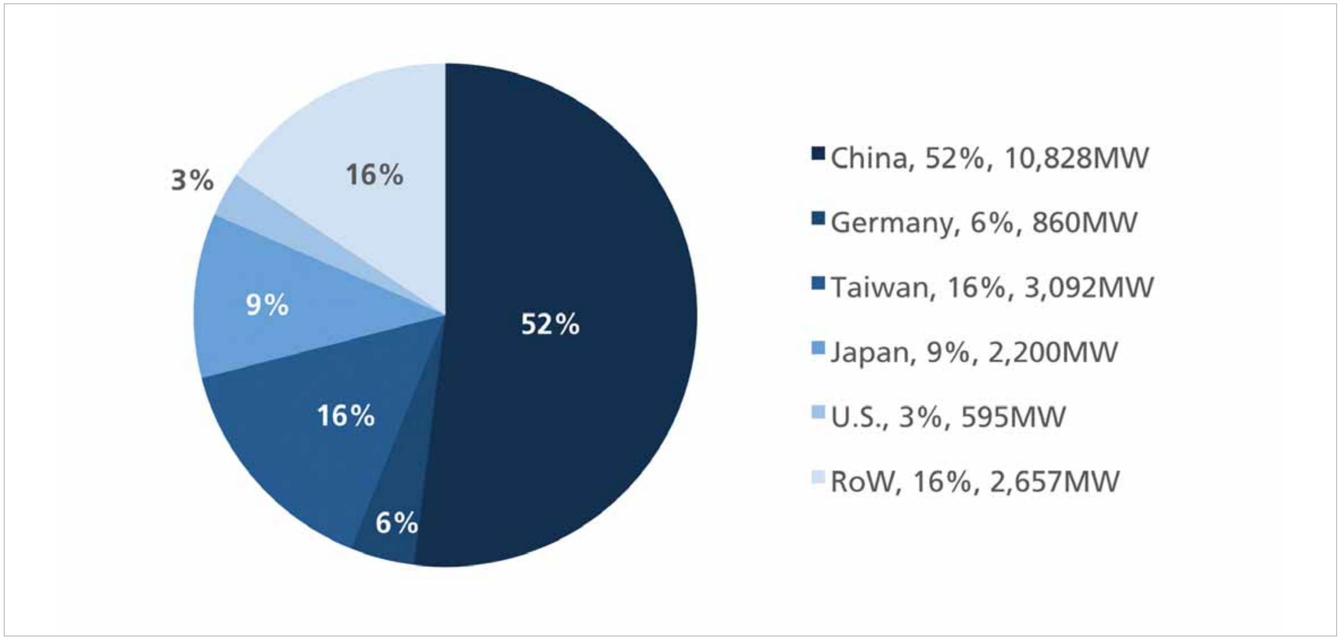

Source: Schott Solar

2.2.2 Ingot and Wafer Production

Once high-purity polysilicon is obtained, it is then melted and cast into large bricks or ingots, which are either cylindrical or rectangular in shape. The large ingot is sawed into smaller bars, which are then sliced into thin (180 to 200 micron) wafers using wire saws.

Global wafer production is dominated by Asian manufacturers, particularly those in China and Taiwan, while Western countries such as the U.S. and Germany have seen their market share fall significantly in recent years. Unlike polysilicon, where the U.S. made up 25% of global production, only 3% of PV wafers manufactured worldwide in 2010 were produced in U.S. facilities. Thus, a large percentage of the value of wafers that eventually become part of installed PV systems in the U.S. is estimated to come from foreign sources.

Figure 2-2: Global PV Wafer Market Share, 2010



Source: GTM Research

For 2009, the percentage of value created domestically by wafers in a U.S.-installed system was estimated based on U.S. share of global production. However, this assumption proves to be overly conservative, as it does not account for the vertically integrated nature of U.S. module manufacturers that produce wafers, cells, and modules in-house in the U.S. An estimated 57 MW of modules produced by such firms was installed in the U.S. in 2010. These modules utilized internally sourced, domestically produced wafers and cells. Accounting for this fact (and utilizing U.S. share of global production for the rest) yields blended domestic content of 11% for U.S.-installed wafers in 2010, as shown in Figure 2-3 below.

Figure 2-3: Estimation of Domestic Content of U.S.-installed PV Wafers, 2010

DOMESTIC CONTENT OF U.S.-INSTALLED PV WAFERS, 2010	
Total consumption in U.S.-installed c-Si modules (MW)	740
Consumption by U.S. wafer-cell-module manufacturers (MW)	61
Consumption by external purchase (MW)	679
U.S. wafer production, 2010 (MW)	595
Production excluding internal consumption (MW)	534
Global wafer production (MW)	20,232
Global wafer production, excluding U.S. internal consumption (MW)	20,171
Market share of remaining production	3%
U.S.-installed, domestically produced, externally purchased wafers (MW)	79
Domestic content of U.S.-installed wafers	11%

Source: GTM Research

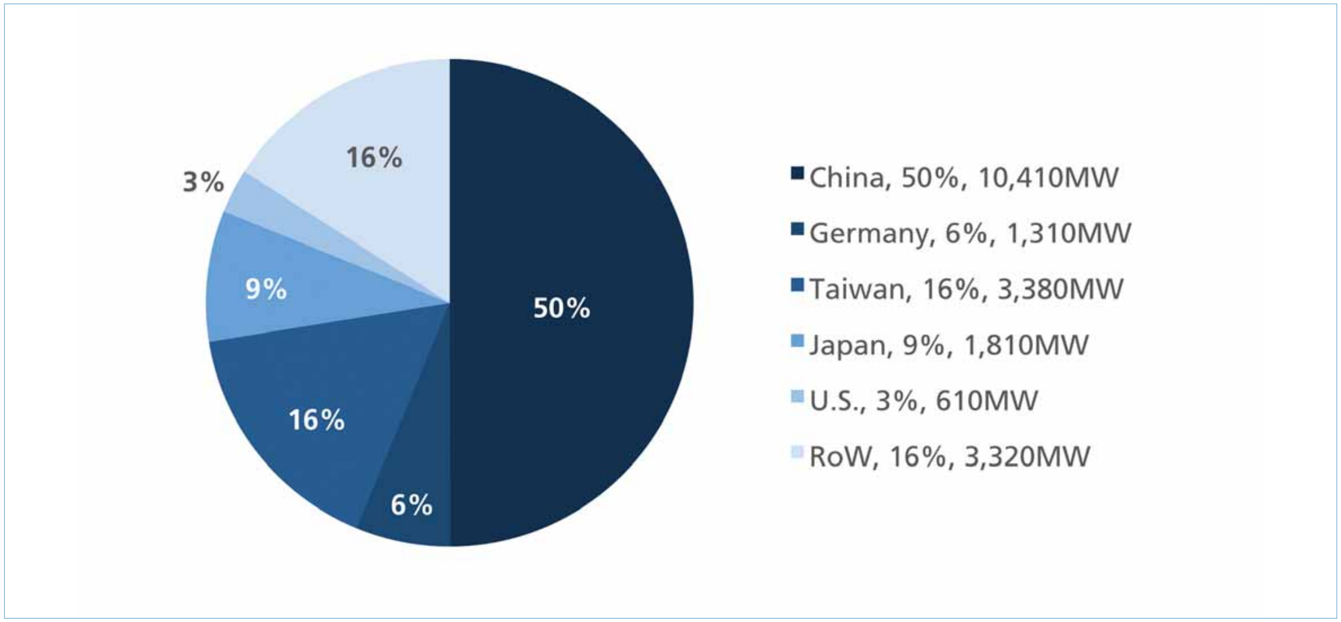
Source: PV-Tech

2.2.3 Cell Production

The photovoltaic cell is the basic energy-producing unit of a PV system. Wafers are converted into cells by means of a highly automated process that involves etching, rinsing, diffusion (introduction of impurities that makes the wafer photoelectrically active), coating, and screen printing.

As with wafers, the U.S. is not a major player when it comes to crystalline silicon cell manufacturing; only 611 MW of the 20,840 MW of c-Si cells produced globally in 2010 were manufactured in the U.S., which amounts to a global market share of 3%.

Figure 2-4: Crystalline Silicon Cell Production by Country, 2010



Source: GTM Research

As is the case with wafers, however, a meaningful proportion of c-Si modules installed in the U.S. in 2010 came from wafer-cell-module integrated firms based in the U.S. which used internally sourced, domestically produced cells in their modules. For all other manufacturers that had c-Si modules installed in the U.S. in 2010, the domestic content of cells consumed was assumed to be in line with U.S. share of global c-Si cell production after subtracting domestically-consumed domestically-produced cells. Overall, this yields average domestic content of 11% for U.S.-installed wafers in 2010, as shown in Figure 2-5 below.

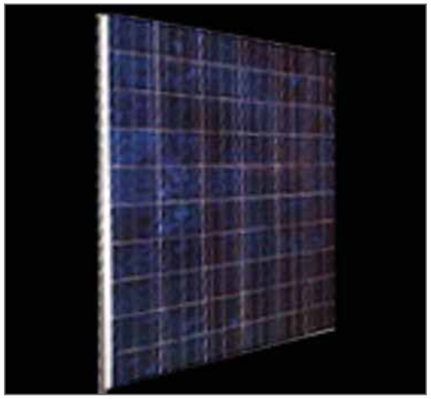
Figure 2-5: Estimation of Domestic Content of U.S.-installed c-Si Cells, 2010

DOMESTIC CONTENT OF U.S.-INSTALLED CRYSTALLINE SI CELLS, 2010	
Total consumption in U.S.-installed c-Si modules (MW)	703
Consumption by U.S. cell-module manufacturers (MW)	58
Consumption by external purchase (MW)	645
U.S. c-Si cell production, 2010 (MW)	611
Production exluding internal consumption (MW)	553
Global c-Si cell production (MW)	20,840
Global c-Si cell production, excluding U.S. internal consumption (MW)	20,782
Market share of remaining production	3%
U.S.-installed, domestically produced, externally purchased cells (MW)	75
Domestic content of U.S.-installed c-Si cells	**11%**

Source: GTM Research

2.2.4 Module Assembly

The final step in the production of a finished crystalline silicon module involves stringing the cells (typically 60 or 72 of them) into a series/parallel connection to obtain the voltage and power level desired for a particular module power capacity. The cell string, arrayed side by side to "fill" a rectangular area, is then packaged and laminated between a sheet of tempered glass, ethyl vinyl acetate (EVA) or alternatives, and a back cover of aluminum foil, a polyvinyl fluoride film, or glass.

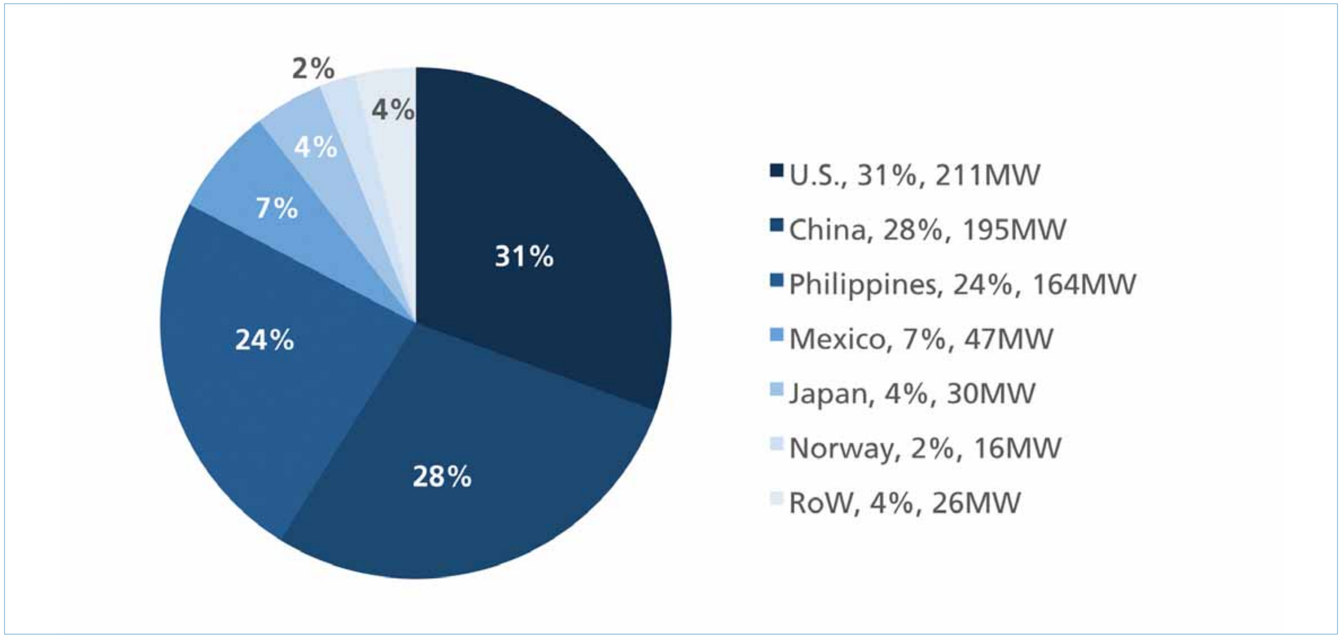


Source: Suntech Power Holdings

To estimate the percentage of value created domestically by module assembly, module manufacturer-specific data from residential and commercial systems from California and New Jersey, as well as national utility-scale installation data, was examined to calculate what percentage of U.S. installations used modules from domestic manufacturers. Overall, 31% of U.S.-installed crystalline silicon modules were assembled domestically in 2010; this is much higher than the U.S. share of global c-Si module manufacturing in 2010, which was only 5%.

It is worth noting that despite the relatively low share of domestic value in U.S.-deployed crystalline silicon modules, U.S. crystalline silicon module production in 2010 (which was 792 MW) actually exceeded domestic consumption of the same (689 MW), suggesting that a meaningful amount of U.S.-produced modules was exported. This was indeed the case: as discussed in Section 2.13.6, domestic module exports exceeded $1.2 billion in 2010.

Figure 2-6: U.S.-Installed Crystalline Silicon Modules by Geographic Origin of Production (Module Assembly Only), 2010

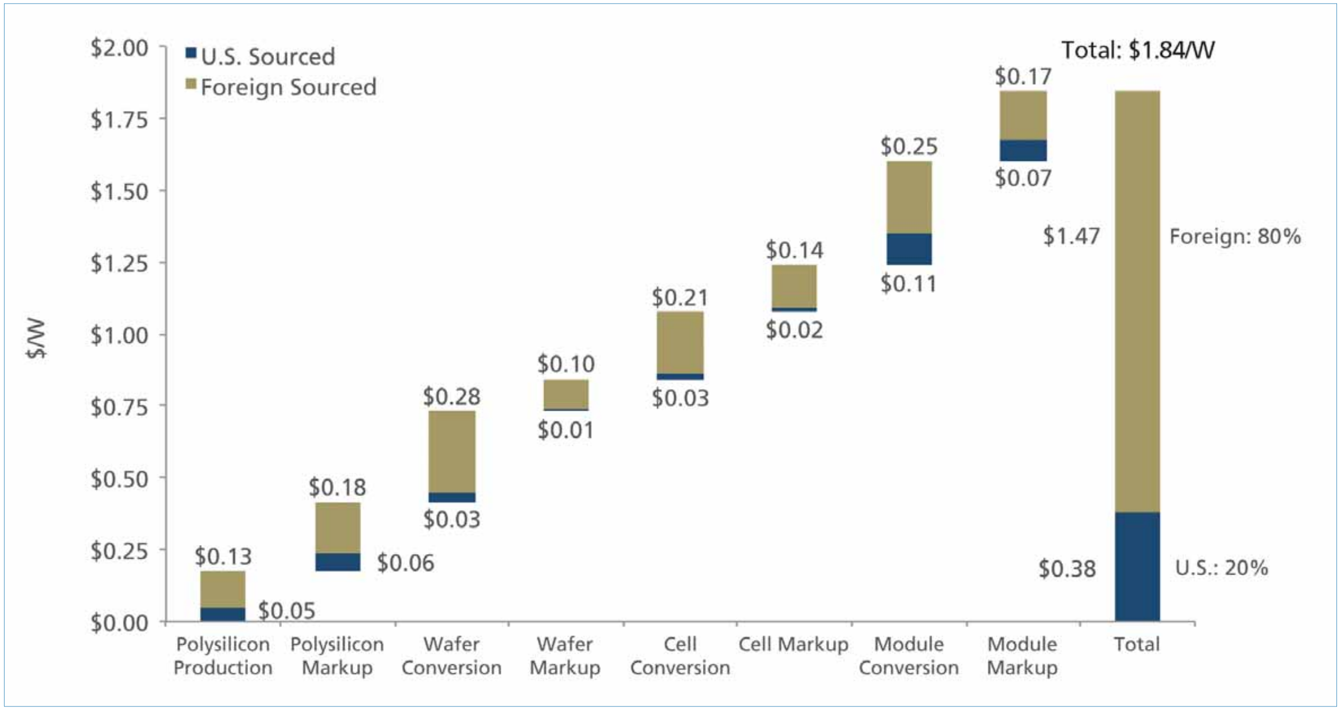


Source: GTM Research

2.2.5 Crystalline Silicon Module

The figure below shows the breakdown of the cost structure for a crystalline silicon module in 2010, including markups; the overall figure is thus indicative of what is known in industry as "factory-gate" pricing. As shown, this amounts to $1.84/W. Polysilicon, cell, and wafer production (including markup) have a roughly equal share of the total (around 22%), while module assembly is the highest-cost process, at 33%. Of this $1.84/W, a total $0.38/W, or 20%, is estimated to be domestically sourced, compared to 24% in 2009. The bulk of this (77%) comes from polysilicon and module assembly. In conclusion, therefore, the majority (80%) of the value of U.S.-installed crystalline silicon modules is created in regions outside the U.S.

Figure 2-7: Percentage of Value Created Domestically, U.S.-installed Crystalline Silicon Module, 2010



Source: GTM Research

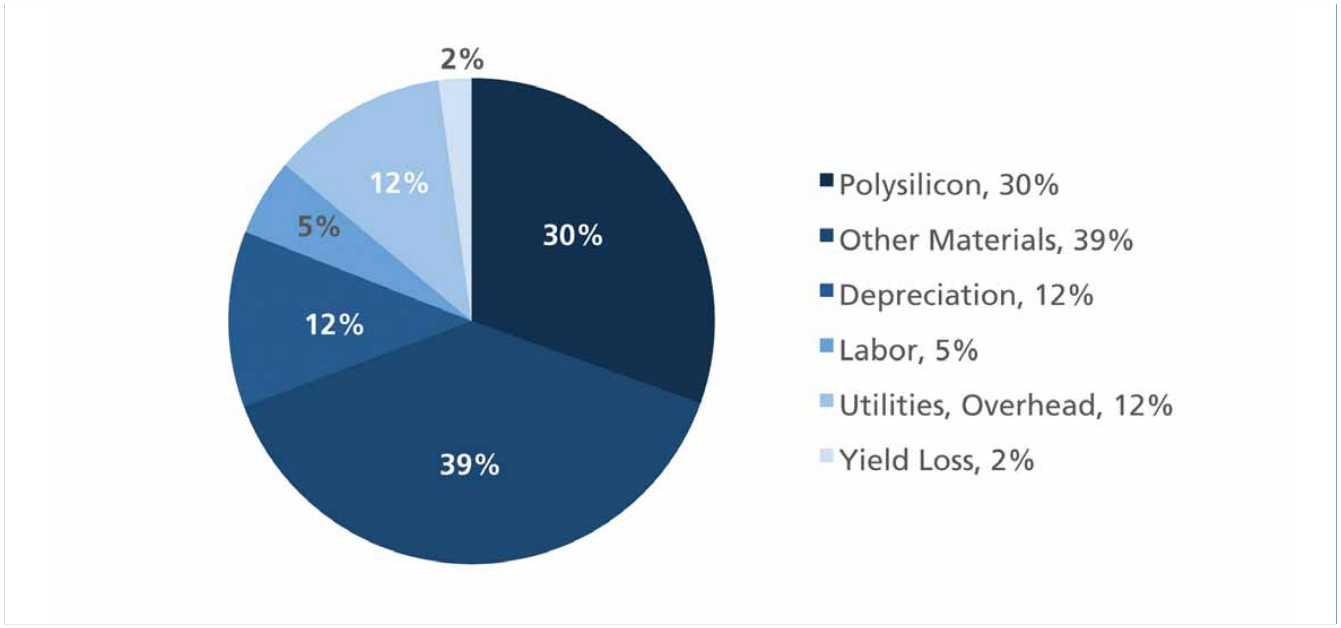
Figure 2-8: Percentage of Value Created Domestically, U.S.-installed Crystalline Silicon Module, 2010

COMPONENT	TOTAL COST ($/W)	DOMESTIC VALUE CREATED (%)	DOMESTIC VALUE CREATED ($/W)	DOMESTICALLY PRODUCED AND CONSUMED (MW)	DOMESTIC VALUE CREATED ($M)	FOREIGN VALUE CREATED (%)	FOREIGN VALUE CREATED ($/W)	FOREIGN-PRODUCED, U.S.-DEPLOYED (MW)	FOREIGN VALUE CREATED ($M)
Polysilicon Production	$0.18	25%	$0.05	1,114	$200.5	75%	$0.13	3,327	$598.8
Polysilicon Markup	$0.24	25%	$0.06	1,114	$263.6	75%	$0.18	3,327	$787.1
Wafer Conversion	$0.31	11%	$0.03	79	$24.7	89%	$0.28	661	$207.2
Wafer Markup	$0.11	11%	$0.01	79	$8.6	89%	$0.10	661	$72.4
Cell Conversion	$0.24	11%	$0.03	75	$17.8	89%	$0.21	628	$149.1
Cell Markup	$0.16	11%	$0.02	75	$12.1	89%	$0.14	628	$101.4
Module Conversion	$0.36	31%	$0.11	211	$76.9	69%	$0.25	478	$174.5
Module Markup	$0.24	31%	$0.07	211	$50.7	69%	$0.17	478	$115.0
Total/Avg	**$1.84**	**20%**	**$0.38**		**$654.9**	**80%**	**$1.47**		**$2,205.5**

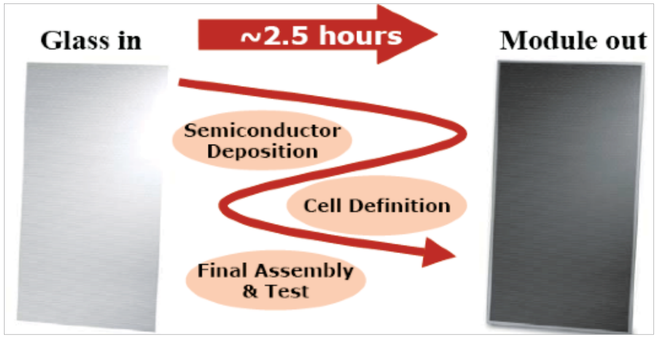
Source: GTM Research

One limitation of this analysis is that it stops at the value chain level. That is, it attributes the entirety of value creation for polysilicon, wafers, cells, and modules to the region of production, ignoring where materials were sourced from. A module may be assembled in the U.S., but the materials that are used in its production (excluding cells, which have been accounted for) – namely glass, encapsulant, backsheet, and junction box – are often sourced from China, Japan, and/or Europe. Conversely, while the large majority of cells and wafers are produced in China and Taiwan, much of the capital equipment used is imported from Germany, Switzerland, and the U.S. Thus, a meaningful amount of the value of PV components produced abroad is created domestically, and vice versa. As shown in the figure below, depreciation of capital equipment for wafers, cells, and modules made up an estimated 12% of the total module cost structure for a China-based manufacturer in 2010, which is a small but meaningful amount. Given that the U.S. exported $1.4 billion of capital equipment for PV in 2010 (see Section 2.13.1), one would expect a significant share of the value attributed to depreciation to have been created domestically. Unfortunately, the identity of equipment and materials vendors for most PV manufacturers is confidential, making it difficult to trace the regions where these are sourced with any degree of exactitude. Moreover, many PV materials are commodities, meaning that data on PV-specific trade flows for materials such as silver paste, glass, and aluminum is difficult to separate from other industries.

