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Elevated Expectations for the U.S. Solar Industry

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Key Points:

- ***As the U.S. solar market continues to mature and attract more investors, reliability and serviceability will become paramount to the success of producers across the entire solar value chain.***
- ***An additional 46 GW of photovoltaic capacity is projected to be installed globally in 2014, growing 22 percent year-over-year.***
- ***The rate of decline in prices for multi crystalline silicon modules has slowed significantly after declining 37 percent annually from January 2011 to January 2013.***
- ***The industry started to see deterioration in module quality only in the last few years. This deterioration, driven entirely by market forces, will be corrected.***
- ***Despite extreme price and margin pressure since 2011, top module firms have proven to be resilient and will likely continue to operate successfully for years to come.***
- ***Strong domestic growth is dependent on competitive PV system prices. However, module prices in the U.S. are likely to rise through 2014, largely because of U.S. countervailing duties and anti-dumping measures on Chinese sourced modules.***
- ***Innovation in the U.S. inverter market will drive the majority of non-module cost reductions over the next ten years.***
- ***The industry's ability to scale manufacturing and installation while reducing the cost of capital will determine growth of the distributed sector, particularly for residential projects.***

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Introduction

The U.S. solar industry is quickly evolving beyond its nascent beginning, as more risk-averse investors enter the market. Scrutiny of the long-term performance of solar assets by the investment community will impose a market driven discipline on product quality. The recent solar industry downturn forced module manufacturers to engage in a race to the bottom with respect to prices. However, module prices have stabilized since the beginning of 2013 and those module manufacturers that survived the downturn remain financially strong. Further down

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the solar value chain, flat module prices are driving significant innovation around reducing non-module costs, particularly among inverter manufacturers. As the U.S. solar market continues to mature and attract more risk-averse debt investors, reliability and serviceability will become paramount to the success of producers across the entire solar value chain.

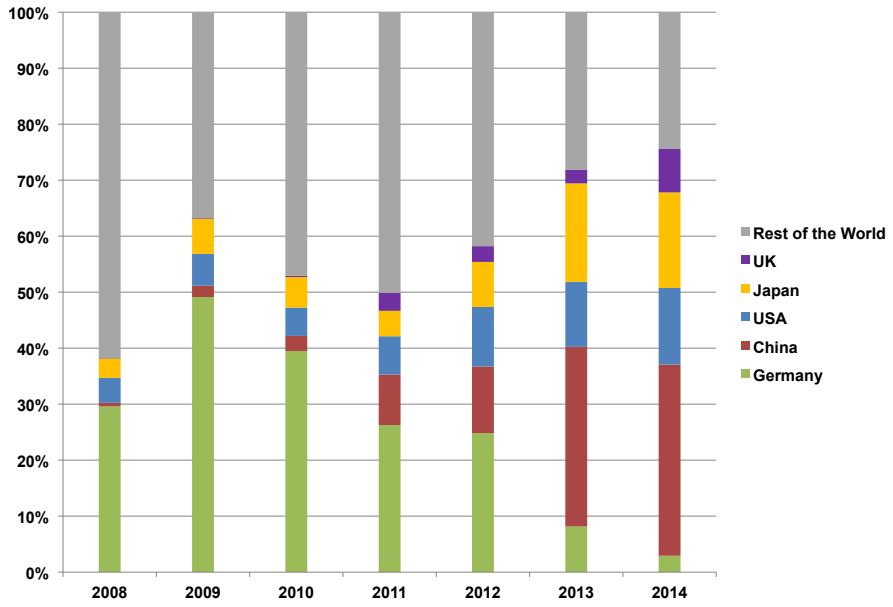
Global PV Industry Overview

The solar industry is emerging from a significant downturn that was triggered by a cooling of European demand. Europe accounted for 70 percent of global photovoltaic (PV) installations between 2006 and 2011. However, with major subsidy reform and high rates of solar penetration, European PV installations are expected to decline to 22 percent of global demand in 2014, while demand in every other major region continues to expand *(see Exhibit 1)*.[1]

The supply side of the solar industry is segmented into companies that produce polysilicon, wafers, cells, and modules with few fully vertically integrated companies *(see Exhibit 2)*. Many new entrants have emerged in the past five years, expanding production capacity across the entire solar value chain. Massive production capacity expansion since 2008, particularly in China, coupled with contraction of European markets, resulted in excess supply in the industry, pressuring pricing and margins.[2] In response, producers maintained very conservative utilization rates and curtailed expansion, allowing the industry to work through a large inventory of solar modules in 2013.