Figure 2-9: Crystalline Silicon Module Cost Structure, Wafer-to-Module Integrated Facility, China, 2010



Source: GTM Research



Source: First Solar

2.3 Thin Film PV Modules

Unlike crystalline silicon, where the photovoltaic material is a 180-200 micron thick wafer, thin film technology utilizes layers only a few microns thick as the light-absorbing material, deposited onto a substrate, such as glass or metal foil, and uses a film manufacturing process. To date, three thin film technologies have been commercialized at mass production scale. These are cadmium telluride (CdTe), amorphous silicon (a-Si), and copper indium (gallium) diselenide (CIGS); the names represent the composition of the film that acts as the photoactive layer in the module.

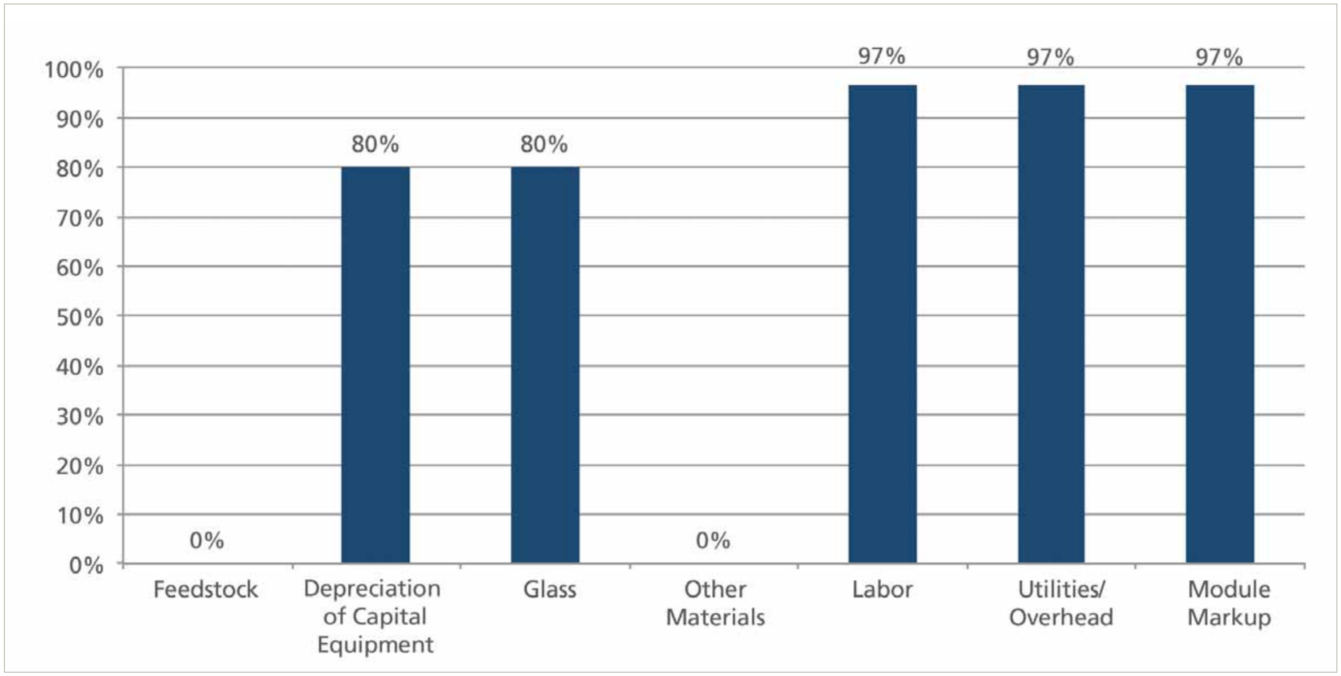
Of the estimated 197 MW of thin film modules installed in the U.S. in 2010, 191 MW (97%) were manufactured domestically, with an estimated 87% from a single supplier, CdTe-based First Solar. Because of CdTe's dominant market share of thin film installations and the limitation of data for other manufacturers/technologies, it is assumed that the thin film module and system in question are CdTe for the purpose of this analysis. A pictorial depiction of the manufacturing process for thin film modules is presented below.

Just as with the nature of the absorber layer, the manufacturing process for thin film modules is also markedly different from that of c-Si: most often, a sheet of glass goes in at one end of the production line, to be converted into a finished module just a few hours later. This means that the entire production process takes place inside one facility, compared to c-Si, where polysilicon, ingot/wafer, cell, and module production often take place in different factories. Because of this, the thin film module must be broken down by its cost components rather than by value chain segment for the purposes of this analysis. At a high level, these are the following:

- Feedstock
- Capital Equipment
- Glass
- Other Materials (encapsulant, junction box, cables)
- Labor
- Utilities
- Overhead
- Module Markup

To determine the percentage of value created domestically for an installed thin film module, the cost components above were examined individually. Unlike c-Si, where more than 100 firms contributed to U.S.-installed modules, 87% of installed thin film modules were produced by a single vendor (First Solar), making it easier to trace where materials and capital equipment were sourced. Figure 2-10 displays the domestic share estimated for each. As shown, non-glass materials were assumed to be 100% sourced from abroad. On the other hand, glass and capital equipment were assumed to be 80% domestically sourced. For labor, utilities, overhead, and the module markup, domestic content was assumed to correspond to domestic manufacturers' share of U.S.-installed thin film modules in 2010, which was 97%.

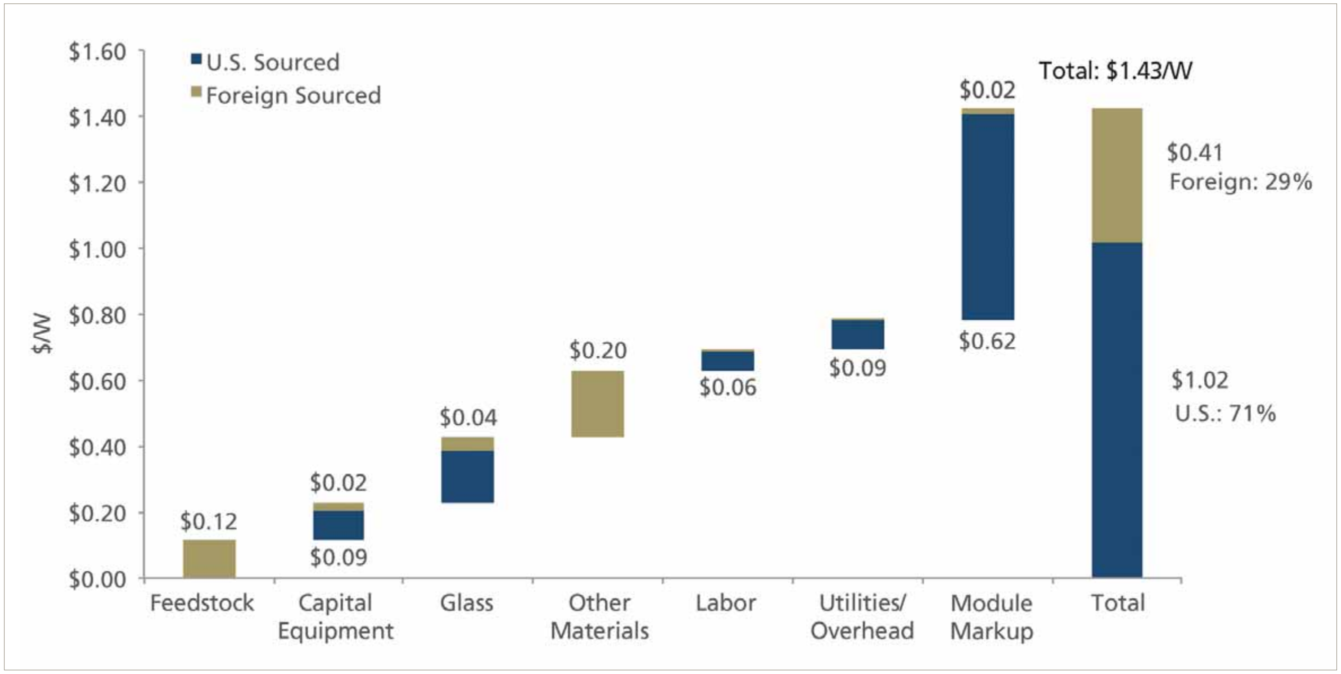
Figure 2-10: Percentage of Value Created Domestically, U.S.-installed Thin Film Module, 2010



Source: GTM Research

As shown below, total thin film module costs (including module markup) for 2010 amounted to $1.43/W. Of this, the cost to the producer is estimated at $0.78/W, while the remaining $0.64/W (45%) is markup at the module level. This may seem unreasonably high. However, it is in accordance with CdTe module economics in 2010, as the dominant CdTe producer reported gross margins at 40%-50% throughout 2010, due to a stable pricing environment for the alternative PV technology (crystalline Si) and an industry-leading module manufacturing cost. Of the installed thin film modules in the U.S., $1.02/W (71%) was sourced domestically, in contrast to only 20% for crystalline silicon modules. This is largely because of two reasons: first, the leading thin film producer in the U.S. in 2010 in terms of module market share has manufacturing operations and is headquartered in the U.S., and second, thin film manufacturing is largely an integrated process. This means that a significant portion of the raw costs as well as the module markup stay mostly within the U.S.

Figure 2-11: Percentage of Value Created Domestically, U.S.-installed Thin Film Module, 2010



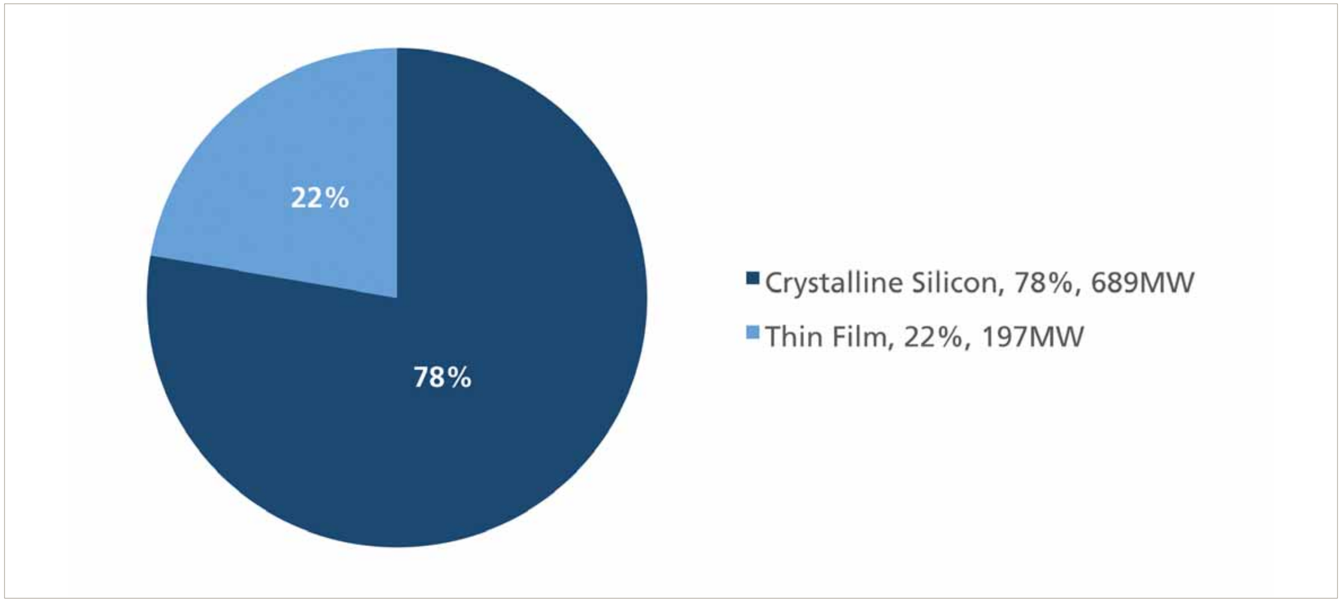
Source: GTM Research

The 71% domestic value of thin film modules installed in 2010, compared to only 20% for crystalline silicon, may lead one to mistakenly conclude that thin film manufacturing is inherently more American. This is not true, and is more a function of the small sample size of prominent thin film manufacturers compared to crystalline silicon. To illustrate this, a crystalline silicon module manufactured by a highly integrated domestic manufacturer such as SolarWorld (which produces wafers, cells, and modules in the U.S.) would have domestic value on par with that of a U.S.-produced thin film module. As such, there is nothing intrinsically American about thin film manufacturing, or intrinsically foreign about crystalline silicon production; it just so happens that the landscape of manufacturers of crystalline silicon PV is distributed across the globe and is extremely competitive, while few thin film firms have thus far been able to compete with the U.S.-based leader.

2.4 Blended PV Module

When considering the market share of crystalline silicon and thin film installations in the U.S. in 2010 (78% and 22% respectively as shown in the figure below), one arrives at a weighted average module cost of $1.75/W. Of this, $0.52/W was created domestically, which amounts to 30% of the total, compared to 31% in 2009. On the whole, therefore, the majority of the value for modules deployed in U.S. installations in 2010 came from foreign sources.

Figure 2-12: 2010 U.S. PV Installations by Module Technology



Source: GTM Research

Figure 2-13: Percentage of Value Created Domestically, PV Module, 2010

Technology	Module Cost	Domestic Value Created ($/W)	Domestic Value Created (%)	2010 Share of U.S. PV Installations
Crystalline silicon	$1.84	$0.38	20%	78%
Thin film	$1.43	$1.02	71%	22%
Blended (weighted average)	**$1.75**	**$0.52**	**30%**	

Source: GTM Research

2.5 Year-Over-Year Comparison

Figure 2-14 displays estimated domestic value content for U.S.-installed modules for 2009 vs. 2010. As shown, the most prominent differences lie in polysilicon, wafer processing, and cell processing. The difference in polysilicon is the result of a decrease in U.S. market share in polysilicon production, due to the proliferation of a number of Asian polysilicon manufacturers. The difference in wafers and cells are largely due to revised methodologies utilized in the 2010 analysis. In aggregate, the domestic content of installed c-Si modules dropped from 24% in 2009 to 20% in 2010, while that of thin film modules dropped from 77% in 2009 to 71% in 2010. However, the greater share of thin film modules in U.S. installations in 2010 results in the domestic content of the blended module being nearly equal in both years (31% in 2009 vs. 30% in 2010).

Figure 2-14: PV Module Domestic Value Creation Year-over-Year Comparison

PV Module Domestic Value Creation Year-over-Year Comparison

	2009		2010		Year-over-Year		
Material/ Component	Total Cost ($/W)	Domestic Value %	Total Cost ($/W)	Domestic Value %	YoY Cost Difference (%)	YoY Domestic Value % Difference	Comments
Polysilicon	$0.51	40%	$0.42	25%	-19%	-15%	Lower market share of U.S.-sourced polysilicon
Crystalline Si Wafer Processing	$0.54	3%	$0.42	11%	-22%	8%	Improved estimation methodology
Crystalline Si Cell Processing	$0.50	25%	$0.40	11%	-20%	-14%	Revised estimation methodology
Crystalline Si Module Assembly	$0.73	29%	$0.61	31%	-17%	2%	Slightly higher share of U.S.-manufacturers in domestic installations
Total Crystalline Si Module	$2.28	24%	$1.84	20%	-19%	-4%	Primarily influenced by lower domestic value creation for polysilicon and cell
Thin Film Module	$1.82	77%	$1.43	71%	-22%	-6%	Slightly lower contribution from domestic components of cost structure
Blended Module	$2.21	31%	$1.75	30%	-21%	-1%	Nearly identical in aggregate

Source: GTM Research

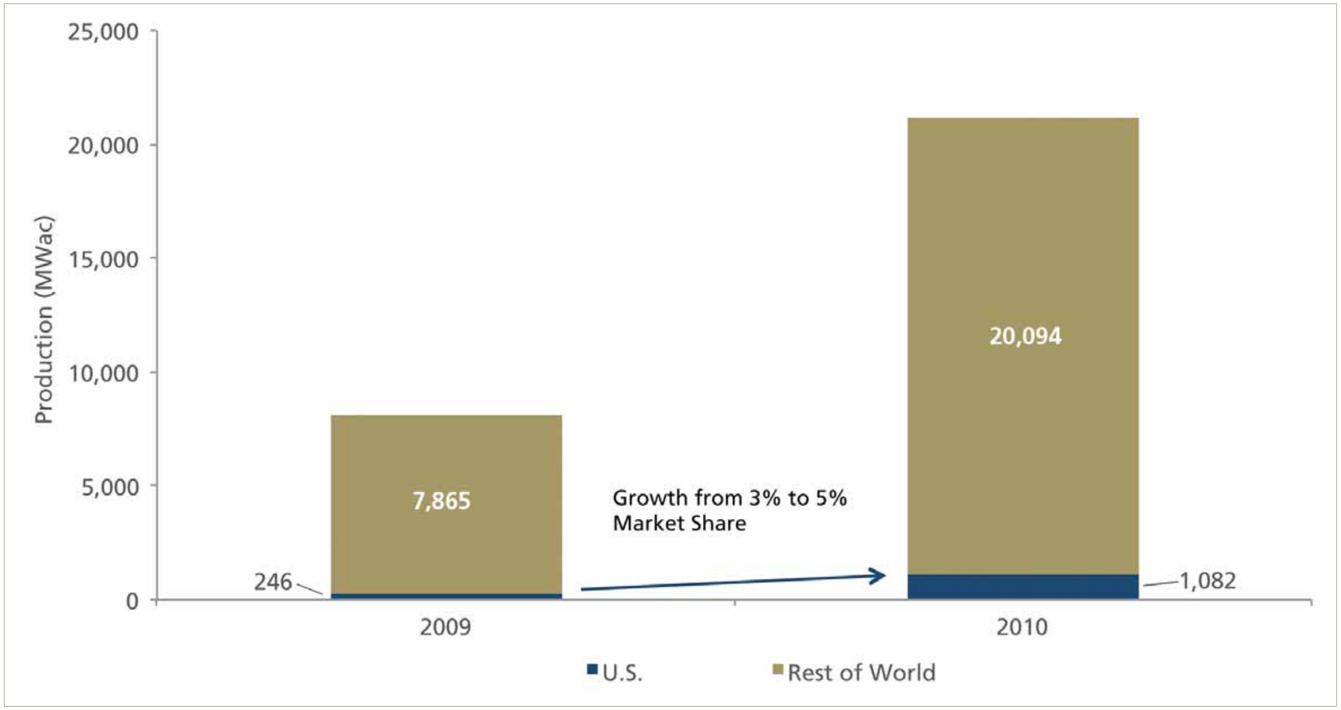
Source: Advanced Energy

2.6 Inverter

PV modules generate direct current (DC) electricity while the electric grid runs on alternating current (AC) requiring one or more inverters in each PV system to convert DC to AC. Ranging from small text book-sized devices for residential-use to bus-sized solutions for utility system-use, inverters represent the main power electronics unit in a typical PV system. Although the inverter is a critical technical component, the direct manufacturing costs only represent 8% of total installed system costs.

The global PV intverter market reached over $6.7 billion in 2010, once again with European inverter companies dominating sales; the top four inverter companies, all of which with predominantly European-based manufacturing, represented more than 60% of global sales in 2010. The PV demand boom in Europe coupled with a lagging semiconductor component industry caused widespread inverter shortages for major European inverter manufacturers, which allowed leading U.S. inverter manufacturers to gain global market share—from just 3% in 2009 to 5% in 2010. With the predicted slowdown in the main European solar markets and the promise of the U.S. installation market, foreign inverter manufacturers have turned their attention towards U.S.-based production. Year-end capacity grew from 750 MW in 2009 to nearly 3.5 GW in 2010, with close to two-thirds of new capacity built by new U.S. inverter manufacturing entrants. Further investment by both domestic and foreign inverter manufacturers have already been made in 2011.

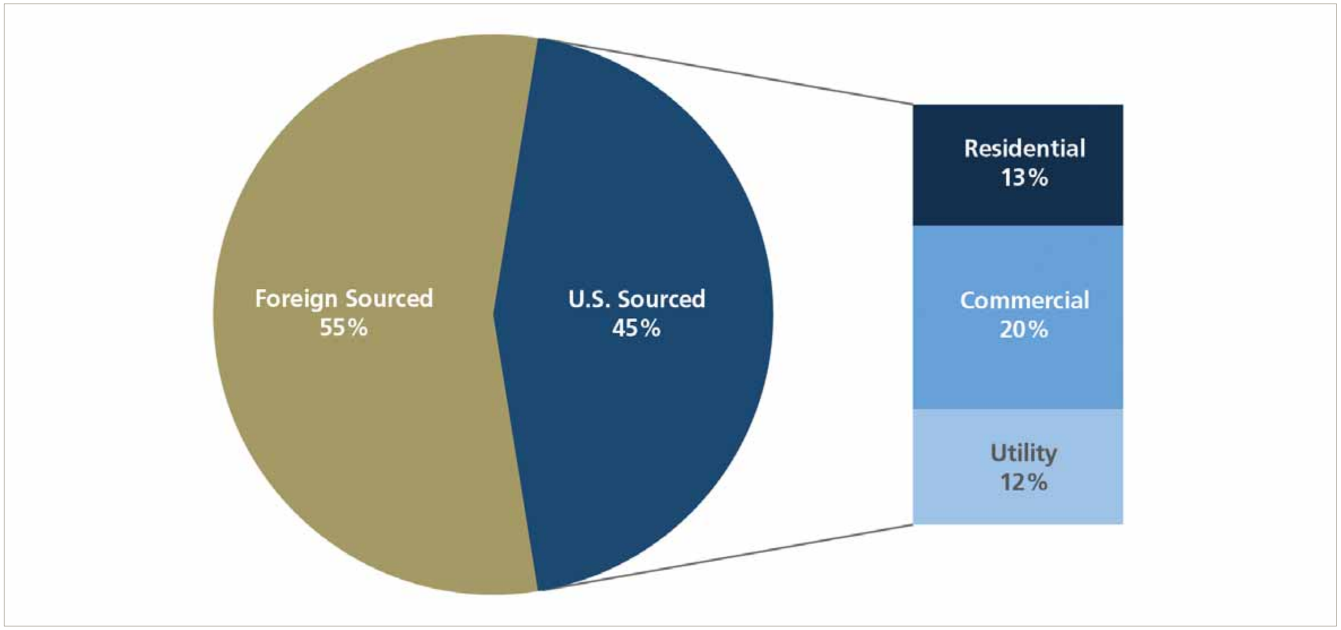
Figure 2-15: U.S. Market Share of Global Inverter Production, 2010



Source: GTM Research

While the size of U.S. inverter manufacturing is a small percentage of the global manufacturing industry, U.S manufacturers have a larger presence in the domestic market—especially the commercial and utility market segments. This trend fits strongly with the macro-level growth pattern of the U.S. PV market. Whereas foreign inverter manufacturers have an estimated 71% market share of U.S.-installed residential inverters, U.S.-manufactured inverters control 56% and 60% of the commercial and utility market respectively. Combined, U.S. manufacturers produced nearly 45% of installed inverter market value in 2010.

Figure 2-16: Domestic Market Share of U.S. and Foreign Manufacturers by Installation Market Segment, 2010



Source: GTM Research

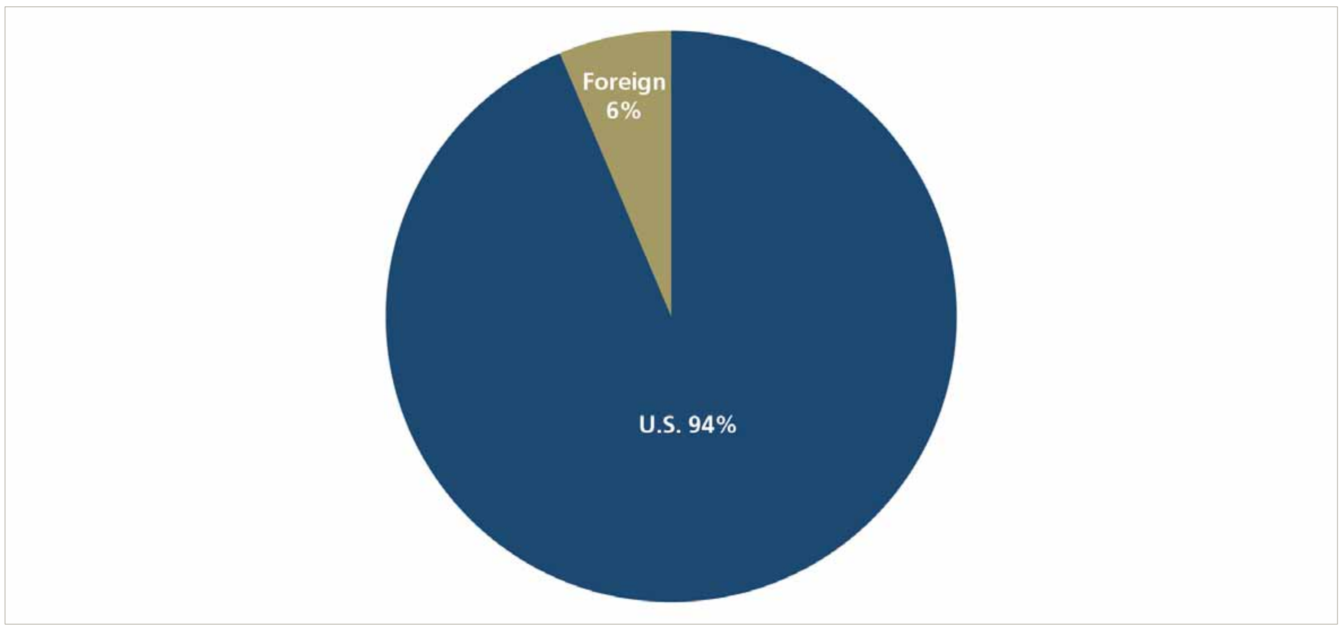
Source: SunLink

2.7 Mounting Structure

Mounting structures for PV modules, typically a pre-engineered system of aluminum or steel racks, accounted for approximately 8% of total PV system costs in 2010. Mounting structures vary depending on the site of the PV system, with different solutions for residential (shingle) and commercial (flat membrane, sloped metal, etc.) roofs in addition to ground-mounted systems (fixed tilt, one-axis tracking, etc.) for field arrays.

Because of the local abundance and substantial weight of racking structures, long distance shipping is prohibitively expensive. As a result, 94% of installed PV capacity in the U.S. utilized mounting structures produced or assembled in America. Foreign-produced mounting structure materials are typically sourced from Mexico, as lower labor costs and proximity can override international freight logistics, duties and other costs.

Figure 2-17: Domestic Content Creation in U.S. PV Mounting Structures, 2010



Source: GTM Research

GTM Research estimates mounting structures to account for a blended average of 8% of total system costs, or roughly $0.46/W. This value is slightly higher than the value estimated in 2009 ($0.40/W), but note that this does not necessarily reflect an upward trend in mounting structure costs. Certainly, the increased adoption of utility-scale tracking system had slight upward pressure on overall blended mounting structure costs. However, the estimation methodology was also adjusted from last year to include a wider network of mounting structure manufacturers and installers with more robust cost blending according to system size and market segment.

Source: Amtec Solar

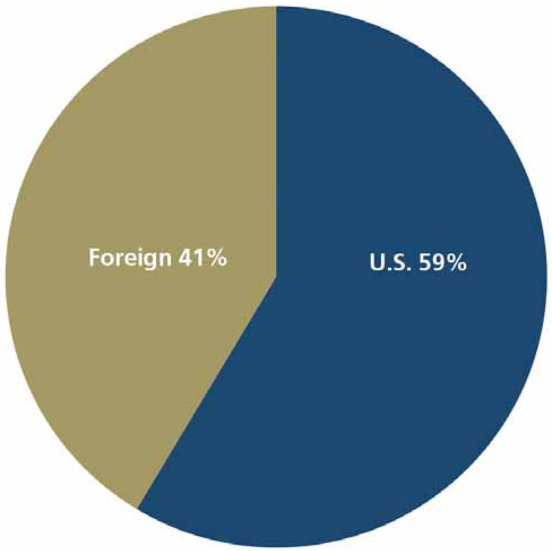
2.8 Combiner Box and Miscellaneous Electrical Equipment

The remainder of installed materials, including combiner boxes, wires/conductors, conduit, data monitoring, and other miscellaneous hardware, are included in this category. Combiner boxes are the only solar-specific product included in this category and are estimated to be 69% sourced from U.S. suppliers. Other miscellaneous electrical hardware is defined as commodity products and the domestic value proportion is estimated based on the domestic production and international trade flows of the general electrical equipment industry, which includes distribution equipment, transformers, electrical motors, switchgear, relays, and controls. While not all of this equipment is applicable to solar installations, data for a solar-specific subset is unavailable at this time. Thus, the domestic value content of miscellaneous balance of electrical equipment for solar PV systems is assumed to follow the trend of the general electrical equipment industry.

U.S. manufacturing of electrical equipment totaled $37.9 billion in revenues in 2010. Imports and exports of electrical equipment during this period totaled $18.3 billion and $13.4 billion respectively. It is thus estimated that the domestic share of the electrical equipment industry to be 57% (see Appendix A for methodology).

These materials are, however, produced in large volumes in the U.S. and imported equipment is typically bought through U.S. wholesalers and integrators, so there is upside potential to the combined estimate that 59% of the total value for balance of electrical equipment comes from the U.S.

Figure 2-18: Domestic Content Creation of Balance of PV Electrical Equipment, 2010



Source: GTM Research

Source: PV-Tech

2.9 Site Preparation, Labor, Soft Costs and Value Chain Markup

Site preparation, labor, soft costs and value chain markup constitute the balance and majority of the costs associated with an installed PV system. Site preparation and labor are defined as any logistical and physical preparation, coordination and work that must be performed to install a PV system at the site. This includes civil, structural or electrical infrastructure improvements, transporting materials on-site, and mechanical and electrical installation. Labor costs vary widely from project to project depending on the existing site conditions, the mounting structure employed, the size of the installation, labor rates, permitting procedures and local fire and safety codes. Site preparation and labor must be done at the site of the installation, ensuring that U.S. workers capture the vast majority value of the estimated cost.

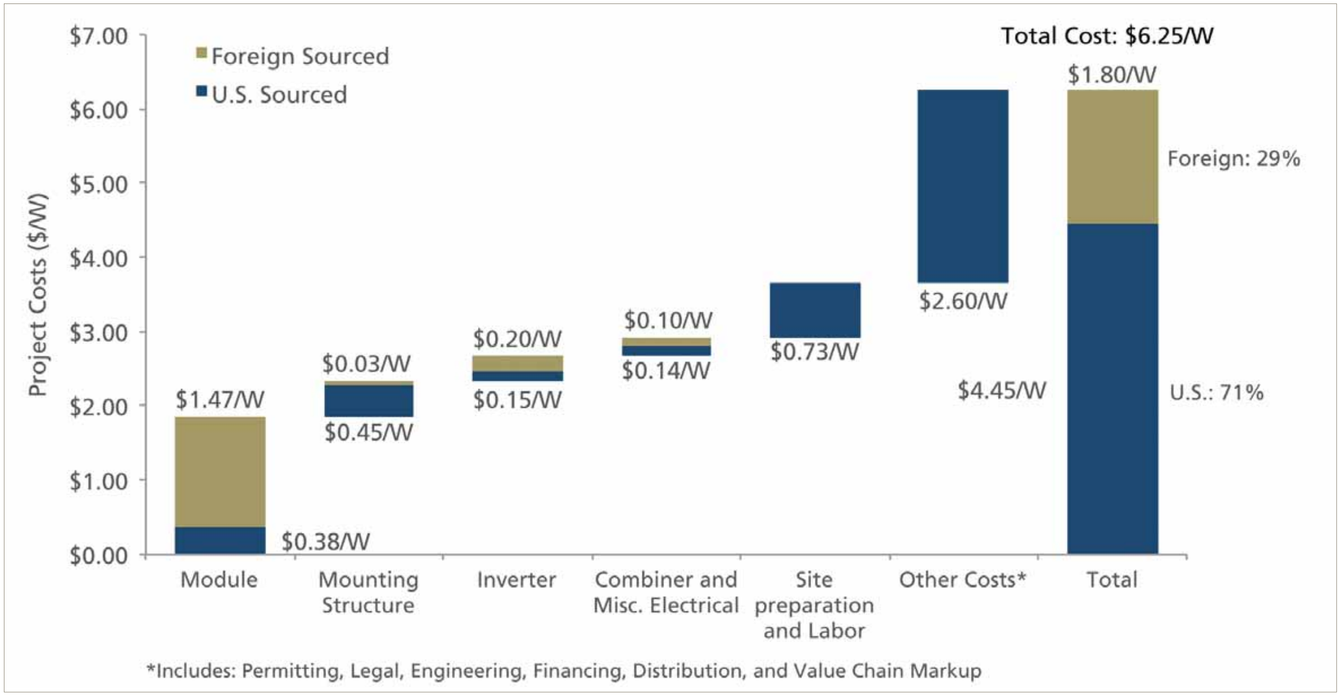
Soft costs include system design and engineering, legal fees, permitting fees, financing preparation, etc., all of which is typically performed by U.S. companies or U.S. subsidiaries of foreign companies. Value chain markup includes overhead and profit margins captured in the period between equipment manufacturing and final installation. In the U.S., more than half of the modules destined for the commercial and residential market are procured from distributors or wholesalers; only companies that procure in large volume purchase directly from solar equipment manufactures. As a result, installed materials often undergo markups by both the distributor and the system installer. The combination of soft costs and value chain markup accounts for approximately 22% of total system costs.

2.10 Domestic Value Creation of PV System by Module Technology

2.10.1 Crystalline Silicon System

Crystalline silicon-based PV systems accounted for 78% of U.S. PV installed capacity in 2010, with a typical installation cost of $6.25/W. Module costs are adjusted to reflect average selling prices for crystalline silicon modules; other system costs are calculated with the same methodology as described above. As explained in earlier sections, the total value of crystalline PV modules is predominantly created abroad, with only 20% of the value created from the average module sourced from the U.S. Although the PV module accounts for nearly one-third of total system costs, the bulk of installed costs remain in the U.S. primarily due to the labor and soft costs necessary to transform PV components to a working system.

Figure 2-19: Cost Breakdown for Crystalline Silicon PV Systems in 2010

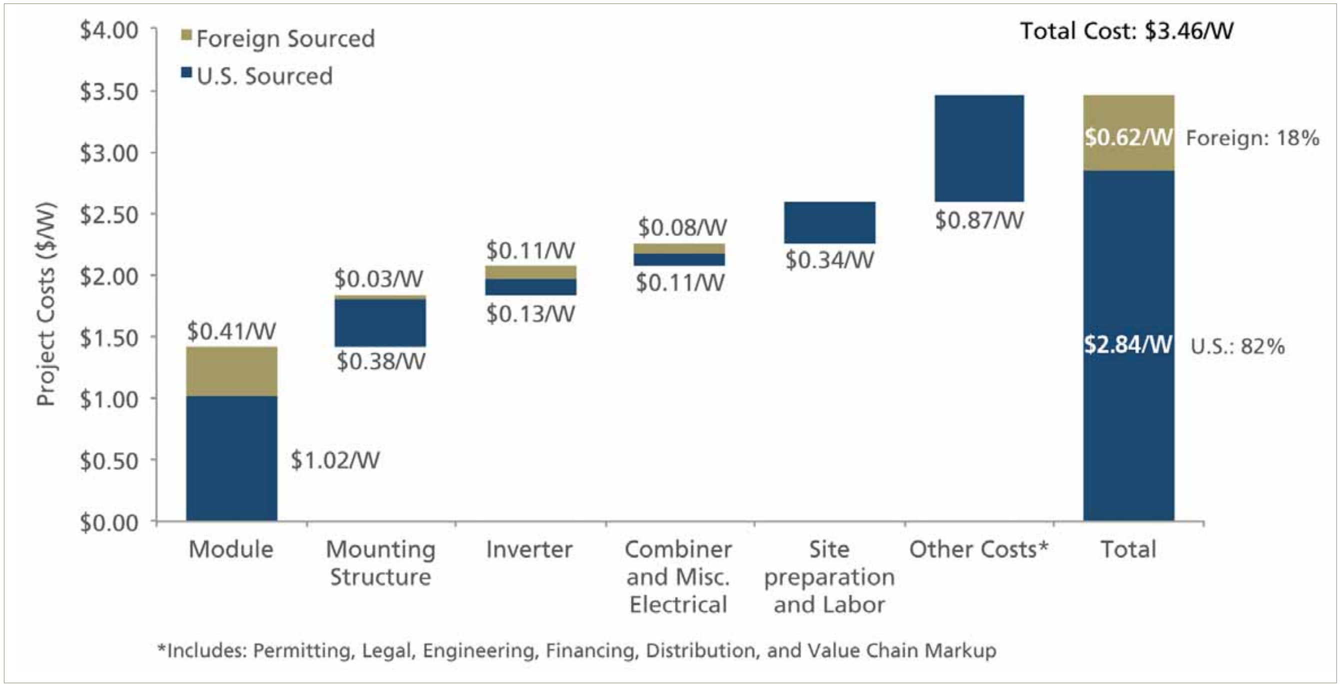


Source: GTM Research

2.10.2 Thin Film System

In 2010, thin film systems are estimated to have drawn 82% of their value from domestic sources, offsetting lower labor, soft costs and markups with a higher domestic content within the PV module. Furthermore, since most thin film capacity was installed in utility-scale projects, these systems utilized utility-scale inverters, which have a higher industry domestic value creation percentage. Note that the reported installed cost of $3.46/W represents a normalized value for the entire industry. It does not approximate any installed thin film systems as the system price is a blend of 150-plus MW of very low cost utility-scale PV with less than 10 MW of comparatively high-priced residential and commercial installations.

Figure 2-20: Cost Breakdown for Thin Film Systems in 2010



Source: GTM Research

2.11 Total Blended PV System

Figure 2-21: Breakdown of Typical U.S. PV Installation and Resulting Value Created for the U.S., 2010

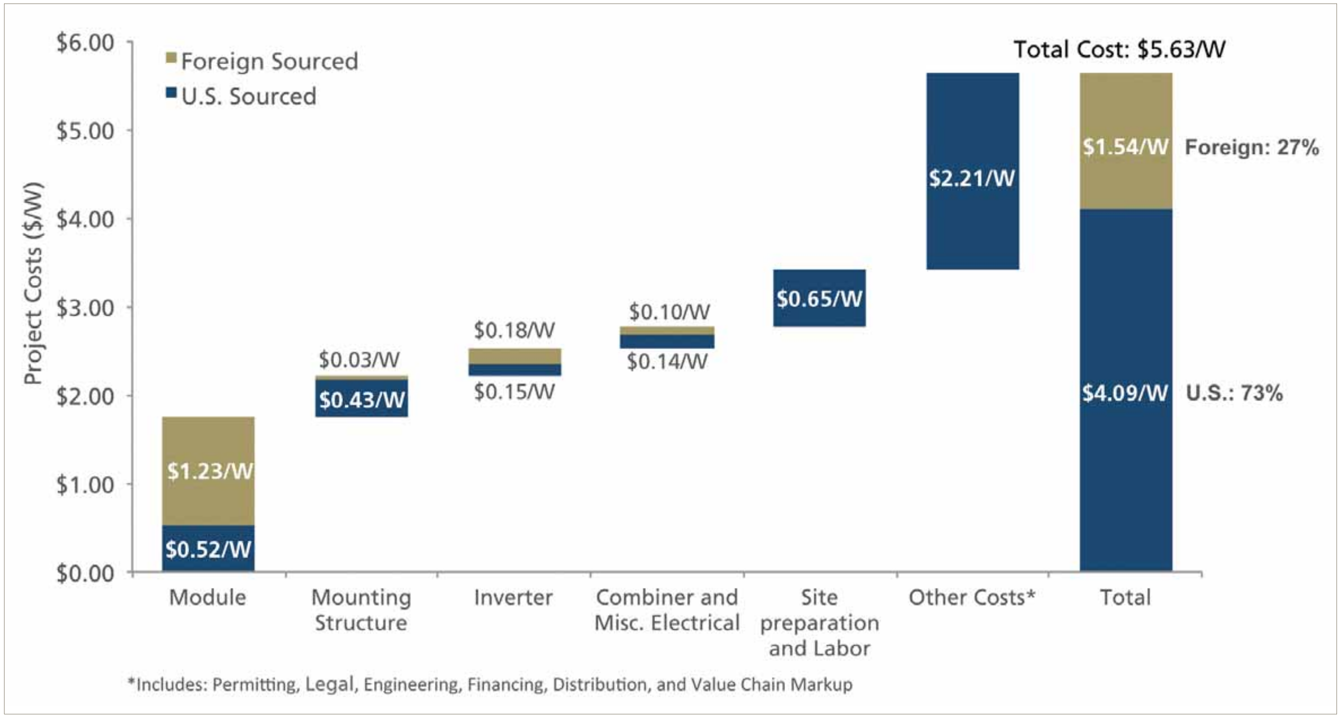
U.S. PV installations in 2010: Total Value Created in the U.S.				
Total Blended System Cost	Blended Cost ($/W)	% of Total System Cost	% Domestic Value	Domestic Value Created ($/W)
Blended PV Module	$1.75	31%	30%	$0.52
Mounting Structure	$0.46	8%	94%	$0.43
Inverter	$0.33	6%	45%	$0.15
Combiner Box and Misc. Electrical	$0.23	4%	59%	$0.14
Site preparation and Labor	$0.65	11%	100%	$0.65
Other Costs*	$2.21	39%	100%	$2.21
Total	**$5.63**		**73%**	**$4.09**
*Includes: Permitting, Legal, Engineering, Financing, Distribution and Value Chain Markup				

Source: GTM Research

Based on the U.S. Solar Market Insight™ Q1 2011 report, capacity-weighted average installed price for all PV systems in 2010 is estimated to be $5.63/W, although project costs exhibited great variability depending on the market segment application, size of installations, location of installation and components employed. Best-practice installed prices were far lower than average system prices, especially for large commercial and utility scale systems. System prices fell quickly throughout 2010, mostly due to drops in module prices. $5.63/W represents a normalized PV system based on weighted industry averages, but can also fairly accurately represent a medium-scale commercial system installed sometime mid-year in 2010.

Integrating the estimated domestic content in each sub-category of PV system costs shows that 73% of PV system value was created in the U.S. The majority of U.S.-created value comes from site preparation, labor, soft costs, and value chain markup—work that is impossible or extremely difficult to outsource. Non-tangible system costs in the form of engineering, logistics, labor and overhead make up 50% of the total system costs, with full value attributed to U.S. sources.

Figure 2-22:
PV System Domestic Value Creation, 2010



Source: GTM Research

Some may criticize that the domestic value creation from labor and other soft costs represents the inefficiency of the U.S. market. Indeed, non-module and non-inverter costs in Germany can be as much as 50% less than those in the U.S. because of easier and quicker permitting regimes, better incentive visibility, and market maturity. This is due in part because the U.S. is driven by 50 state markets rather than one federal policy body. Nevertheless, it should be noted that when examining only physical components, at least 45% ($1.23/W out of $2.77/W) of the value created by modules, mounting structures, inverters, and balance of systems remains in the U.S. Considering that some amount of domestic soft costs will always be required (i.e. local engineering, labor, etc.), the domestic benefit of PV systems should continue to outweigh the benefit to foreign entities, even if some soft costs fall or are outsourced.

Figure 2-23: Breakdown of PV Hardware Components and Resulting Value Created for the U.S., 2010

Domestic Value Creation of PV System Hardware Components			
PV Hardware Component	Total Cost ($/W)	% Domestic Value	Domestic Value Created ($/W)
Blended PV Module	$1.75	30%	$0.52
Mounting Structure	$0.46	94%	$0.43
Inverter	$0.33	45%	$0.15
Combiner Box and Misc. Electrical	$0.23	59%	$0.14
Total PV Hardware Only	$2.77	45%	$1.23

Source: GTM Research

2.12 Year-Over-Year Analysis

Blended average PV system prices in the U.S. dropped by 18% in 2010 compared to 2009 prices of $6.90/W. This decrease was driven mostly by a sharp drop in PV module pricing for both dominant technologies, a shift in the U.S. market towards lower-priced commercial and utility systems, and the boom of utility-scale thin film plants. The higher mix of thin film plants, which at this juncture is represented almost entirely by a single U.S.–based, vertically-integrated company, also contributed to higher domestic value creation, despite the expansion of many foreign (mostly Asian) module manufacturers.