Regional trends in module production show a 1 percent year-over-year (YoY) decline in China's market share to 64 percent in 2013, representing the first decline after a decade of continuous production share expansion.[3] Lack of Chinese capacity expansion and low utilization rates among weak Chinese manufacturers are the main drivers of this decline in market share. Asian nations outside of China make up 22 percent of global production. Of these, Japan is the fastest growing, increasing production by 24 percent in 2013. Other notable Asian producers include Malaysia, South Korea and Taiwan.

Exhibit 1: Global PV Demand Share by Major Market



Source: Bloomberg

Close to 90 percent of solar modules produced in 2013 were crystalline silicon (c-Si). Approximately 75 percent of c-Si modules are multi c-Si, which represents a significant shift from 2008 when multi and mono c-Si production was even. The shift has been driven by the fact that multi c-Si modules tout cost advantages in a market that is keenly focused on upfront module costs.

An additional 46 gigawatts (GW) of PV capacity is projected to be installed globally in 2014, a 22 percent increase YoY. The PV module manufacturing industry will likely maintain 37 percent spare capacity (approximately 17 GW) through 2014.[4] This ratio of demand to production capacity represents a relatively well-balanced PV module market, allowing prices to remain stable through 2014.

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Exhibit 2: Photovoltaic Solar Supply Chain

Raw Material: Silicon dioxide is processed to remove impurities to levels that are between metallurgical and semiconductor grade silicon.

Ingot: Process of melting polysilicon into ingots and subsequently cutting the ingots with wire saws into multiple wafers a few microns thin.

Wafer: Thin slice of silicon crystal used to build integrated circuits and other micro devices.

Solar Cell: Comprises technical applications of adjoining, texturing, coating and layering of wafers.

Solar Module: A number of interconnected solar cells (typically 36 connected in series) encapsulated into a single, long lasting, stable unit.

Balance of Systems: Includes mount structures, tracking systems, combiner boxes, inverters, monitoring systems, cables and connectors.

Installation: Engineering, Procurement, and Construction (EPC) firms and developers install PV systems.

Sources: CoBank, Vertical Research Partners

The rate of decline in prices for multi c-Si modules has slowed significantly after declining 37 percent annually from January 2011 to January 2013 *(see Exhibit 3)*. Through the first half of 2014, average multi c-Si module prices have declined only 9 percent. Beyond 2014, global module prices are likely to maintain a steeper downward trajectory, dropping below 50 cents per watt (W) for Tier 1 Chinese modules before the end of this decade.[5]

Module prices are likely to decline through 2014 despite rising silicon based input costs. Polysilicon spot prices are projected to increase 20 percent YoY to $24/kg in Q4 2014.[6] Spot poly prices should peak in 2014, declining thereafter to around $18/kg in 2017, due to increased supply coming online.[7]

The manufacturing process accounts for the largest share of PV module costs, 44 percent in 2014 *(see Exhibit 4)*. To maintain margins in the face of increased silicon-based input costs and declining module prices, the industry will continue to focus on cost reductions in consumables (wear and spare parts) and non-silicon related materials.[8] Further reductions to non-silicon costs will be realized through the optimization of installed production capacity and increasing cell efficiencies without significantly increasing processing costs.[9]

Top Module Manufacturers Remain Strong

During the recent industry downturn, the less competitive manufacturers utilized relatively stagnant technology, meaning they could not increase module or production efficiency to keep pace with falling prices. To curtail their losses, many of these companies increased throughput by lowering the acceptable quality level for their factory. These manufacturers reduced their costs by substituting cheaper, unproven materials, or they cut short processes to increase throughput beyond what is realistically possible.[10]

The industry started to see deterioration in module quality only in the last few years. This deterioration, driven entirely by market forces, will be corrected. Moreover, in the current competitive environment, manufacturers will be forced out of the market if they do not provide a high-quality product.