Figure 2-24: Year-over-Year Comparison of PV Domestic Value Creation, 2009 v. 2010

Blended PV System Domestic Value Creation Year-over-Year Comparison

	2009		2010		Year-over-Year		
System Component	Total Cost	Domestic Value %	Total Cost	Domestic Value %	YoY Cost Difference (%)	YoY Domestic Value % Difference	Comments
PV Modules	$2.21	31%	$1.75	30%	-21%	-1%	Factory-gate module pricing drops precipitiously YoY due to booming supply conditions; shift of PV wafer, cell, and module manufacturing towards vertically-integrated Chinese companies
Mounting Structure	$0.40	84%	$0.46	94%	15%	10%	Slightly higher mounting costs year-over-year does not reflect industry trend but rather methodology refinement from previous year's study (see Section 2.7)
Inverter	$0.35	26%	$0.33	45%	-7%	19%	Shift towards commercial- and utility-scale and new investment in inverter manufacturing equates to significantly increased domestic value creation
Combiner Box and Misc. Electrical	$0.47	61%	$0.23	59%	-50%	-3%	Significant shift of market towards utility scale causes blended normalized cost of misc. electrical components to scale down quickly
Site Preparation and Labor	$0.95	100%	$0.65	100%	-32%	0%	Labor costs drop by almost 1/3 YoY as market matures and balance of systems manufacturers focus on reducing labor costs
Other Costs*	$2.52	100%	$2.21	100%	-12%	0%	Other costs scale downwards as markets shift towards commercial and utility-scale systems
Total Blended System Cost	$6.90	71%	$5.63	73%	-18%	2%	Increase in domestic value creation throughout value chain as well as major drops in initial hardware component costs

*Includes: Permitting, Legal, Engineering, Financing, Distribution and Value Chain Markup

Source: GTM Research

For members of the industry, the flat growth in domestic value creation percentage for PV modules is unsurprising—low-cost and bankable supply has flooded into the U.S. from overseas, mostly from vertically-integrated Asian manufacturing that produce PV wafers, cells, and modules abroad, offset by increasing deployment of domestically manufactured, utility-scale thin film modules. However, increased U.S. production of mounting structures and inverters with domestic value content percentage rising by 10% and 19% year-over-year respectively means that total domestic value creation as a percent of total system cost actually increased from 71% to 73% for the overall PV industry. As mentioned in Section 2.7, the revised methodology for calculating the market value and domestic value creation of PV mounting structures slightly diminishes the year-over-year domestic value gains, but the overall trend remains positive.

For 2011, similar trends are expected; overall system costs should continue to fall dramatically through a combination of market segment shifts, global module oversupply and market maturity forcing down labor and other soft costs. 2011 will likely also see greater foreign value percentage in modules as once booming European markets begin to slow down and foreign module manufacturers seek greener pastures in the U.S. installation market. Some foreign crystalline silicon companies have invested in domestic manufacturing facilities and increased foreign investment in U.S. inverter manufacturing should continue to push domestic content of inverters up, creating a promising opportunity for U.S.-made PV components. In the longer term, the emergence of U.S. thin film PV module manufacturing could potentially reverse the flow of module value overseas and bring U.S. module manufacturing back into global prominence.

2.13 Trade Flow Analysis

Separate from, but related to, the issue of domestic value created is the issue of trade flows. The essential question is simple: how much solar energy-related materials and components does the U.S. import vs. export, and to which countries? In keeping with the segmented nature of the PV value chain (crystalline silicon PV technology in particular), trade flows are assessed separately for the following aspects, before being combined in the final analysis:

- Capital Equipment
- Polysilicon
- Wafers
- Cells
- Thin film feedstock
- Modules (both crystalline Si and thin film)
- Inverters

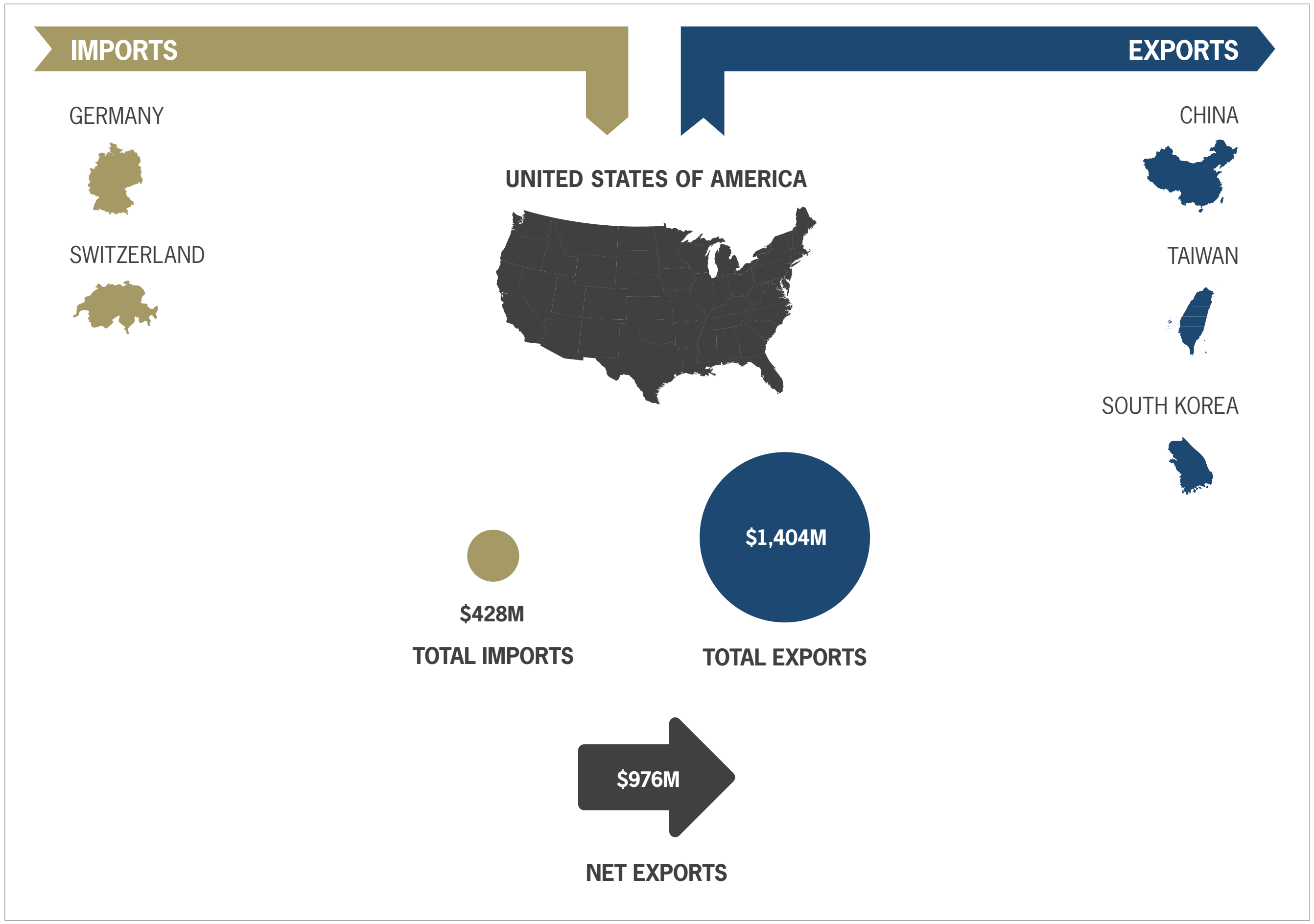
2.13.1 Capital Equipment

To assess trade flows for PV capital equipment in 2010, the following methodology was used:

- Total U.S. sales of capital equipment for 2010 were calculated by aggregating sales across all U.S.-based capital equipment providers.
- Sales of capital equipment to U.S. PV manufacturers by U.S. and foreign equipment vendors were calculated based on geographical sales data provided by publicly traded equipment manufacturers where available. Where this data was not available, U.S. sales were estimated on a variety of factors, primarily 2010 U.S. capacity additions by technology and value chain segment.
- Exports were estimated by taking the difference of total sales of U.S.-based vendors and sales by these firms to U.S. PV manufacturers as estimated above.
- Imports were estimated by taking the difference of domestic equipment purchases and U.S. equipment production that was sold domestically, calculated earlier.

The results of this process are displayed below. As shown, the U.S. exported considerably more capital equipment ($1,404 million) than it imported in 2010 ($428 million). The U.S. leads the world in solar factory equipment manufacturing, but its relatively small PV manufacturing industry yields insufficient demand for this equipment, causing substantial U.S. factory equipment exports. While country-specific trade flows were unavailable due to corporate confidentiality polices, primary export locations corresponded to global PV manufacturing bases, namely China (including Taiwan) and South Korea, while import locations included Germany and Switzerland.

Figure 2-25: PV Capital Equipment Imports and Exports by Source/ Destination, 2010



Source: GTM Research

2.13.2 Polysilicon

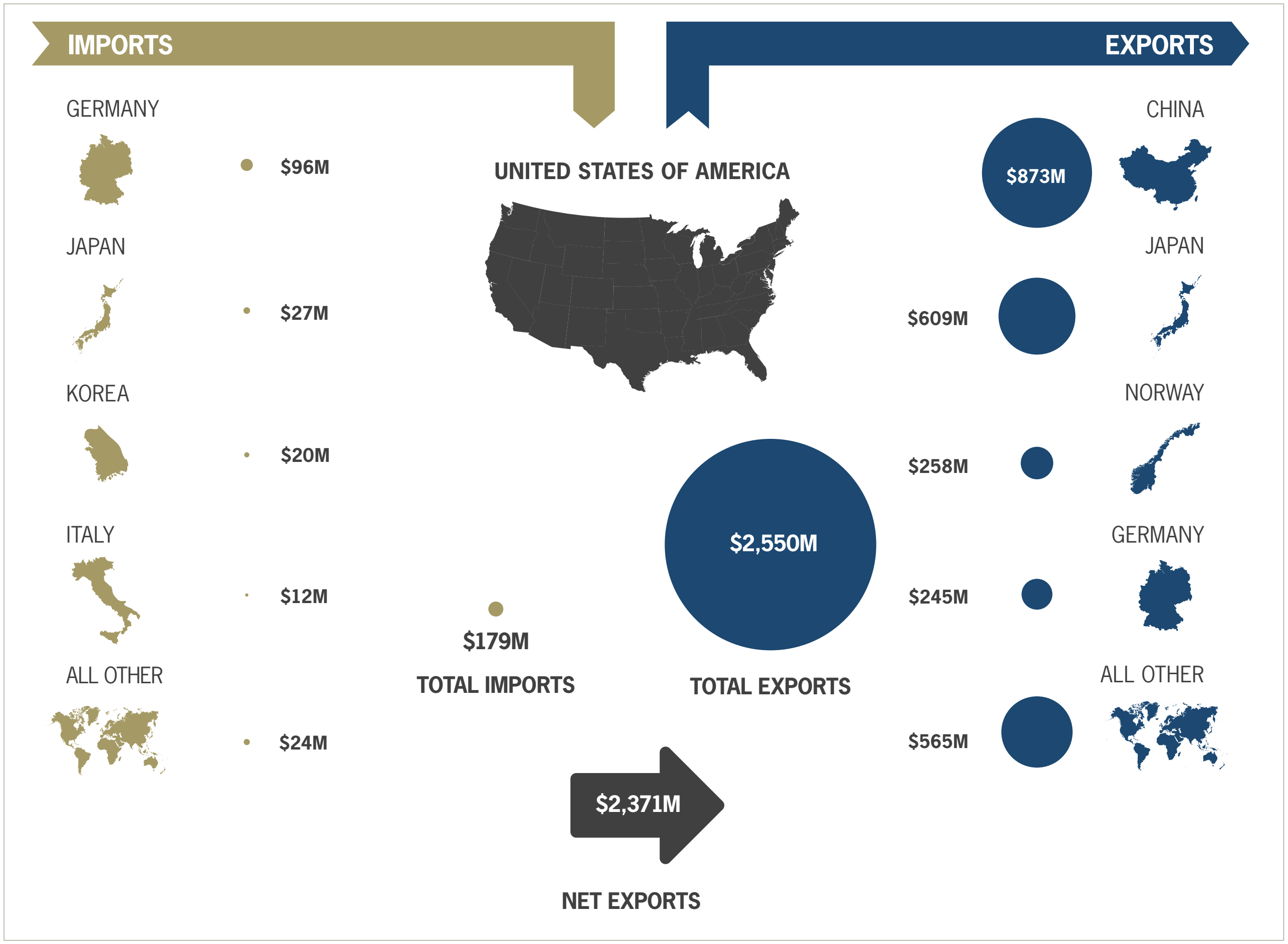
To assess polysilicon trade flows in 2010, the following methodology was used:

- GTM Research's proprietary database was first used to track polysilicon production by manufacturer.
- Total polysilicon consumption by domestic wafer producers was estimated based on domestic wafer production (tracked by GTM Research by facility) and an assumed silicon utilization of 6 grams per watt.
- Total U.S. polysilicon production was calculated by aggregating across all U.S. facilities.
- The amount of domestically produced polysilicon that was consumed by domestic wafer manufacturers was estimated based on domestic wafer production and by tracking polysilicon sales agreements for these firms.
- Exports were estimated by taking the difference of domestic polysilicon production and domestically produced, domestically consumed polysilicon as estimated above.
- Imports were estimated by taking the difference of domestic polysilicon consumption and U.S. production that was sold domestically, calculated earlier.

The results of this process are displayed below. As shown, the U.S. exported far more polysilicon ($2,550 million) than it imported in 2010 ($179 million). The main reason for this is a strong domestic polysilicon manufacturing base and the near-absence of domestic wafer producers. This means that (i) the U.S. produces large quantities of polysilicon, (ii) very little of this is consumed domestically, and (iii) there is little or no need to import polysilicon.

As one would expect, the primary export locations corresponded to global PV wafer manufacturing bases, namely China (including Taiwan), Japan, Norway, and Germany. Import locations included Germany, Japan, and South Korea.

Figure 2-26: PV Polysilicon Imports and Exports by Source/ Destination, 2010

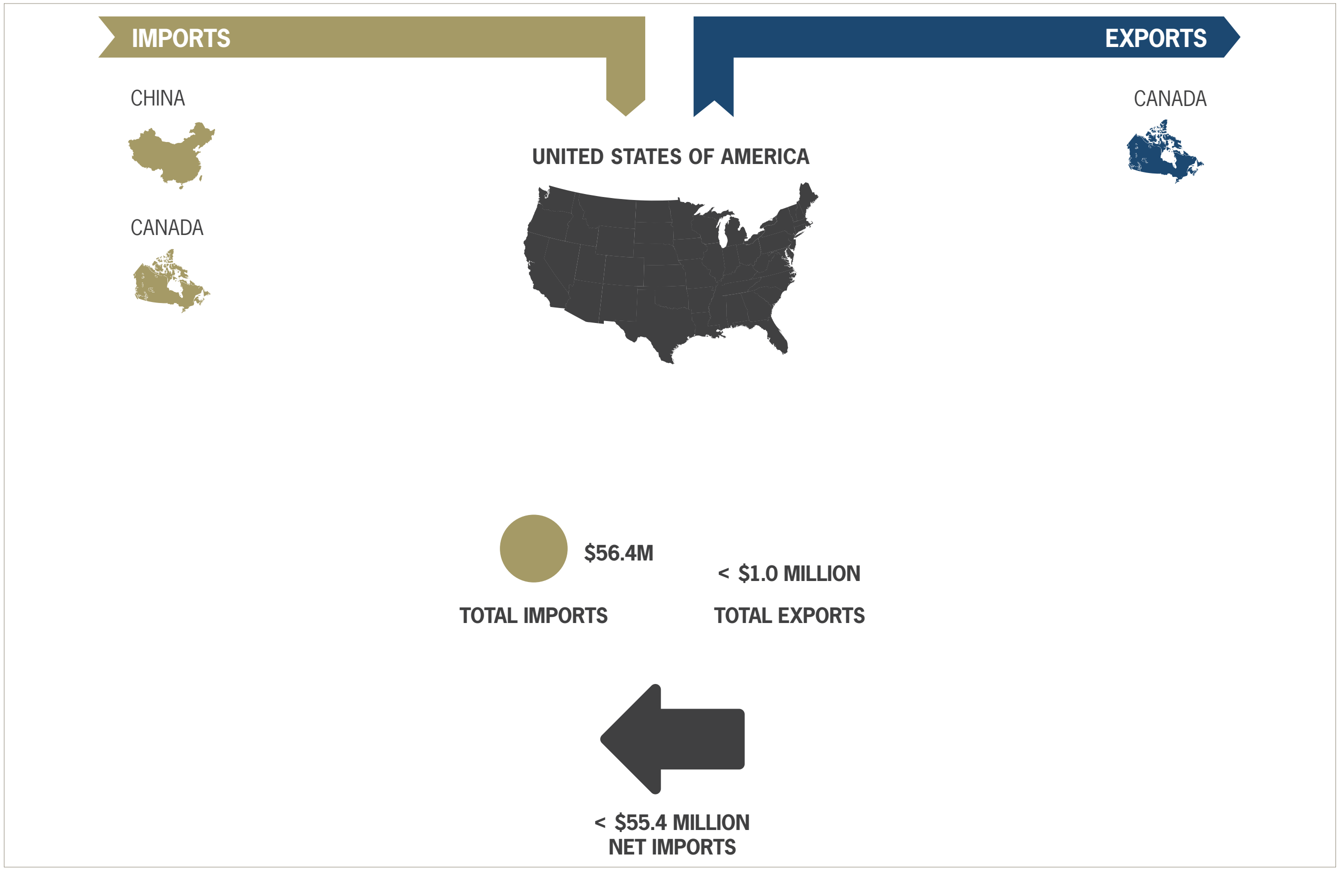


Source: GTM Research

2.13.3 Thin Film Feedstock

Thin film feedstock includes cadmium and tellurium for CdTe-based modules; copper, indium, gallium, and selenium for CIGS-based modules; and silane for thin film silicon-based modules. Trade flows for thin film feedstock were estimated based on domestic thin film module production and U.S. International Trade Commission data on metal imports and exports. Overall, exports totaled less than $1 million, while imports amounted to $56.3 million, yielding a net import figure of around $56 million. Although exact country-specific breakdowns were unavailable, primary import locations included China and Canada.

Figure 2-27: PV Thin Film Feedstock Imports and Exports by Source/Destination, 2010



Source: GTM Research

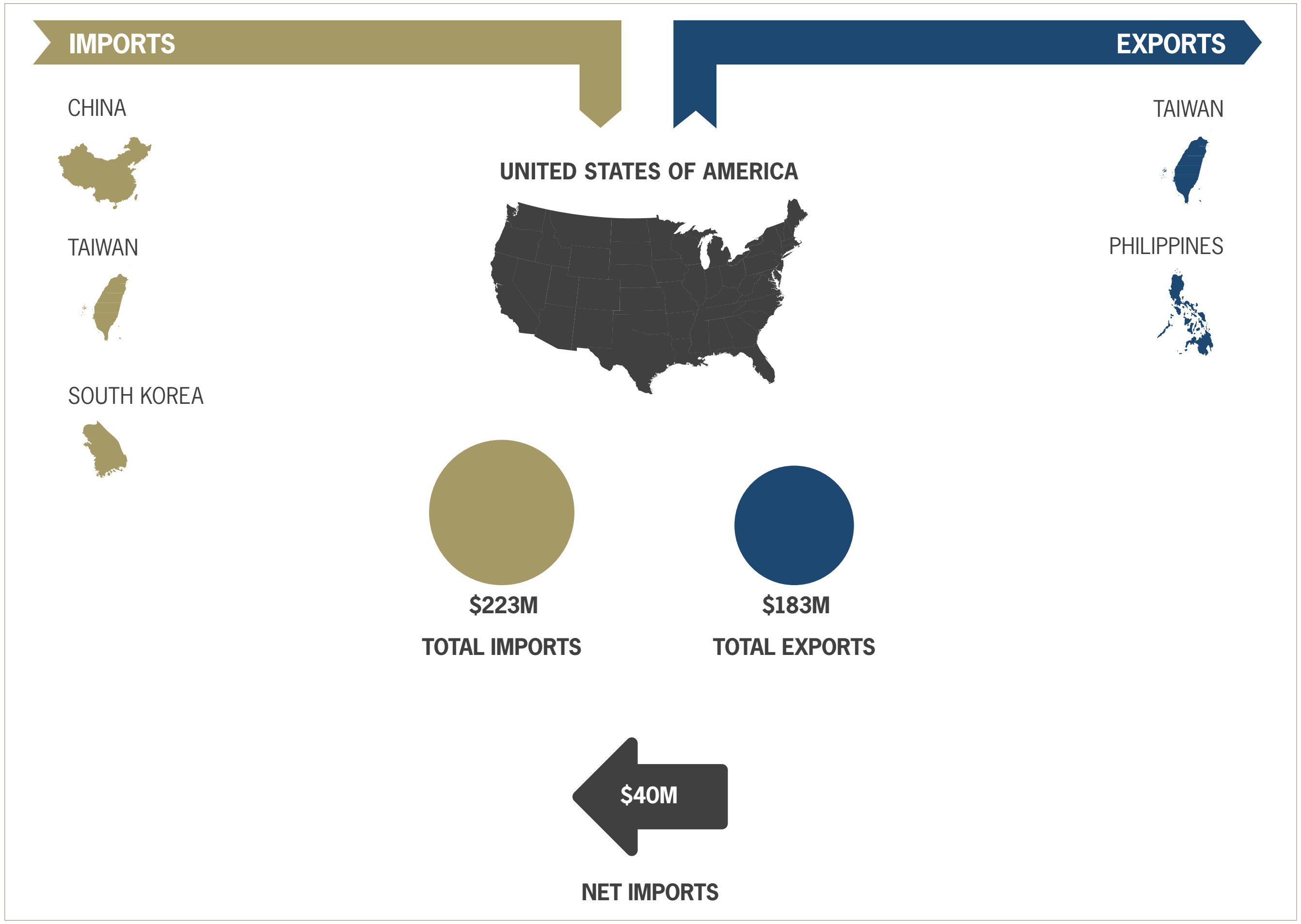
2.13.4 Wafer

To assess PV wafer trade flows in 2010, the following methodology was used:

- GTM Research's proprietary database was first used to track wafer and c-Si cell production by manufacturer and estimate total U.S. wafer and c-Si cell production.
- Total U.S. wafer consumption was estimated based on U.S. c-Si cell production, assuming a yield of 95%.
- The amount of U.S. wafer production sold domestically was then estimated based on available data and interviews with wafer vendors.
- Exports were estimated by taking the difference of U.S. wafer production and U.S. wafer production that was sold domestically.
- Imports were estimated by taking the difference of U.S. wafer consumption and U.S. wafer production that was sold domestically, calculated earlier.

As shown below, the U.S. was a slight net importer of PV wafers ($40.4 million) in 2010. Since it is not a major wafer or crystalline silicon cell manufacturing center, neither exports ($183.0 million) nor imports ($223.4 million) are large in magnitude. While quantitative data for country-specific imports and exports was not available for wafers, major importers to the U.S. are China and Taiwan according to analysis of major sales contracts and data on global wafer and cell production. Major wafer exports were shipped to Taiwan and the Philippines.

Figure 2-28: PV Wafer Imports and Exports by Source/ Destination, 2010

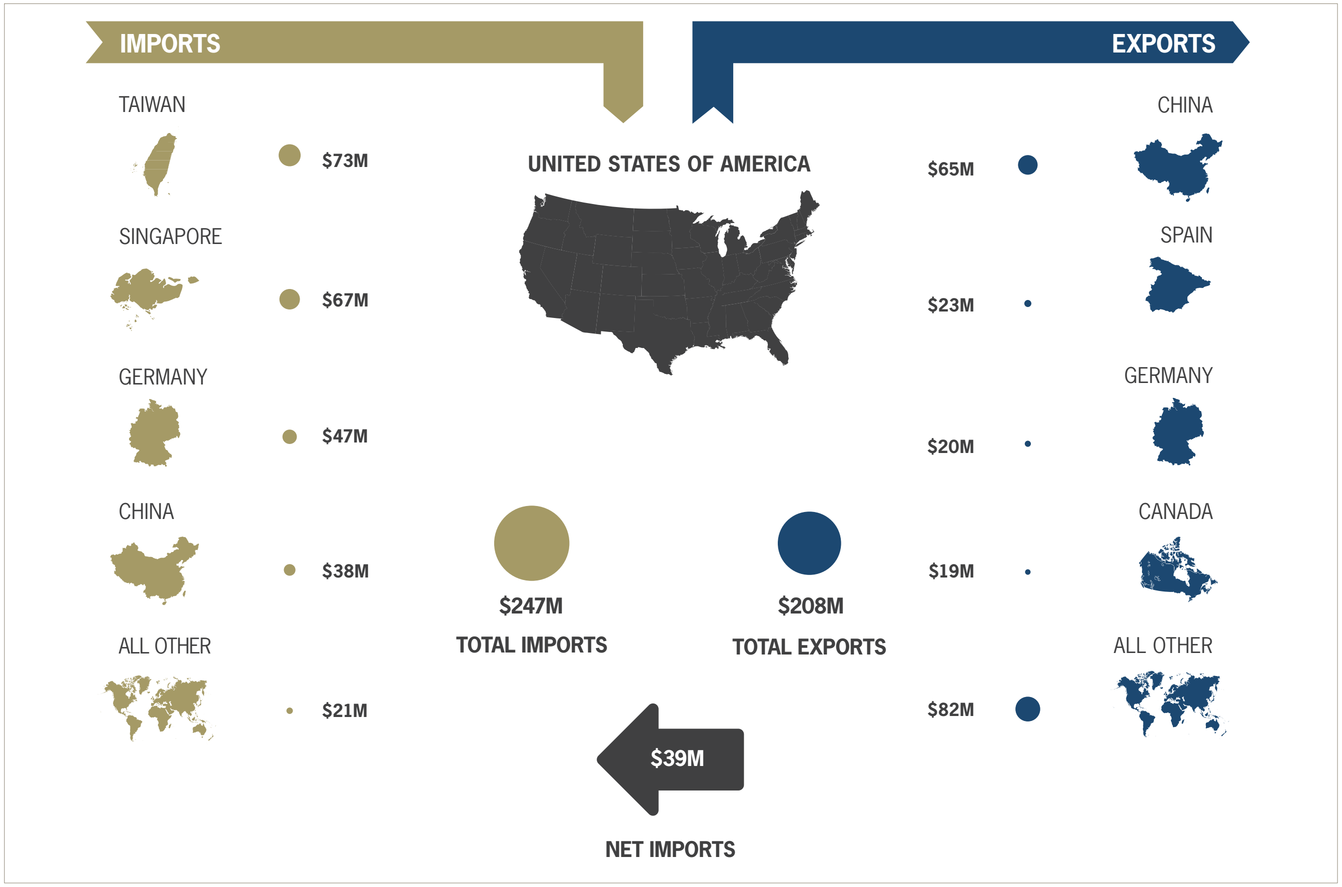


Source: GTM Research

2.13.5 Cell

Data for PV cell imports and exports was obtained from the U.S. International Trade Commission. The customs values in this case are only for cells that were not already assembled into modules; given the integrated nature of thin film manufacturing, it is therefore assumed that almost all of these cells are crystalline silicon in nature. As shown below, the U.S. exported almost as many cells ($207.9 million) as it imported in 2010 ($246.9 million). Key import sources included Taiwan, Singapore, Germany, and China, while export destinations included China, Spain, and Germany.

Figure 2-29: PV Cell Imports and Exports by Source/ Destination, 2010

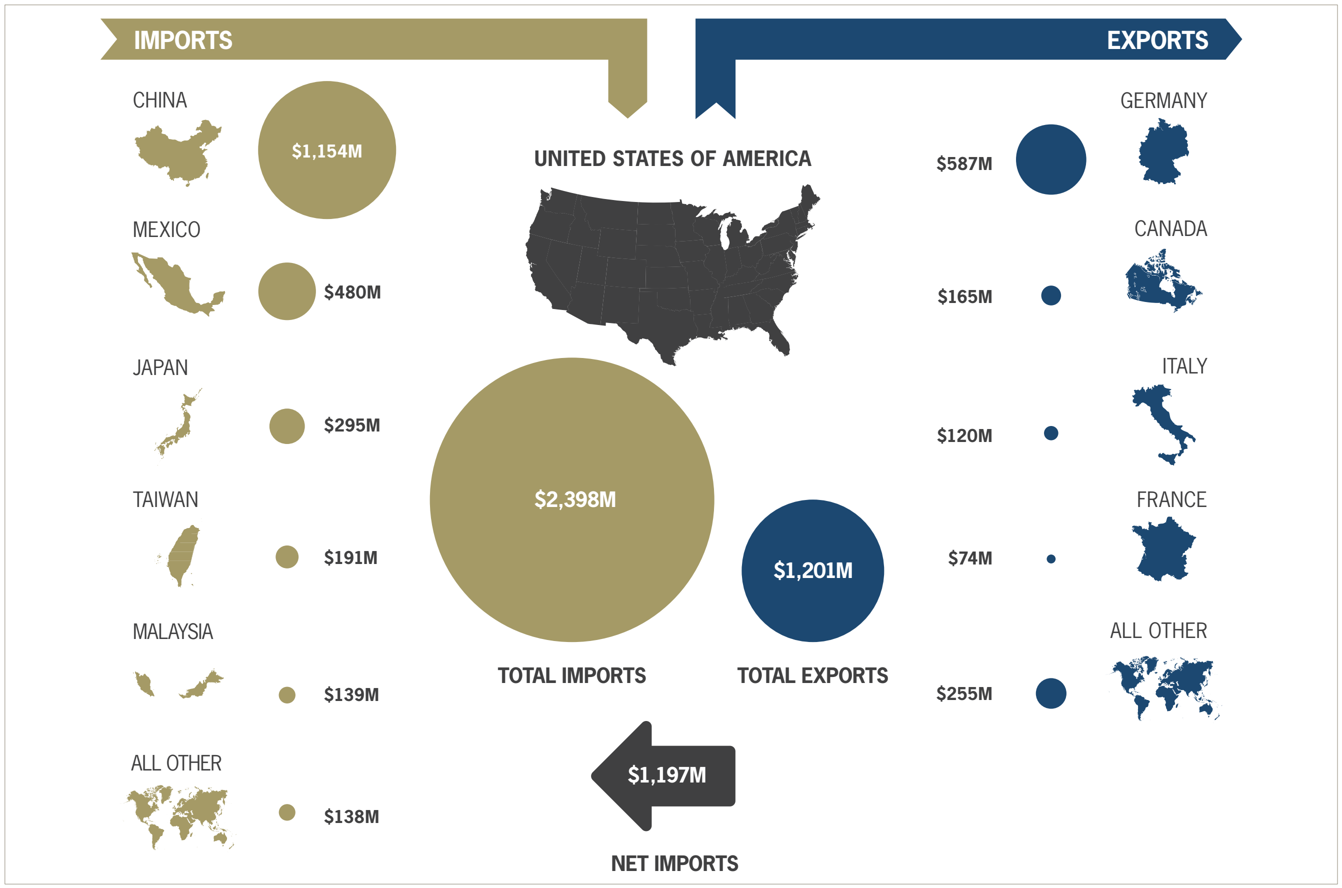


Source: GTM Research

2.13.6 Module

As with cells, data for PV module imports and exports was obtained from the U.S. International Trade Commission; here, this would include both crystalline silicon and thin film modules. Total module exports amounted to $1,201 million in 2010, while exports totaled $2,398 million, which yields net module imports of $1,197 million. While imports arose mostly from China, Mexico, and Japan and indicate the presence of a strong domestic end-market, exports were directed towards nations that also deployed PV installations in significant quantities, such as Germany, Canada, Italy, and France.

Figure 2-30: PV Module Imports and Exports by Source/ Destination, 2010

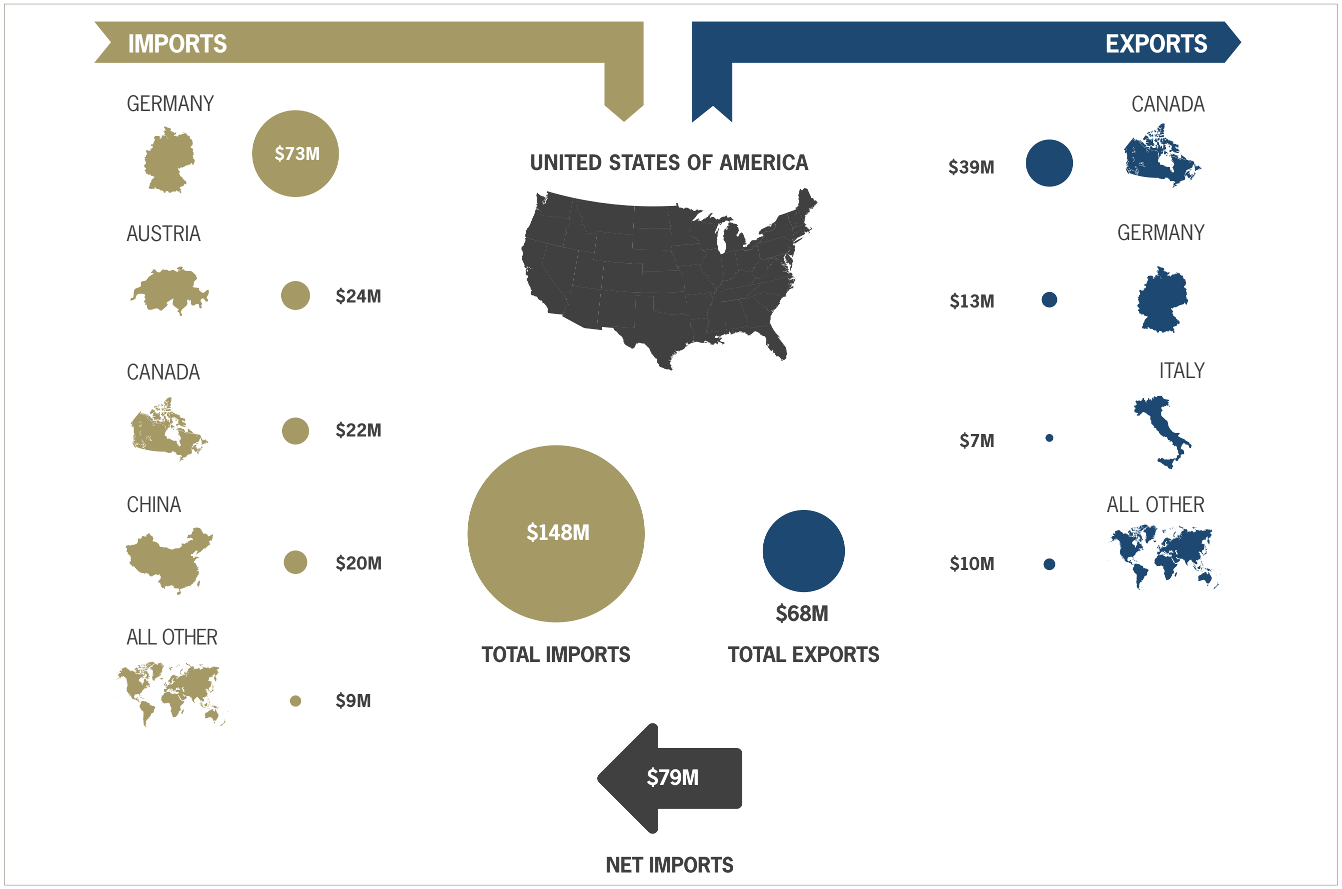


Source: GTM Research, U.S. International Trade Commission

2.13.7 Inverter

Given the small fraction of domestic inverter assembly and manufacturing in the context of the global industry, an imbalance of trade is expected. Imports from Germany alone, accounted for nearly 50% of an estimated $147.6 million of domestic inverter imports. Exports by U.S. suppliers, mostly to North America with some trickle into Europe as well, reached only approximately $68.2 million. Foreign investment has poured into North America with many companies establishing new inverter manufacturing facilities in the U.S. While U.S. manufacturers were able to opportunistically sell into Europe, the difference in technological requirements and certifications prevented most American manufacturers from selling beyond North America.

Figure 2-31: PV Inverter Imports and Exports by Source/ Destination, 2010

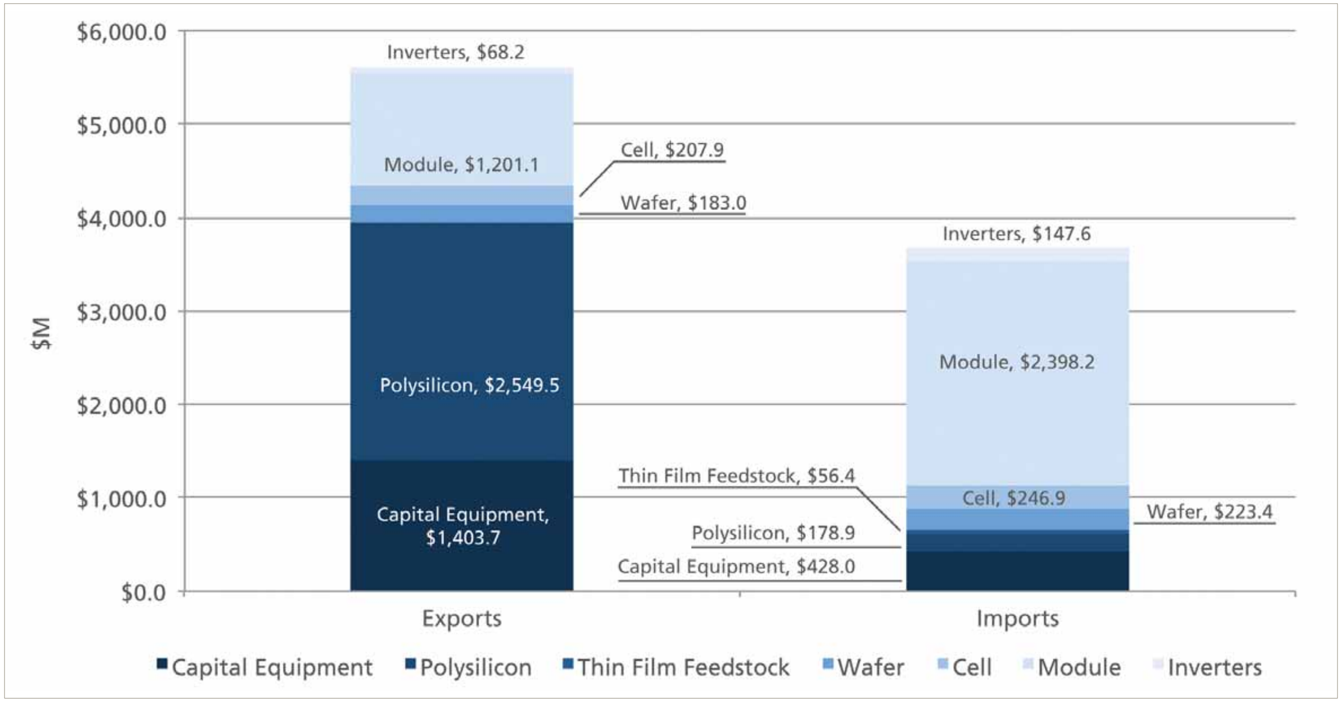


Source: GTM Research

2.13.8 Total PV Trade Flows

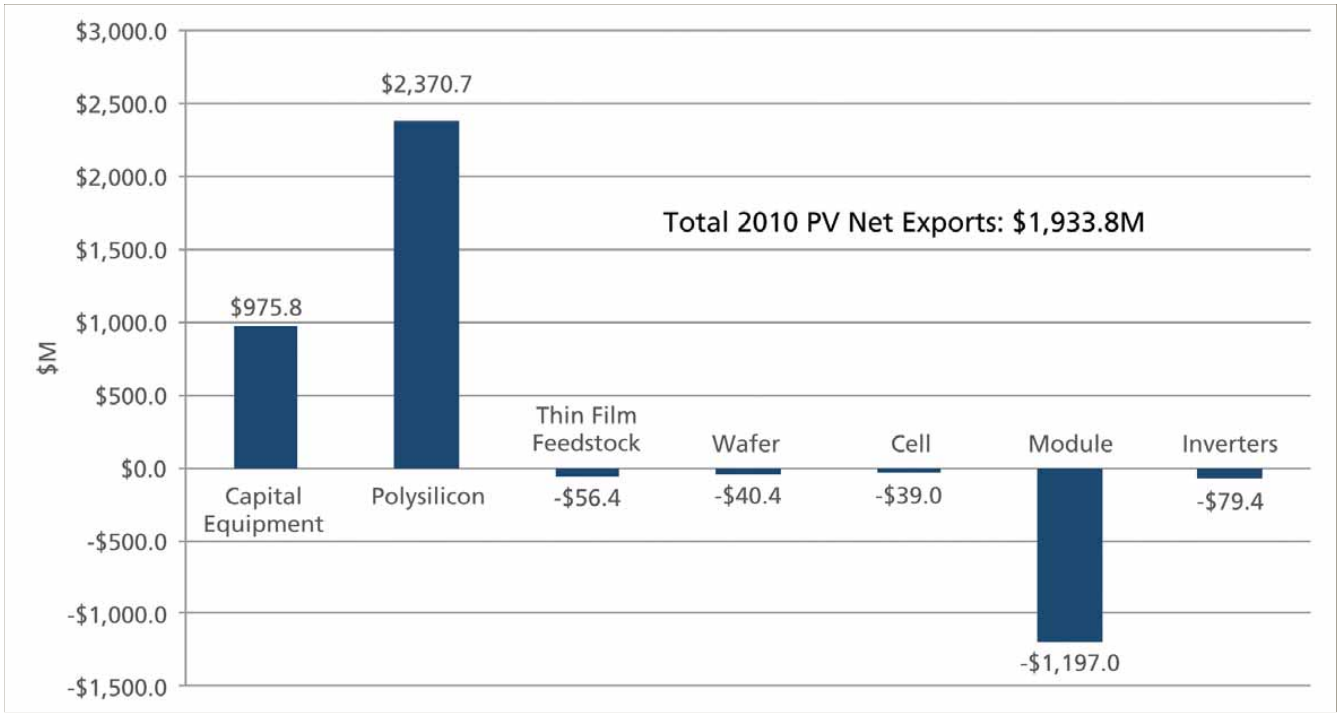
By summing trade flows for the individual components assessed, one arrives at total PV import and export volumes, which puts 2010 PV exports at $5,613 million. This compares to imports of $3,679 million, which yields net PV exports of $1,934 million. As shown, the primary export goods for PV in 2010 were capital equipment, polysilicon, and modules, while modules were by far the main components imported. In terms of net exports, polysilicon and capital equipment had the highest surplus for 2010, while modules had the highest trade deficit.

Figure 2-32: U.S. PV Trade Flows by Value Chain Segment, 2010



Source: GTM Research

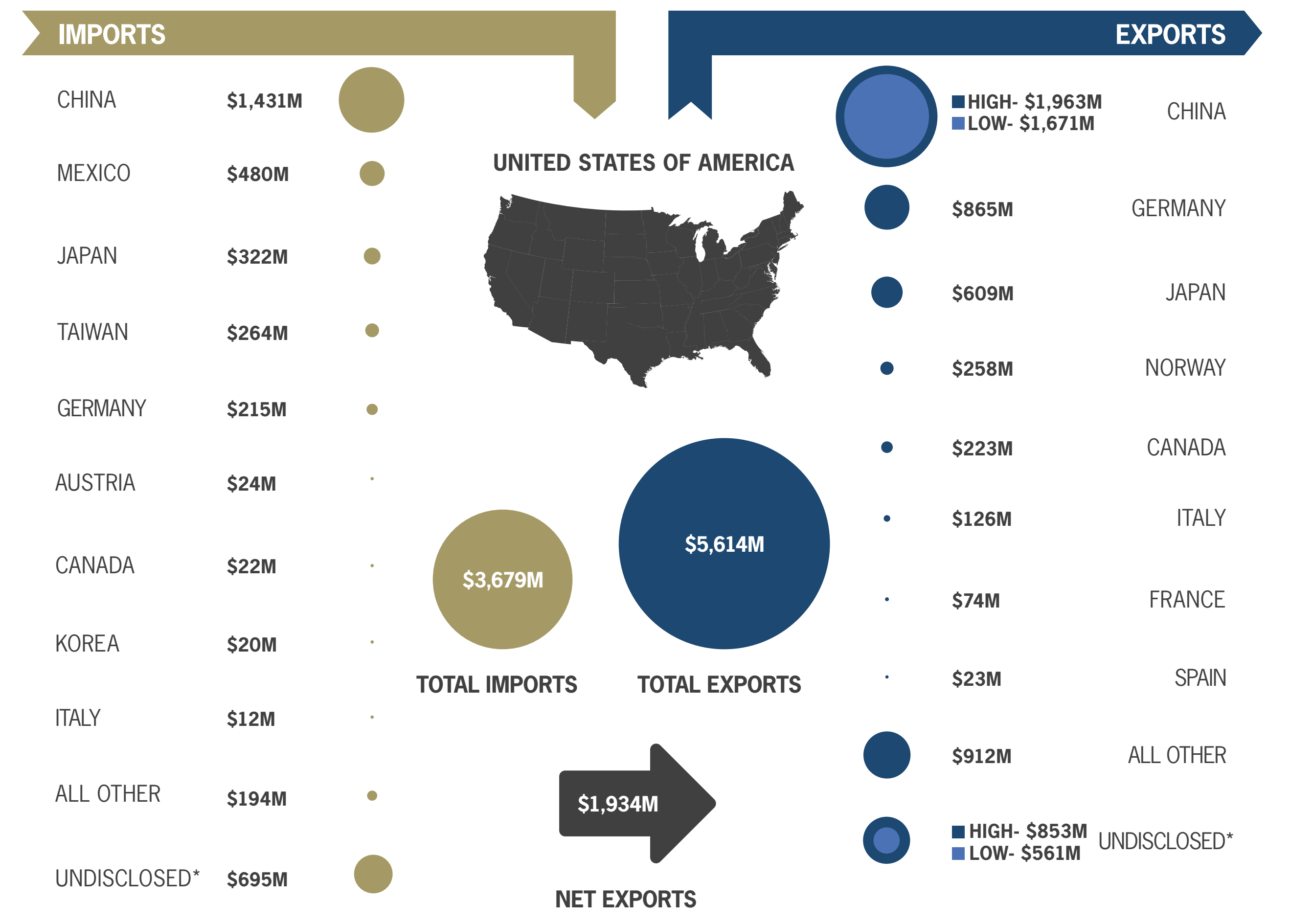
Figure 2-33: U.S. PV Net Exports by Value Chain Segment, 2010



Source: GTM Research

China was the number one source and destination of PV products, driven mainly by exports of polysilicon and capital equipment, whereas PV modules served as the primary imports. The U.S.-China trade balance for PV-specific products is estimated to range from $250 million to $550 million, indicating that the U.S. is a net exporter of PV products to China. Mexico was the second highest source of imports, with three PV module facilities as the origin of much of these imports. Similarly, Germany was the number two destination for U.S. exports, as PV module manufacturers were able to sell into a booming 2010 German PV market. Unsurprisingly, countries with robust PV end markets (aside from China) serve as top destinations for exports and well developed PV manufacturing regions were the primary sources for imports.