Activity among module manufacturers in recent years indicates slow growth among less competitive suppliers with growth largely concentrated among the top suppliers. GTM Research estimates that the top ten module manufacturers increased production 22 percent

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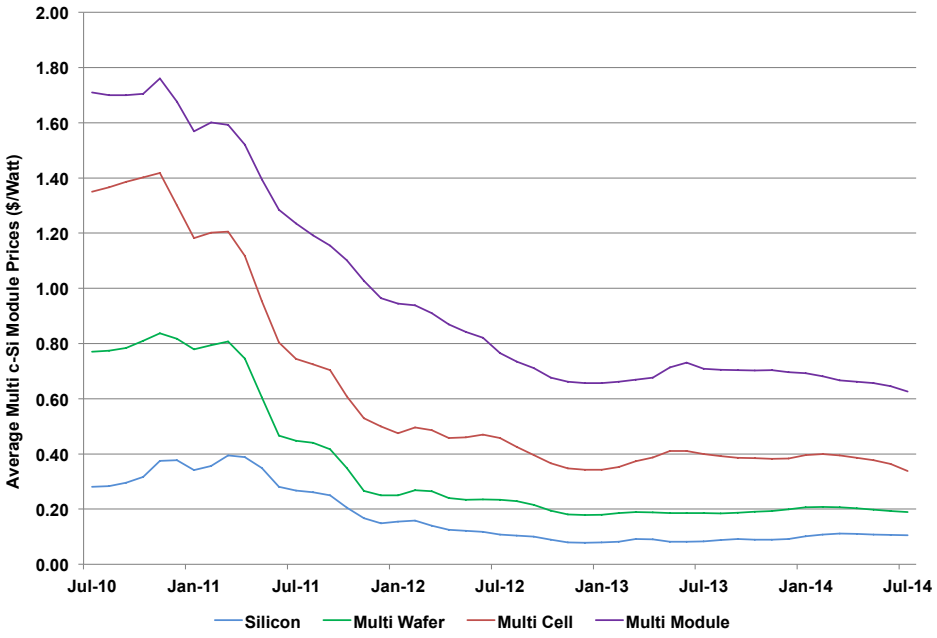
Exhibit 3: Price Trends for Poly-Si, Wafers, Cells, and c-Si Modules



Sources: Bloomberg, International Technology Roadmap for Photovoltaic, CoBank (Assumptions: 5 g/watt; 44.1 wafers/kg)

YoY in 2013, compared to 3 percent production growth across the entire sector.

Comparing the top ten firms by number of modules shipped in 2009 versus 2013, seven have maintained a spot in the top ten since 2009. Only three new names appear; Jinko Solar, Renesola and JA Solar *(see Exhibit 5)*.[11] It is important to note, two of these companies are not new to the solar industry. Renesola was historically a large wafer manufacturer, and JA Solar was the number one solar cell manufacturer in 2009. The sustainability of top solar module manufacturers goes against the common perception that bankruptcy plagues the entire industry. Despite extreme price and margin pressure since 2011, the top module firms have proven to be resilient and will likely continue to operate successfully for years to come.

U.S. PV Market

The U.S. is among the fastest growing PV markets in the world and, similar to other high growth regions, is partially supported by government incentives and subsidies. This year an additional 7 GW of PV will be installed in the U.S., doubling installations from 2012 and increasing 36 percent from 2013 *(see Exhibit 6)*.[12] Utility installations outpaced residential and commercial installations for the first time in 2013. This is due to utilities moving forward with solar projects to take advantage of the 30 percent Investment Tax Credit (ITC) before it steps down to 10 percent after December 31, 2016. From 2014-16, the fastest growing segment will be commercial (39 percent CAGR), followed by the residential segment (29 percent CAGR) and the utility segment (17 percent CAGR).

Strong domestic growth is dependent on competitive PV system prices. However, module prices in the U.S. are likely to rise through 2014, largely because of U.S. countervailing duties and anti-dumping measures on Chinese sourced modules. Furthermore, supplies of solar cells and components are limited outside of China and Taiwan, and other countries might not be able to satisfy demand immediately. As a result, U.S. module prices are likely to rise during 2H 2014 from $0.72/W to $0.80/W.[13]

There are three relevant cases related to import taxes imposed by the U.S. Department of Commerce (DOC) on Chinese solar module manufacturers. Each case has a separate timeline and they will influence U.S. module prices differently.