Figure 2-34: U.S. PV Trade Flows by Country, 2010



*Non-China Capital Equipment, Thin Film Feedstock, and PV Wafers; estimates provided as a range due to corporate confidentiality policies.

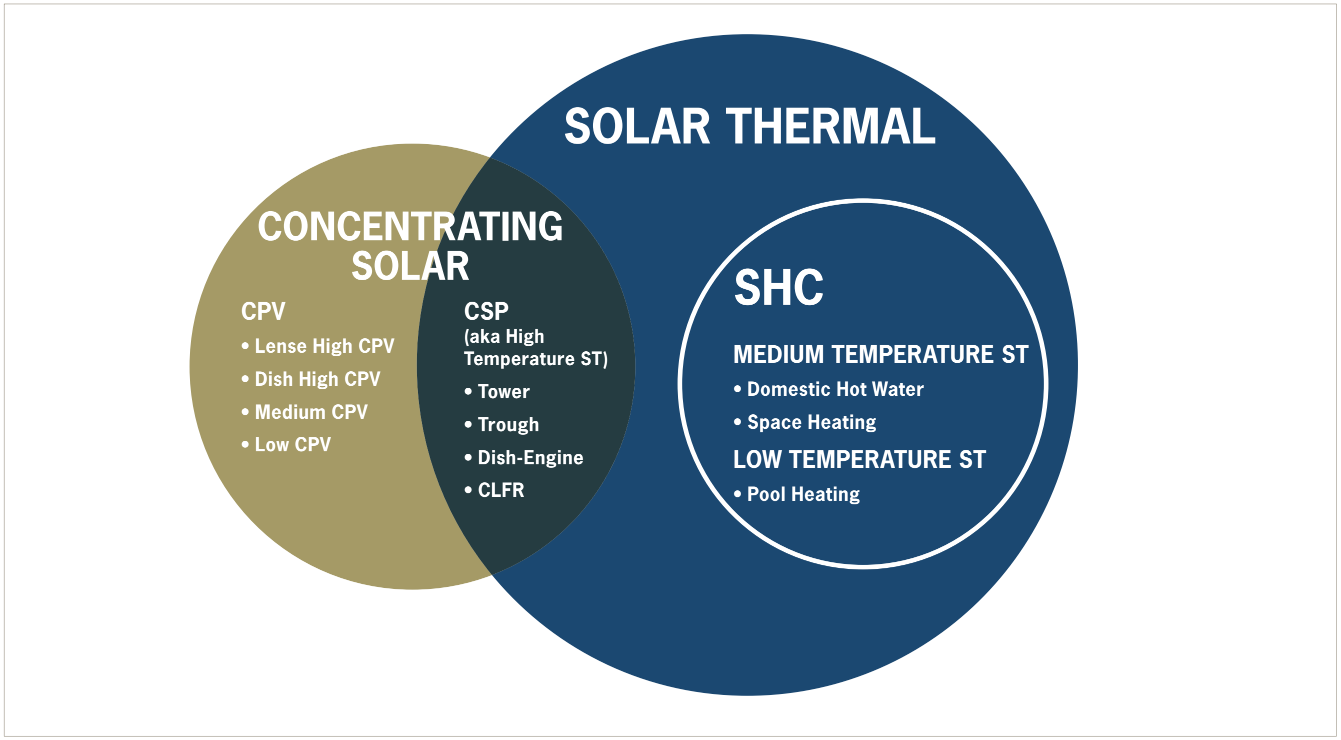
Source: GTM Research

3 CONCENTRATING SOLAR POWER (CSP)

3.1 Domestic Value Created

Concentrating solar is a category of technologies that concentrate sunlight to either generate electricity directly (concentrating photovoltaics or CPV) or to generate steam for process heat or electricity generation (concentrating solar power or CSP). A diagram illustrating the technologies included in the concentrating solar category is shown below.

Figure 3-1: Concentrating Solar includes both Concentrating PV (CPV) and Concentrating Solar Power (CSP) technologies

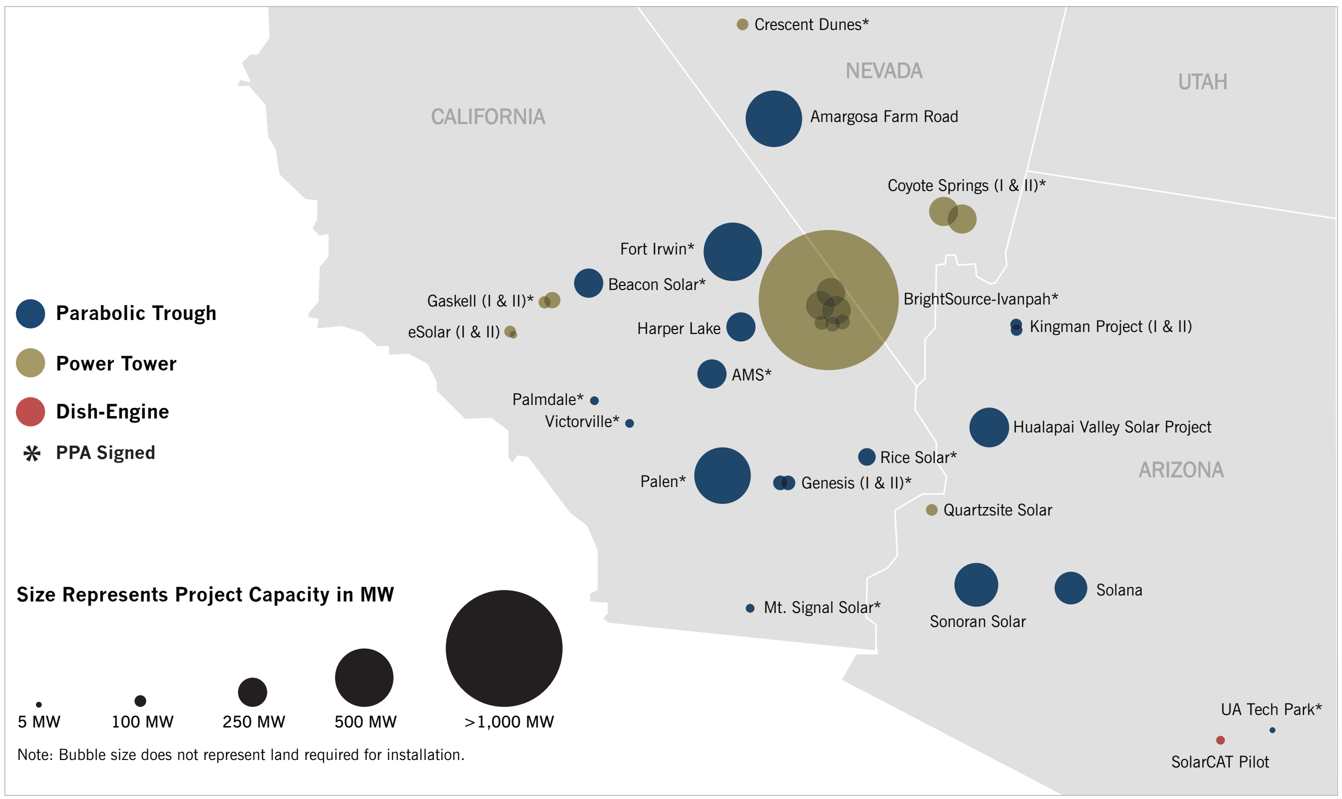


Source: GTM Research

In 2010, less than 5 MW of CPV was installed in the U.S., compared with 75 MW of CSP, and over 800 MW of non-concentrating PV. Because CPV represented less than 0.5% of the total solar installed, it is not included in this analysis – and this section will therefore focus solely on CSP.

As shown in the U.S. CSP project map below, the majority of the projects with signed power purchase agreements (PPAs) will be utilizing parabolic trough and power tower technology.

Figure 3-2: U.S. CSP Project Map for U.S. Southwest



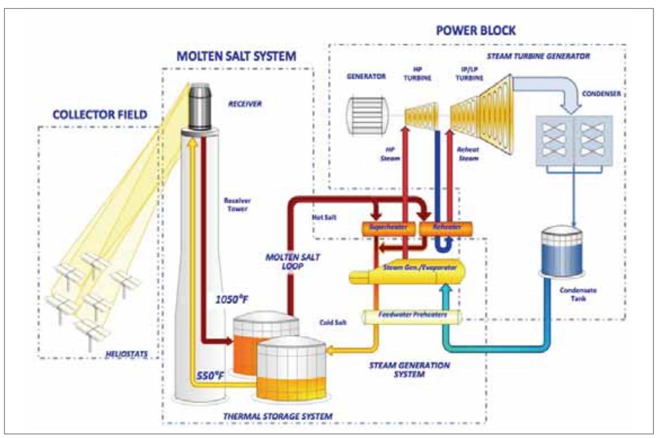
Source: GTM Research

The two primary CSP technologies are power tower and parabolic trough. Images for both types of plants are shown below. Power tower plants use flat mirrors called heliostats to direct sunlight onto a receiver mounted atop a central tower.

Source: BrightSource Energy

Parabolic trough plants used curved mirrors to direct sunlight onto a receiver tube that runs the length of the collector. Inside the tube is a heat transfer fluid, such as synthetic oil, which is heated by the sunlight, and eventually used to generate steam to power a turbine.

Source: Abengoa Solar



As illustrated in the diagram below, a CSP plant has several major components. The collector field is the mirrors/heliostats that collect the sunlight and direct it towards the central receiver. The next part is the molten salt system/tower, which is where the heat transfer fluid is heated and then carried to the thermal storage system. The steam generation system uses the heat transfer fluid (either oil or molten salt) to produce steam which is carried to the final part of the plant. Lastly, there is the power block, where the steam powers a turbine generator to create electricity.

Source: SolarReserve

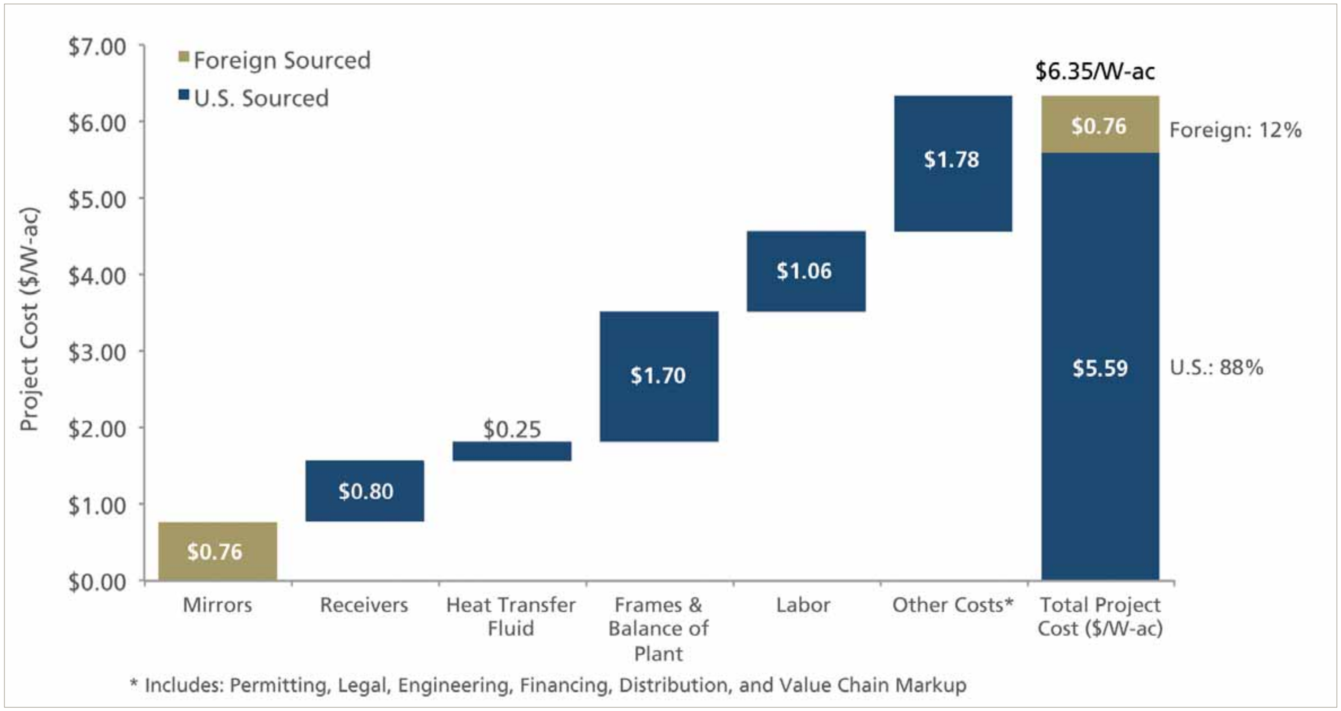
CSP only had one large-scale plant installed in 2010, the 75-MW Martin Next Generation Solar Plant in Florida – developed and owned by FPL. This parabolic trough plant was used to determine trade flows and domestic value creation for CSP.

Figure 3-3: CSP Percent of Value Created in the U.S.

U.S. CSP PROJECTS IN 2010: TOTAL VALUE CREATED IN THE U.S.				
CSP Component	**Total Project Cost ($/W-ac)**	**% of Total Cost**	**% U.S. Sourced**	**U.S. Content ($/W-ac)**
Mirrors	$0.76	12%	0%	$0.00
Receivers	$0.80	13%	100%	$0.80
Turbine	$0.00	0%	100%	$0.00
Heat Transfer Fluid	$0.25	4%	100%	$0.25
Storage Tanks	$0.00	0%	100%	$0.00
Frames & Balance of Plant	$1.70	27%	100%	$1.70
Labor	$1.06	17%	100%	$1.06
Other Costs	$1.78	28%	100%	$1.78
Total	**$6.35**		**88%**	**$5.59**

Source: GTM Research. Cost breakdown estimated using NREL and UC Berkeley data, and was not provided by FPL.

Figure 3-4: CSP Project Domestic Value Creation, 2010



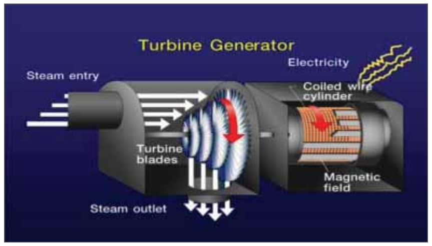
Source: GTM Research. Cost breakdown estimated using NREL and UC Berkeley data, and was not provided by FPL.

Total system costs of $6.35/W-ac are 88% sourced domestically, which equates to $5.59/W-ac. All CSP costs are shown in cost per watt-AC (alternating current). Whereas PV plants produce direct current (DC) power that needs to be converted to AC, CSP plants produce AC directly. For an apples-to-apples comparison between CSP and PV cost per watt, the PV cost should be multiplied by roughly 1.18 to convert to cost per watt-ac. The cost of $6.35/W-ac is not typical for a CSP plant, as the Martin plant required much more expensive tempered glass and heavy-duty frames to resist the hurricane-force winds which occasionally visit Florida. But it also benefited on the cost side, as no new turbine was required, since the plant feeds steam into an existing fossil fuel plant. In the U.S. in 2010, there was $476 million spent on CSP projects (FPL's Martin plant), of which $419 million in value was retained in the U.S. CSP plants have a higher domestic value creation percentage than PV, as many of the components for CSP are commodity items and therefore have low value per pound (aluminum, cement, gravel, etc.). Therefore, it is more economical for CSP plants to use domestic suppliers to avoid transport costs.

3.1.1 Mirrors

Mirrors represent 12% of the total cost of a CSP project. In the case of the Martin Solar Project, mirrors were sourced from Rioglass in Spain, as no domestic manufacturer could produce parabolic trough mirrors from tempered glass. Mirrors are therefore considered to be 100% imported. Note that Rioglass recently established a facility in Arizona that could impact future import/export trends.

Source: Desertec-UK



Source: Geothermal Education Office

3.1.2 Receivers

Glass receiver tubes represent 13% of the total cost of a CSP project. For this analysis, we assume the receiver tubes were sourced domestically, as there was sufficient domestic capacity to supply the 75 MW project. The image to the left depicts a row of receiver tubes mounted above a parabolic trough collector.

3.1.3 Turbine

The steam turbine generator traditionally comprises 6% of the total cost for a CSP plant. In the case of Martin, however, the solar field feeds steam to an existing steam turbine for the adjacent natural gas power plant – and therefore no additional turbine was required. A diagram of the major elements in a steam turbine is pictured below.

3.1.4 Molten Salt

For a CSP plant with storage, molten salt would represent 4% of the total cost. It is a mixture of 60% sodium nitrate and 40% potassium nitrate (saltpeter), and is used for thermal energy storage. For Martin, there is no storage and as such no cost for molten salt.

Source: ACS-Grupo Cobra

Source: Hydro Aluminum and Gossamer Space Frames

3.1.5 Storage Tanks

Storage tanks typically represent 5% of the total cost of a CSP plant. As Martin Solar does not have thermal storage, no tanks were required. Pictured below are the molten salt storage tanks at the Andasol plant in Spain.

3.1.6 Frames and Balance of Plant

The frames and bases for parabolic troughs and heliostats are largely made from steel/aluminum and concrete (cement, gravel, rock, and sand). Martin Solar sourced its aluminum frames locally from Hydro Aluminum's facilities in Florida and South Carolina. The frame for a parabolic trough system is pictured below.

3.1.7 Labor

Labor is considered to be 100% domestically sourced.

3.1.8 Other Costs and Value Chain Markup

As with PV, other costs include:

- Site preparation
- Permitting fees
- Project management costs
- Sales and property taxes
- Land
- Insurance
- System design, engineering, and architectural costs
- Interconnection fees
- Public relations, legal fees and environmental mitigation
- Finance related (debt reserve, lender fees)

All of these tasks are typically performed by U.S. companies or U.S. subsidiaries of foreign companies. Site preparation is defined as any logistical and physical preparation, coordination and work that must be performed to install a system at the site. This includes civil, structural or electrical infrastructure improvements, and transporting materials on-site.

Value chain markup includes overhead and profit margins captured in the period between equipment manufacturing and final installation. Installed materials often undergo markups by both the distributor and the EPC firm. The combination of other costs and value chain markup represents 28% of total system costs.

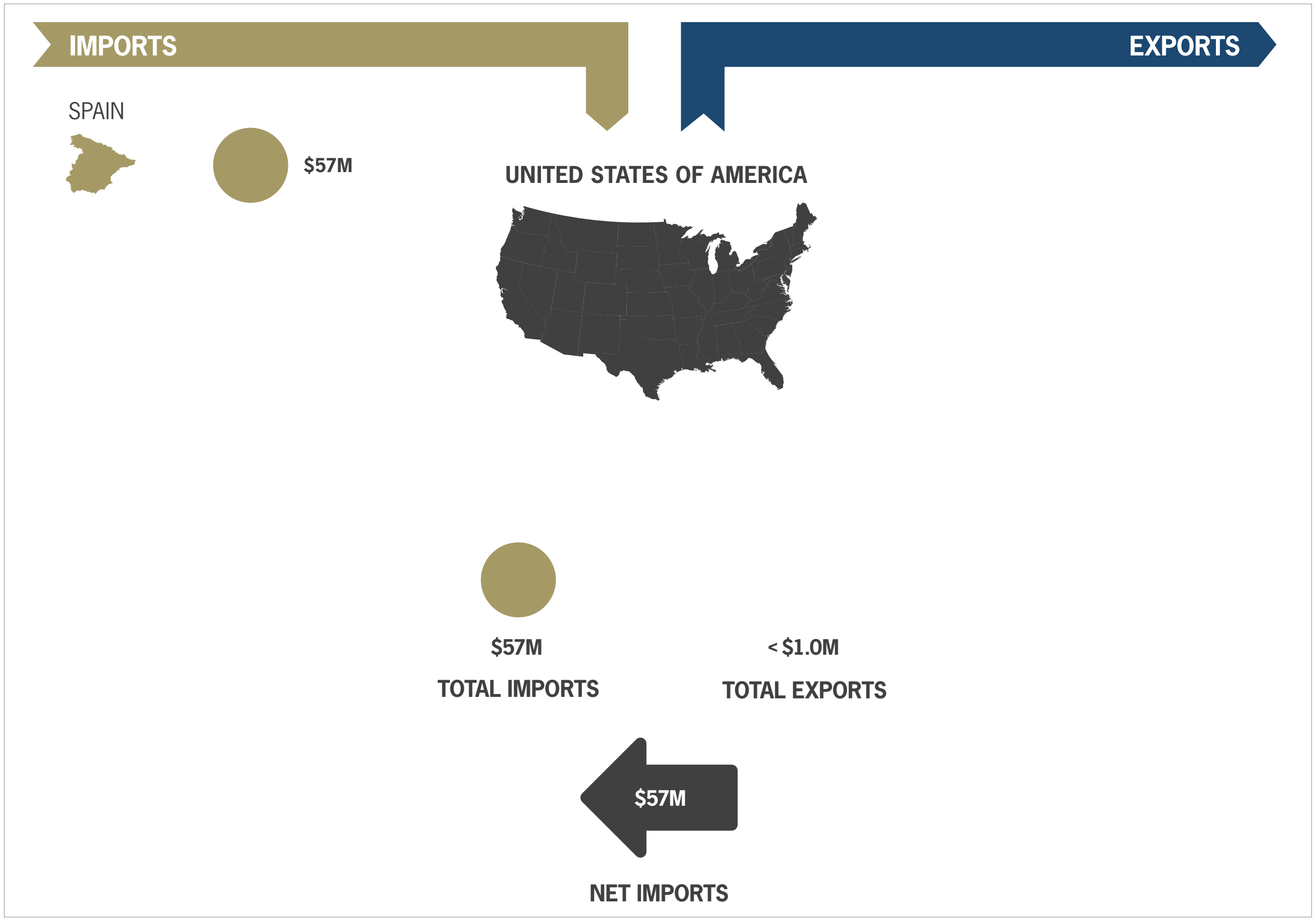
Other costs and value chain markup costs were calculated by a top-down methodology by taking the total project cost less the known component costs (mirrors, receivers, turbine, etc.).

Other costs and value chain markup are considered to be 100% domestic.

3.2 Concentrating Solar Trade Flow Analysis

In 2010, the U.S. did not export any components for CSP projects in the rest of the world. The U.S. did import mirrors for the Martin Solar project. The effective value of the imports was estimated at $57 million. Overall, the dollar flows are small compared to the trade flows from PV. In 2012 and beyond, we anticipate substantial Concentrating Solar additions in the U.S. Several 200 MW+ plants are under construction in the U.S. that should be operating in 2012-2014. As more concentrating solar plants are built in the U.S. and abroad, the volume of trade flows for all components should significantly increase - resulting in both higher imports and exports.

Figure 3-5: CSP Imports and Exports by Source/ Destination, 2010



Source: GTM Research

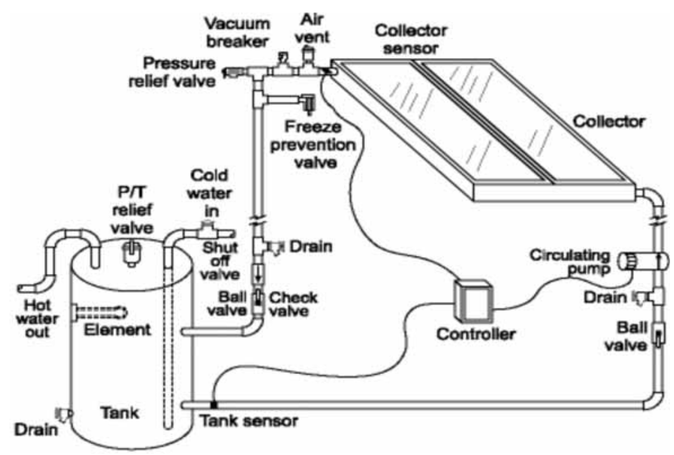
4 SOLAR HEATING & COOLING

4.1 Solar Water Heating (SWH)

4.1.1 Domestic Value Created

Solar water heating systems are most commonly medium temperature collectors that are used to heat domestic hot water. A typical system is composed of 3 main parts: collectors, storage tank, and all other equipment (controller, pump, valves, etc.).

Figure 4-1: Diagram of the Primary Components of a SWH System



Source: GTM Research

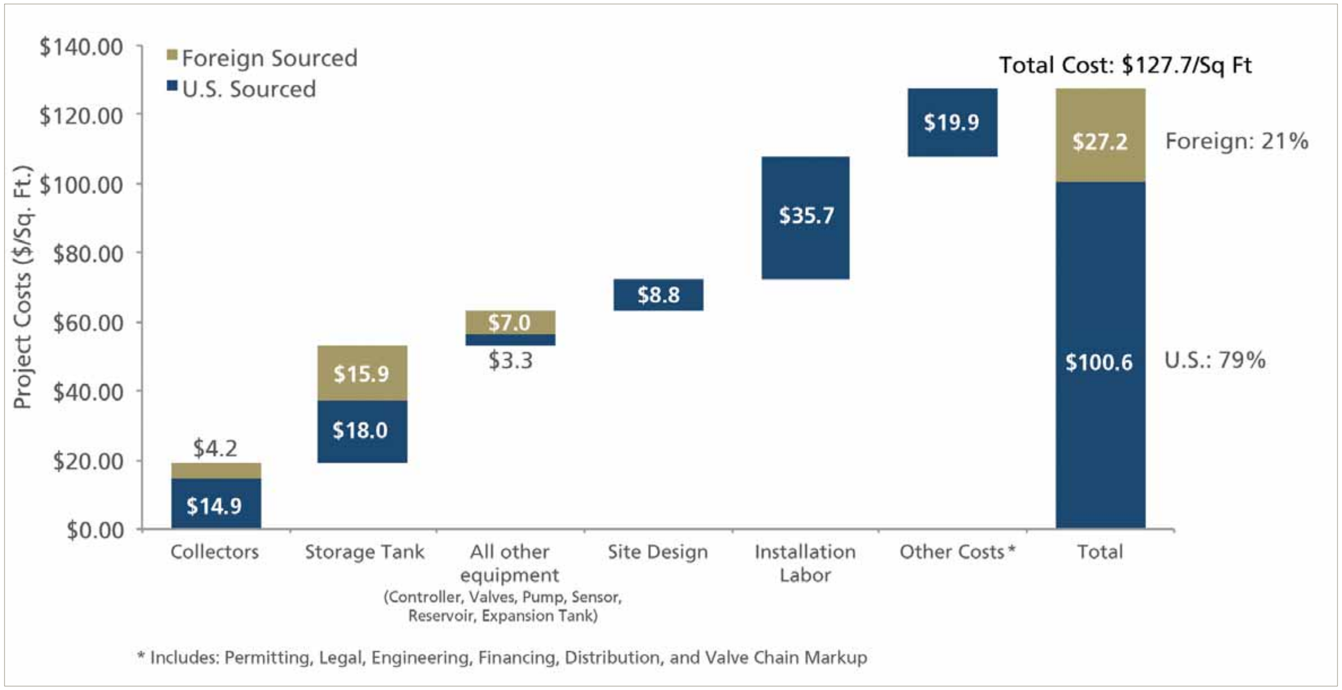
Figure 4-2: SWH Percent of Value Created in the U.S.

U.S. SWH INSTALLATIONS IN 2010: TOTAL VALUE CREATED IN THE U.S.					
SWH System Component	**Component Cost ($/Sq Ft)**	**Component Cost($)**	**% of Total**	**% U.S. component in SWH System**	**Domestic Value Created ($/Sq Ft)**
Collectors	$19.13	$1,308	31%	78%	$14.89
Storage Tank	$33.93	$2,321	27%	53%	$17.98
All other equipment (controller, valves, pump, sensor, reservoir, expansion tank)	$10.32	$706	8%	32%	$3.30
Site Design	$8.76	$599	7%	100%	$8.76
Installation Labor	$35.69	$2,441	28%	100%	$35.69
Other Costs	$19.91	$1,361	16%	100%	$19.91
Total System	**$127.73**	**$8,739**		**79%**	**$100.52**
Total Systems Installed, 2010	35,464				
Sq. Ft. per System	68.4				
Total Sq. Ft. Installed, 2010	2,426,456				
Total Domestic Value Creation, 2010	$243,912,944				
Total Foreign Value Creation, 2010	$66,010,593				
Total Value Creation	$309,923,537				

Source: GTM Research

SWH total system costs of $128/sq. ft. were 79% sourced domestically, which equates to $101/sq ft. In the U.S. in 2010, there was $309 million spent on SWH installations. With 79% of the value being retained in the U.S., this equates to $244 million.

Figure 4-3: SWH Domestic Value Creation, 2010



Source: GTM Research

Source: TiSUN

Source: TiSUN

Source: Thermo Technologies

4.1.1.1 SWH Collectors

Collector price per square foot is based on EIA data for medium-temperature collectors (ICS/thermosiphon, flat plate, and evacuated tube). This is a factory-gate price, which excludes distributor/wholesaler markup. Overall, 78% of collectors were domestically sourced. This is calculated by dividing the 1.89 million square feet of U.S.-made collectors installed in the U.S. by the 2.43 million square feet of total collectors installed in the U.S. in 2010.

4.1.1.2 Storage Tank

Storage tanks represented 27% of the total cost of a SWH system in 2010, or around $2,321 for a blended system (mix of open and closed loop, mix of residential and non-residential). Storage tank price is based on data from state rebate agencies which provide system cost breakdowns. The price is a blend of one and two tank systems, and stainless and non-stainless tanks. Based on a survey of solar water heating tank manufacturers, it was estimated that 53% of tanks were sourced domestically. For systems installed on the East Coast, many tanks are manufactured domestically of stainless steel. For Western states, a significant percentage of the tanks used are assembled in Mexico and shipped to the U.S.

4.1.1.3 All Other Equipment

All other equipment includes:

- Controller
- Valves
- Pump
- Sensor
- Reservoir
- Expansion tank

Costs were based on published online pricing, and work out to $706 per system – or 8% of total system cost. The percent sourced domestically was based on conversations with pump and controller manufacturers, and was estimated at 32%.

4.1.1.4 Site Design and Installation Labor

Costs were based on installation data sourced from state rebate agencies. They represent 35% of the total system cost, or a blended cost of around $3,041 per installation (residential and non-residential). Costs were considered to be 100% domestic.

4.1.1.5 Total Domestic Value Creation Year-Over-Year

Comparing 2009 domestic value creation to 2010 domestic value creation, the overall percentage (78% to 79%) remained relatively flat. While domestic solar water heating system installations increased from 2009 to 2010, there was a more significant increase in commercial units installed. The domestic units are more likely to use a foreign sourced tank, which can be seen by an increase in imports from Mexico. Recently, a prominent heating and cooling company opened a tank and collector manufacturing facility in Mexico. However, the most significant jump in installed capacity year-over-year came in the non-residential sector. Here, tanks are industrial sized and generally sourced from American manufacturers, thus pushing up the percentage of domestically sourced tanks and auxiliary components.

The most significant change was seen in domestically sourced collectors, which dropped from 86% to 78% from 2009 to 2010. Imports of collectors increased from Austria, Mexico, China and Germany. Prominent manufacturers in Austria and Germany, who have traditionally sold into European markets, are now pushing into the United States with imports of flat plate collectors. As mentioned above, an American company has opened a manufacturing facility in Mexico and has been producing flat plate collectors in addition to tanks at this location. Finally, many Chinese companies have been producing low-cost evacuated tube collectors and aggressively marketing them in the U.S. A good number have been shipped to the U.S. but many installers shy away from these products due to reliability issues.

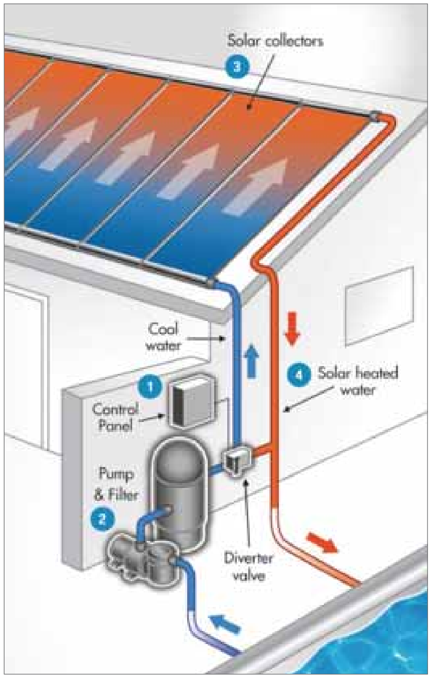
The domestic value of site design, installation labor and other costs (permitting, legal, and engineering fees as well as value chain markup) remains 100% domestic.

Figure 4-4: Total Value Creation 2009 - 2010

TOTAL VALUE CREATED IN U.S. SWH INSTALLATIONS - 2009 VS 2010

SWH System Component	2009			2010		
	U.S. $/ Sq Ft	% U.S. component in SWH System	Domestic Value Created ($/Sq Ft)	U.S. $/ Sq Ft	% U.S. component in SWH System	Domestic Value created/Sq Ft
Collectors	$19.61	86%	$16.89	$19.13	78%	$14.89
Tank & all other equipment	$36.01	38%	$13.83	$44.25	48%	$21.28
Site Design	$7.18	100%	$7.18	$8.76	100%	$8.76
Installation Labor	$33.99	100%	$33.99	$35.69	100%	$35.69
Other Costs	$16.54	100%	$16.54	$19.91	100%	$19.91
Total	**$113.33**	**78%**	**$88.43**	**$127.73**	**79%**	**$100.52**

Source: GTM Research



Source: Abacus Energy Partners

4.2 Solar Pool Heating (SPH)

4.2.1 Domestic Value Created

Solar pool heating systems are relatively simple systems with two main parts: collectors and all other equipment (including pump, valves, and the controller). A diagram of a typical solar pool heating system is pictured below.

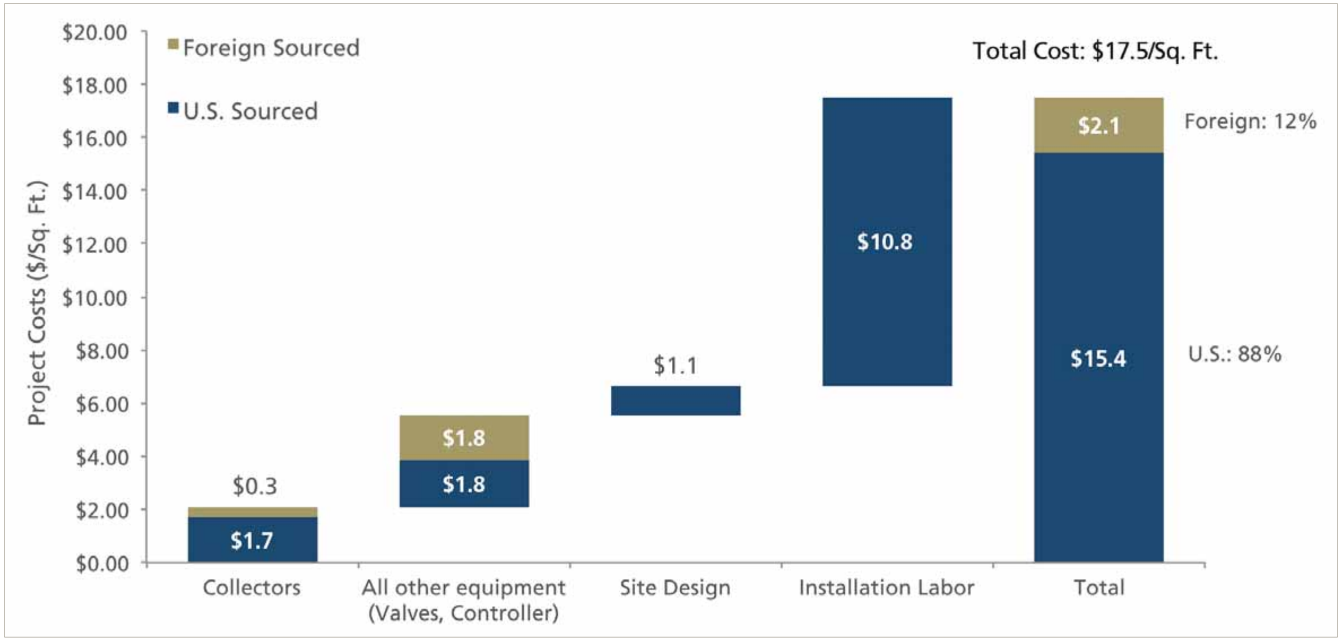
SPH total system costs of $17.51/sq ft are 88% sourced domestically, which equates to $15.43/sq ft. In the U.S. in 2010, there was $176.8 million spent on SPH installations. With 88% of the value being retained in the U.S., this equates to $155.7 million.

Figure 4-5: SPH Percent of Value Created in the U.S., 2010

U.S. SPH installations in 2010: Total Value Created in the U.S.					
SPH System Component	$/Sq Ft	% of Total	U.S. $/System	% U.S. component in SPH System	Domestic Value created ($/Sq Ft)
Collectors	$2.08	12%	$692	84%	$1.74
All other equipment (valves, controller)	$3.50	20%	$1,167	50%	$1.75
Site Design	$1.11	6%	$369	100%	$1.11
Installation Labor	$10.82	62%	$3,609	100%	$10.82
Total	**$17.51**	**100%**	**$5,839**	**88%**	**$15.43**
Total systems installed in 2010	30,273				
Sq Ft per system	333.5				
Sq Ft installed in 2010	10,096,182				
Total Value Creation for U.S. companies by SPH Installed in the U.S. 2010	$155,770,536				
Total Value Creation for foreign companies by SPH Installed in the U.S. 2010	$21,014,715				
Total	**$176,785,252**				

Source: GTM Research

Figure 4-6: SPH Domestic Value Creation, 2010



Source: GTM Research

Source: Pool Solar Panels

4.2.1.1 SPH Collectors

Collector price per square foot is based on the EIA data for low-temperature collectors. This is a factory-gate price and excludes the distributor/wholesaler markup. The percent of collectors that are domestically sourced is 84%. This is calculated by dividing the 8.4 million square feet of U.S.-made collectors installed in the U.S. by the 10 million square feet of total collectors installed in the U.S. in 2010. Collectors represent 12% of the total system cost.

4.2.1.2 Other Equipment

Other equipment cost is based on typical pricing for a residential system and includes the pump, valves, and controller. The 50% domestic content is based on information from leading controller and pump manufacturers. All other equipment is estimated at $1,668 for an average blended (residential and non-residential) system – which works out to 20% of the total system cost.

4.2.1.3 Site Design and Installation Labor

Site design costs were based on the percentage of total installation cost for a SWH system (which was derived from installation data from state rebate agencies). Combined, site design and installation labor comprise 68% of the total system cost.

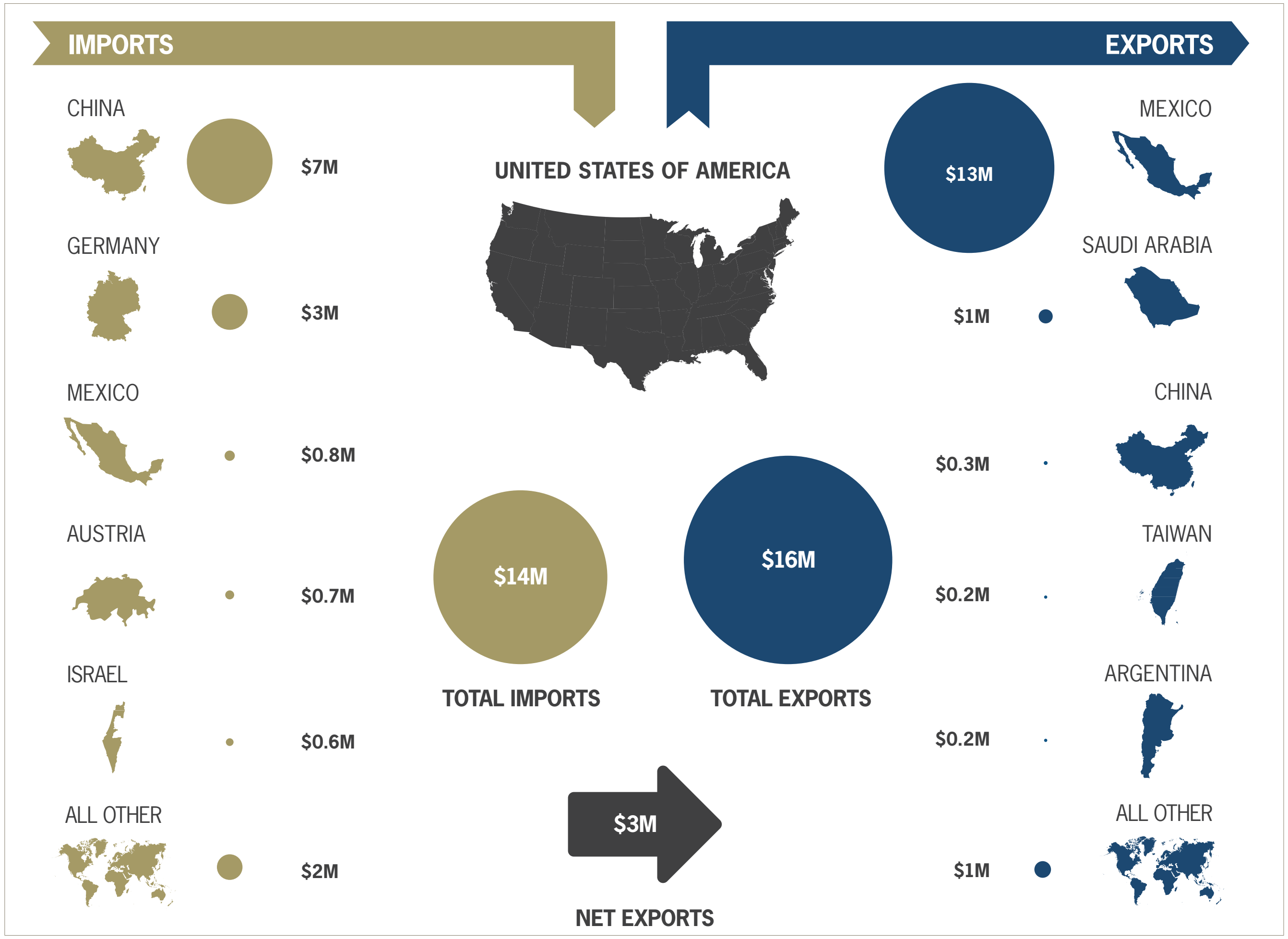
4.3 SWH and SPH Trade Flow Analysis

The U.S. imported $13.6 million of SWH and SPH collectors, with evacuated tube SWH collectors coming from China, flat plate SWH collectors coming from Germany and Austria, and unglazed plastic SPH collectors from Israel. As mentioned previously, imports from Austria and Mexico jumped significantly due to greater interest in the U.S. market and new manufacturing facilities, respectively. Israel's imports dropped due to a weakness in the domestic SPH market, which is tied to the poor economy and slow new home sales.

The U.S. exported $16.3 million of SWH and SPH collectors, primarily unglazed plastic SPH collectors to Mexico. There was also an increase in shipments of unglazed collectors to Saudi Arabia. The country's climate is hot and sunny enough that these low-cost collectors normally intended for SPH applications can sufficiently heat water for domestic use. Exports to China slowed as that country's domestic manufacturing capacity has ramped up to better meet domestic demand.

Even with a 23% increase in imports and only a 6% increase in exports, the U.S. still has a positive trade balance of $2.7 million, making the country a net exporter of SWH and SPH collectors.