The first is the original 2012 countervailing duties case aimed at taxing subsidized Chinese module imports. The World Trade Organization (WTO) upheld the 2012 countervailing case on July 14, 2014. However, this ruling will have little effect on the fundamentals of the U.S. module market, due to a loophole that allows Chinese suppliers to avoid paying duties by assembling modules

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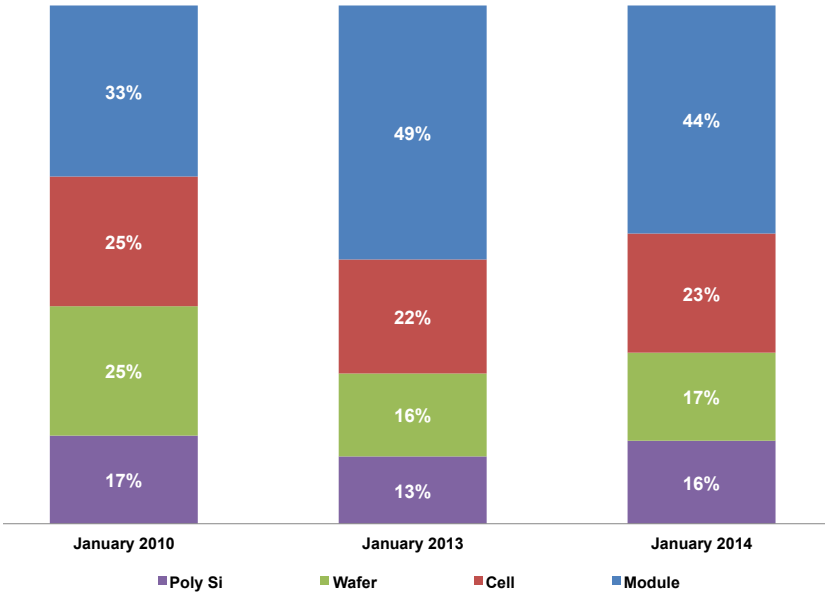
Exhibit 4: Percent Share of PV Module Cost Elements in 2010, 2013 and 2014



Source: International Technology Roadmap for Photovoltaic

in Taiwan. The second is a new DOC countervailing duties case aimed at closing the Taiwan loophole. The DOC provided a final ruling for this case on June 2, 2014, which will likely increase module prices in the U.S. by approximately 10 percent in 2014. The third case is the DOC's preliminary anti-dumping measures aimed at Chinese and Taiwanese module imports sold at less than fair value. If the DOC upholds the preliminary anti-dumping measures, U.S. module prices could increase by an additional 35 percent. The DOC will provide a final anti-dumping ruling on or around December 16, 2014. The WTO has not addressed the new countervailing or anti-dumping measures imposed by the DOC.

In 2013, 31 percent of all solar panels installed in the U.S. were Chinese modules. Within the distributed sector alone, China supplied the U.S. with more than 50 percent of installed panels.[14] The new countervailing duties could increase residential- and commercial-scale project costs by approximately 2.5 percent for projects using Chinese modules. However, utility-scale project costs could rise by 6 percent, due to a greater percentage of project costs attributable to modules *(see Exhibit 7)*.[15]

Of the three sectors (residential, commercial, and utility), utility-scale projects have the thinnest margins. Utility-scale projects have to earn a positive return while operating in wholesale energy markets, or by entering into competitively bid Power Purchase Agreements (PPA). The combination of increased module costs and the inability to materially increase prices will cut into margins for utility-scale projects.