Figure 4-7: SWH and SPH Imports/Exports by Source/ Destination, 2010



Source: GTM Research

Figure 4-8: SWH and SPH Imports and Exports by Source/ Destination, 2010

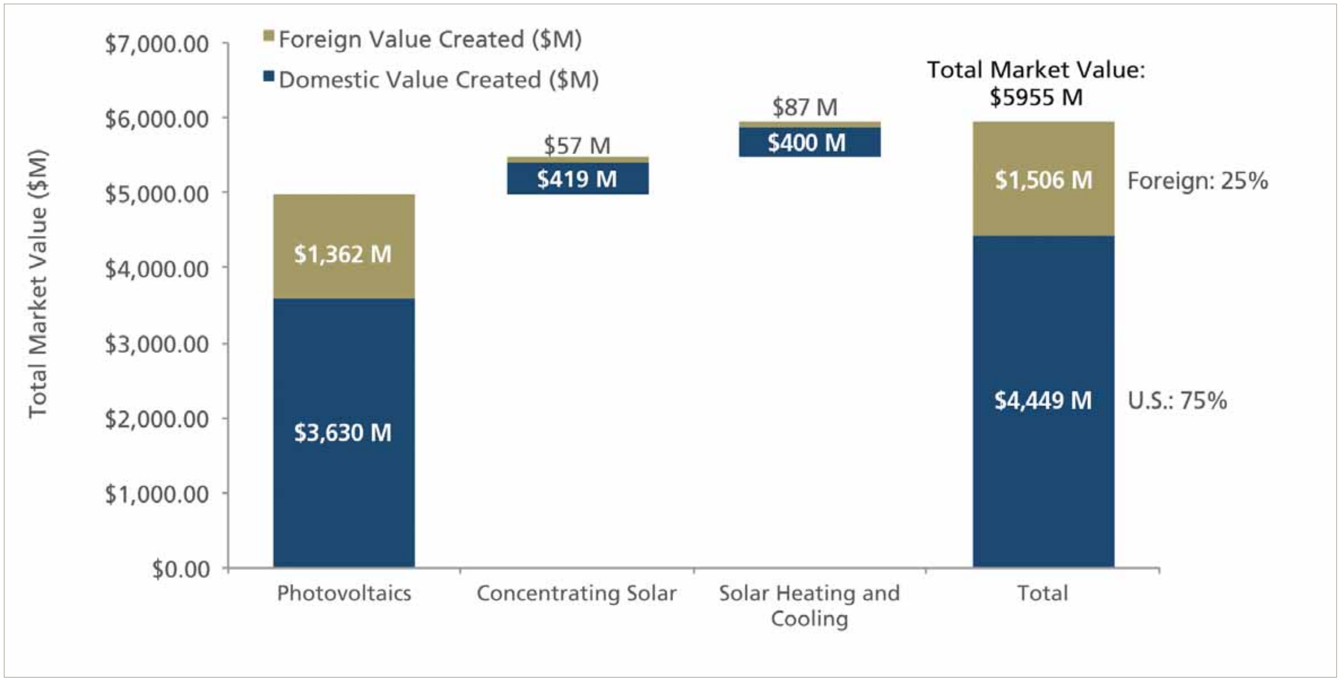
SWH and SPH Trade Flows by Source/Destination Country							
	Exports (in Thousands $)			Imports (in Thousands $)			
Country	Value 2009	Value 2010	% Change	Country	Value 2009	Value 2010	% Change
Mexico	$10,074	$13,312	32%	China	$4,122	$6,660	62%
Saudi Arabia	$284	$1,055	271%	Germany	$1,814	$2,849	57%
China	$749	$257	-66%	Mexico	$189	$796	322%
Taiwan	$190	$205	8%	Austria	$95	$675	610%
Argentina	$0	$189		Israel	$1,558	$601	-61%
ROW	$4,058	$1,311	-68%	ROW	$3,312	$2,033	-39%
Total	**$15,355**	**$16,329**	**6%**	**Total**	**$11,090**	**$13,614**	**23%**

Source: GTM Research

5 AGGREGATE FINDINGS

The figure below details total and domestic value creation for all solar energy-related goods and services in 2010, created by summing all the analysis conducted in previous sections. In total, $6.0 billion of value was created in the U.S., of which $4.4 billion, or 75%, was sourced domestically. PV clearly constituted the majority of domestic sourcing, at $3.6 billion, with non-module costs playing a material role in the outcome. At the same time, almost all of the value created from foreign sources also came from PV, primarily in the area of module manufacturing.

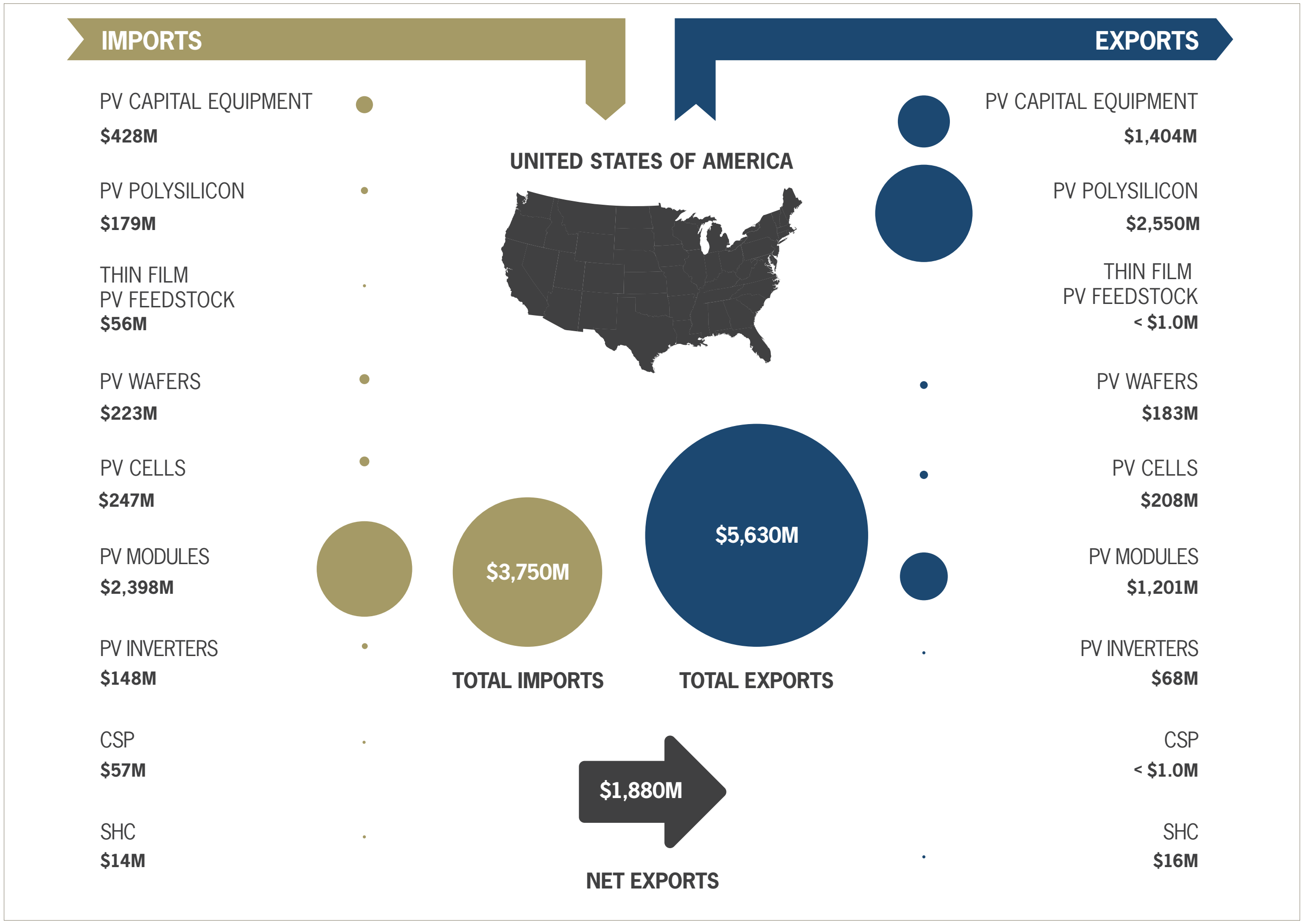
Figure 5-1: Solar Industry Domestic Value Creation, 2010



Source: GTM Research

Aggregating trade flows for all solar energy segments for 2010 yields a total export figure of $5.6 billion, while imports total $3.8 billion. Net exports, therefore, totaled $1.9 billion for 2010. The bulk of this, as indicated below, comes from polysilicon and PV capital equipment, where the U.S. has a strong manufacturing presence. While module exports to Germany amounted to $587 million in revenue, they were offset by imports of $1.2 billion from China.

Figure 5-2: Solar Industry Trade Flows, 2010



Source: GTM Research

The net export figure of $1,879.6 million by the total solar industry is a 73% improvement over 2009's net export value of $1,089 million. The trend of foreign PV module deployment in the U.S. has continued with a near-doubling of imports from 2009 to 2010, with exports remaining relatively stable. However, these imports were more than offset by doubled exports of both capital equipment and polysilicon. While CSP and SHC both moved towards net importation, their contribution to the overall trade balance of the solar industry remained small. As with last year, PV made up the overwhelming majority of the volume of imports and exports, with the U.S. being strong exporters of the beginning of the PV value chain (i.e. capital equipment, polysilicon) and net importers of thin film feedstock, wafers, cells, modules and inverters.

Figure 5-3: Year-over-Year Solar Industry Trade Flows Comparison, 2009 vs. 2010

U.S. Solar Industry Trade Flows (2009 vs. 2010)

	Imports ($M)		Exports ($M)		Trade Balance ($M)		
	2009	2010	2009	2010	2009	2010	YoY (%)
Total PV	**$1,976.0**	**$3,679.3**	**$3,064.0**	**$5,613.5**	**$1,088.0**	**$1,934.2**	**78%**
PV Capital Equipment	$339.0	$428.0	$750.0	$1,403.7	$411.0	$975.8	137%
PV Polysilicon	$84.0	$178.9	$1,139.0	$2,549.5	$1,055.0	$2,370.6	125%
PV Thin Film Feedstocks	$45.0	$56.4	$0.0	$0.0	-$45.0	-$56.4	-25%
PV Wafers	$119.0	$223.4	$115.0	$183.0	-$4.0	-$40.4	-910%
PV Cells	$13.0	$246.9	$37.0	$207.9	$24.0	-$39.0	62%
PV Modules	$1,242.0	$2,398.2	$1,010.0	$1,201.1	-$232.0	-$1,197.0	-416%
PV Inverters	$134.0	$147.6	$13.0	$68.2	-$121.0	-$79.4	34%
Concentrating Solar Power	**$4.0**	**$57.4**	**$0.0**	**$0.0**	**-$4.0**	**-$57.4**	**-1334%**
Solar Heating and Cooling	**$11.0**	**$13.6**	**$16.0**	**$16.3**	**$5.0**	**$2.7**	**-46%**
Total Solar Industry	**$1,991.0**	**$3,750.2**	**$3,080.0**	**$5,629.8**	**$1,089.0**	**$1,879.6**	**73%**

Source: GTM Research

It is important to consider the domestic value creation analysis in this report in conjunction with the trade balance analysis in order to better understand the impact of solar imports and exports on the U.S. economy. Although the U.S. enjoys solid export balances at the beginning of the value chain, and relies on imports further down the value chain, it is important to understand that the U.S. also benefits substantially from activities at the very end of the value chain as well, as domestic firms generate revenues and create jobs in engineering, siting, legal, and installation services associated with solar deployment.

APPENDIX A: METHODOLOGY

Technology	Component	Methodology for Determining U.S. Domestic Value Creation
PV	Polysilicon	The percentage of value created domestically by polysilicon in a U.S.-installed system was estimated based on U.S. share of global polysilicon production.
	Wafer	Total consumption of wafers in U.S.-installed PV systems was determined based on data on crystalline silicon module installations (see below), and assuming a yield of 98% for cell-to-module and 95% for wafer-cell. Installed modules produced by U.S. wafer-cell-module integrated module firms were assumed to have 100% domestically sourced, internally produced wafers. For all other c-Si module manufacturers, domestic content was assumed to be in line with the U.S.'s share of global wafer production in 2010.
	Cell	Total consumption of c-Si cells in U.S.-installed PV systems was determined based on data on crystalline silicon module installations (see below), and assuming a yield of 98% for cell-to-module. Installed modules produced by U.S. cell-to-module integrated module firms were assumed to have 100% domestically sourced, internally produced cells. For all other c-Si module manufacturers, domestic content was assumed to be in line with the U.S.'s share of global c-Si cell production in 2010.
	Crystalline Module	Module manufacturer-specific data from residential and commercial systems from California and New Jersey, as well as GTM Research's proprietary U.S. utility-scale project tracker was examined to calculate what percentage of U.S. installations used modules from domestic manufacturers. In the case where the manufacturer had facilities in both the U.S. and abroad, it was assumed that the module was produced by the U.S.-based facility to the extent sufficient capacity was available.
	Thin Film Module	To determine the percentage of value created domestically for a thin film installation, the cost components above were examined individually. Non-glass materials were assumed to be 100% sourced from abroad. Glass and capital equipment were assumed to be 80% domestically sourced. For labor, utilities, overhead, and the module markup, domestic content was assumed to correspond to domestic manufacturers' share of U.S.-installed thin film modules in 2010, which was 97%.
	Blended PV Module	To estimate the overall percentage of value created domestically in U.S.-installed crystalline silicon modules, one simply needs to attach the proportions of the individual value chain segments (polysilicon, wafer, cell, module) determined above to their contribution to the overall module cost structure. Here, the markup (or profit) for each segment must also be included, as it contributes to the overall cost of the system. The percentage of value created domestically for the markup is assumed to be identical to that of the relevant component; so if 40% of the polysilicon content is created domestically, for example, the polysilicon markup is also assumed to be 40% domestically sourced.
	Inverter	Market shares of inverter manufacturers for each market segment used in installations in 2010 were determined by utilizing public data and GTM Research's proprietary databases. By using average factory-gate pricing for each market segment, a total market size for each manufacturer in each market segment was calculated. For companies with only foreign-based or only U.S. manufacturing, 100% of this value was assigned to foreign or U.S. manufacturing respectively. For companies with both U.S. and foreign production capacity, non-exported domestic production was exhausted before using foreign production on a per-market-segment basis.

PV	Mounting Structure	Average mounting structure costs were determined through conversations with major mounting structure manufacturers and real project costs breakdowns from PV installers. Manufacturing and assembly location was determined through conversations with major mounting structure manufacturers. Total value of the market was determined by multiplying average factory-gate pricing by market segment application (residential rooftop, commercial rooftop, and ground mount).
	Combiner Box and Misc. Electrical	Balance of systems equipment costs were determined by real project cost breakdowns from installers and integrators. Conversations with major suppliers of combiner boxes were used to determine origination of combiner box manufacturing and assembly. U.S. manufacturing of the overall electrical equipment industry served as a proxy for the miscellaneous electrical equipment industry and values for industry market size and trade flows were found through third party research. The domestic content of miscellaneous electrical equipment was estimated by using: (Total Domestic Production – Exports) / (Total Domestic Production + Imports – Exports).
	Other Costs	Site preparation, labor, soft costs and value chain markup costs were calculated by a top-down methodology from total average system price less material and component costs. Further breakdown between site preparation and labor costs versus soft costs and value chain markup were based on sample project cost breakdowns obtained from PV installers and data from state and utility solar incentive programs
	CrystallineSilicon Systems	Total crystalline silicon PV system costs were collected from state and utility rebate programs as well as GTM Research's Utility Project Tracker with known thin film projects removed. Systems costs beyond two standard deviations from the average cost-per-watt were removed. Capacity weighted average pricing was determined by dividing all remaining system costs by total remaining installed capacity. Further guidance was given from real project system breakdowns provided by installers. Factory-gate crystalline module costs as determined above were used for module costs. Inverter costs were blended based on the estimated market segment blend specific to crystalline silicon systems. All other system category costs and domestic value percentage use the same methodology as described above.
	Thin Film Systems	Total thin film PV system costs were collected from the California Solar Initiative rebate programs as well as GTM Research's Utility Project Tracker for known Thin Film projects. Capacity weighted average pricing was determined by dividing all system costs by total installed capacity. Further guidance was given from real project system breakdowns provided by installers. Factory-gate thin film module costs as determined above were used for module costs. Inverter costs were blended based on the estimated market segment blend specific to thin film silicon systems. All other system category costs and domestic value percentage use the same methodology as described above.
	Blended PV Systems	Total blended PV system costs for 2010 are derived from capacity-weighted average national system prices from SEIA/GTM Research's Solar Market Insight™ 2010 Year in Review report
CSP	All components	Conversations with the primary developers regarding sourcing and suppliers
	Total System Cost	Based on publically available data on FPL's Martin Solar Plant and the cost breakdown by component is based on the 2009 UC Berkeley study on CSP.
SWH	Collectors	The collector pricing was based on the EIA 2009 data for medium temperature collectors. Percent sourced domestically is based on the following calculation: total U.S. manufactured collectors installed in the U.S. divided by the total installations in the U.S. (which includes imported collectors)

SWH	Tanks	Storage tank price is based on data from state rebate agencies which provide system cost breakdowns. The price is a blend of one and two tank systems, and stainless and non-stainless tanks. The percent of tanks sourced domestically is based on a survey of solar water heating tank manufacturers
	All other equipment	Price is based on data from state rebate agencies which provide system cost breakdowns. The percent sourced domestically was based on conversations with pump and controller manufacturers
	System Cost	The total system cost came from installer data and state rebate agency data as published in the SEIA/GTM Research Solar Market Insight™ report
SPH	Collectors	The collector pricing was based on the EIA 2009 data for low temperature collectors. Percent sourced domestically is based on the following calculation: total U.S. manufactured collectors installed in the U.S. divided by the total installations in the U.S. (which includes imported collectors)
	All other equipment	Other equipment cost is based on typical system pricing and includes the pump, valves, and controller. Domestic content percentage is based on conversations with leading controller and pump manufacturers
	System Cost	The total system cost came from installer data and state rebate agency data as published in the SEIA/GTM Research Solar Market Insight™ report

APPENDIX B: SOURCES

Sources for Domestic Value Creation Analysis

Technology	Component	Sources
PV	Polysilicon	• GTM Research proprietary manufacturing database • Conversations with manufacturers
	Cell	• GTM Research proprietary manufacturing database • Quarterly earnings statements from publicly traded companies • Conversations with manufacturers • State and utility solar rebate programs (California, New Jersey)
	Crystalline Module	• GTM Research proprietary manufacturing database • Quarterly earnings statements from publicly traded companies • Conversations with manufacturers • Public announcements and reporting for major U.S. projects • State and utility solar rebate programs (California, New Jersey)
	Thin Film Module	• GTM Research proprietary manufacturing database • Quarterly earnings statements from publicly traded companies; specifically, gross margin (markup) for thin film modules were obtained from First Solar's quarterly and annual financial statements, available at http://investor.firstsolar.com • Conversations with manufacturers • Public announcements and reporting for major U.S. projects • State and utility solar rebate programs (California, New Jersey)
	Cell	• GTM Research proprietary manufacturing database • Quarterly earnings statements from publicly traded companies • Conversations with manufacturers • State and utility solar rebate programs (California, New Jersey)
	Inverter	• State solar rebate programs (California, New Jersey) • Quarterly earnings statements from publicly traded companies • Conversations with manufacturers • Public announcements and reporting for major U.S. projects
	Mounting	• Conversations with major suppliers of mounting structure solutions and PV installers
	Combiner Box and Misc Electrical	• Conversations and sample project breakdowns from installers • Channel checks with combiner box suppliers • IBISWorld industry report on Electrical Equipment Manufacturing in the U.S.
	Other Costs	• Sample project cost breakdowns from PV installers • Data from state and utility rebate programs

PV	Crystalline Silicon System Costs	• SEIA/GTM Research Solar Market Insight™ 2010 Year-In-Review report, which draws data from over 70 state and utility solar incentive programs • State and utility solar rebate programs (California, New Jersey, Arizona, Florida, Massachusetts) • GTM Research's Utility PV Market Tracker • Sample cost breakdowns from PV installers • Public announcements and reporting for major U.S. projects
	Thin Film System Costs	• GTM Research's Utility PV Market Tracker • Public Data from state utility programs (California Solar Initiative) • Public announcements and reporting for major U.S. projects
	Blended PV Costs	• SEIA/GTM Research Solar Market Insight™ 2010 Year-In-Review report, which draws data from over 70 state and utility solar incentive programs • State and utility solar rebate programs (California, New Jersey, Arizona, Florida, Massachusetts) • Sample cost breakdowns from PV installers • Public announcements and reporting for major U.S. projects
CSP		• Conversations with developers, system manufacturers, and suppliers • System manufacturers' websites and press releases • "Concentrating Solar Power" by Russell Muren and Eric Gimon, UC Berkeley (2009)
SWH		• SEIA/GTM Research Solar Market Insight 2010 Year-in-Review • U.S. EIA data from 2009 • SWH installation data from CT state rebate program • Department of Commerce / U.S. International Trade Commission data for 2010 • Conversations with component manufacturers
SPH		• SEIA/GTM Research Solar Market Insight 2010 Year-in-Review • U.S. EIA data from 2009 • Department of Commerce / U.S. International Trade Commission data for 2010 • Conversations with component manufacturers

SOURCES FOR TRADE FLOW ANALYSIS

Technology	Component	Sources
PV	Capital Equipment	• Quarterly earnings statements from publicly traded companies • GTM Research proprietary manufacturing database
	Polysilicon	• GTM Research proprietary manufacturing database • Conversations with manufacturers • Department of Commerce / U.S. International Trade Commission data for 2010
	Wafer	• GTM Research proprietary manufacturing database • Conversations with manufacturers
	Cell	• Department of Commerce / U.S. International Trade Commission data for 2010
	Module	• Department of Commerce / U.S. International Trade Commission data for 2010
	Inverter	• Quarterly earnings statements from publicly traded companies • Conversations with manufacturers • Public announcements and reporting for major U.S. projects
CSP	Mirrors	• Conversations with manufacturers
	Receivers	• Conversations with manufacturers
SWH	Collectors	• Department of Commerce / U.S. International Trade Commission data for 2010
SPH	Collectors	• Department of Commerce / U.S. International Trade Commission data for 2010

OWNERSHIP RIGHTS

All Reports are owned by Greentech Media protected by United States Copyright and international copyright/intellectual property laws under applicable treaties and/or conventions. User agrees not to export any Report into a country that does not have copyright/intellectual property laws that will protect Greentech Media's rights therein.

GRANT OF LICENSE RIGHTS

Greentech Media hereby grants User a personal, non-exclusive, non-refundable, non-transferable license to use the Report for research purposes only pursuant to the terms and conditions of this Agreement. Greentech Media retains exclusive and sole ownership of each Report disseminated under this Agreement. User agrees not to permit any unauthorized use, reproduction, distribution, publication or electronic transmission of any Report or the information/forecasts therein without the express written permission of Greentech Media. Users purchasing this report may make a Report available to other persons from their organization at the specific physical site covered by the agreement, but are prohibited from distributing the report to people outside the organization, or to other sites within the organization.

DISCLAIMER OF WARRANTY AND LIABILITY

Greentech Media has used its best efforts in collecting and preparing each Report.

GREENTECH MEDIA, ITS EMPLOYEES, AFFILIATES, AGENTS, AND LICENSORS DO NOT WARRANT THE ACCURACY, COMPLETENESS, CURRENTNESS, NON INFRINGEMENT, MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE OF ANY REPORTS COVERED BY THIS AGREEMENT. GREENTECH MEDIA, ITS EMPLOYEES, AFFILIATES, AGENTS, OR LICENSORS SHALL NOT BE LIABLE TO User OR ANY THIRD PARTY FOR LOSSES OR INJURY CAUSED IN WHOLE OR PART BY OUR NEGLIGENCE OR CONTINGENCIES BEYOND GREENTECH MEDIA'S CONTROL IN COMPILING, PREPARING OR DISSEMINATING ANY REPORT OR FOR ANY DECISION MADE OR ACTION TAKEN BY User OR ANY THIRD PARTY IN RELIANCE ON SUCH INFORMATION OR FOR ANY CONSEQUENTIAL, SPECIAL, INDIRECT OR SIMILAR DAMAGES, EVEN IF GREENTECH MEDIA WAS ADVISED OF THE POSSIBILITY OF THE SAME. User AGREES THAT THE LIABILITY OF GREENTECH MEDIA, ITS EMPLOYEES, AFFILIATES, AGENTS AND LICENSORS, IF ANY, ARISING OUT OF ANY KIND OF LEGAL CLAIM (WHETHER IN CONTRACT, TORT OR OTHERWISE) IN CONNECTION WITH ITS GOODS/SERVICES UNDER THIS AGREEMENT SHALL NOT EXCEED THE AMOUNT YOU PAID TO GREENTECH MEDIA FOR USE OF THE REPORT IN QUESTION.