The sheer volume of Chinese-manufactured panels within the residential and commercial sector means that price hikes will cause overall system costs to rise.[16] This

Exhibit 5: Top Module Firms by Shipments

Company	2013 Ranking	2009 Ranking	2013 Module Shipments (MW)
Yingli Solar	1	4	3,234
Trina Solar	2	6	2,585
Canadian Solar	3	8	1,894
Jinko Solar	4	NA	1,765
ReneSola	5	NA (Wafer #2)	1,729
Sharp Solar	6	2	1,623
First Solar	7	1	1,600
Hanwha SolarOne	8	9	1,280
Kyocera	9	5	1,200
JA Solar	10	NA (Cell #1)	1,170

Source: GTM Research

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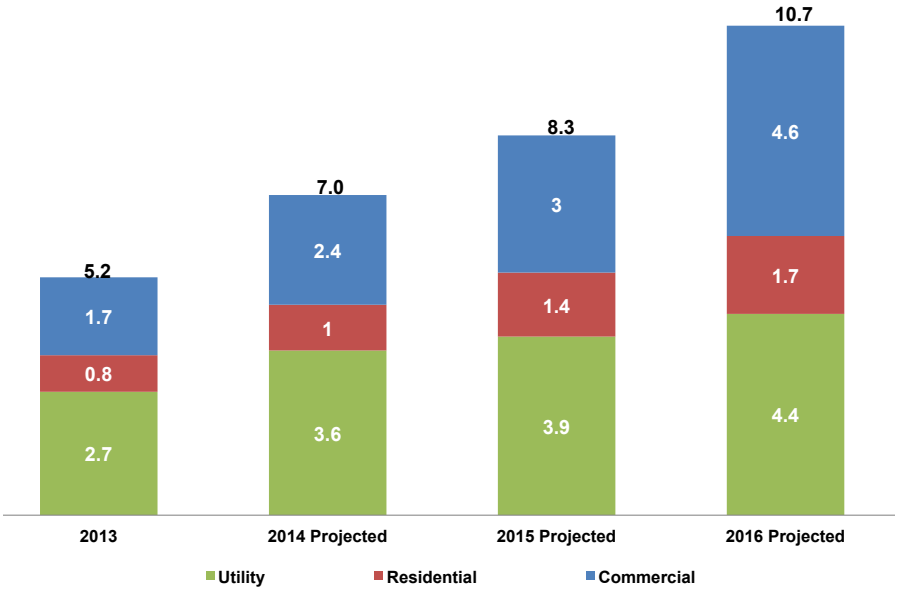
Exhibit 6: U.S. PV Demand (GW)



Source: REC Solar Second Quarter 2014 Outlook

will pressure developers to reduce other system costs to maintain margins.

Balance of System Cost Reductions

To sustain growth in an environment of flat to increasing module prices and waning tax credits, the focus on reducing PV system costs is shifting from modules to balance of systems (BoS) costs. BoS costs are non-module costs that can be divided into two general categories: (1) inverter and other BoS hardware costs and (2) non-hardware costs.[17] BoS costs represent approximately half of a residential PV system's total cost.

For systems in the U.S. that are greater than 100 kilowatts (kW), BoS costs are projected to decrease by 30 percent in 2024, relative to 2013 *(see Exhibit 8)*. Innovation in the U.S. inverter market will drive the majority of BoS cost reductions over the next ten years. No "soft costs" such as permitting or financing are included, as these costs vary greatly from state to state.

With ailing PV demand in Europe, many European inverter suppliers are looking for new opportunities in the U.S. Aggressive marketing campaigns in the U.S. since 2013 have created a more fragmented domestic supplier base. The three largest inverter suppliers in the U.S. remained unchanged in 2013. However, their combined market share declined from 64 percent to 53 percent, as an increasing number of competitors emerged.[18] The increasingly competitive inverter market in the U.S. resulted in rapid price erosion with average prices declining 20 percent in 2013. Currently the blended price of inverters is close to $0.17/W; IHS, an international consultancy firm, expects downward price pressures to continue, bringing the average inverter price to $0.14/W in 2016.

Price pressures will drive consolidation among inverter manufacturers. Successful producers will be able to

Exhibit 7: Comparative Cost per Watt for Different Project Scales

Project Scale	System Size	Pre-Tariff Project Cost w/ Chinese Module ($/w)	Post-Tariff Project Cost w/ Chinese Module ($/w)	Project Cost with U.S. Module ($/w)
Residential	2 kW – 10 kW	$3.50-4.50	$3.60-4.60	$3.80-4.80
Commercial	50 kW – 5 MW	$1.80-2.80	$1.90-2.90	$2.10-3.10
Utility	5 MW +	$1.50-1.90	$1.60-2.00	$1.80-2.20

Source: Sol Systems

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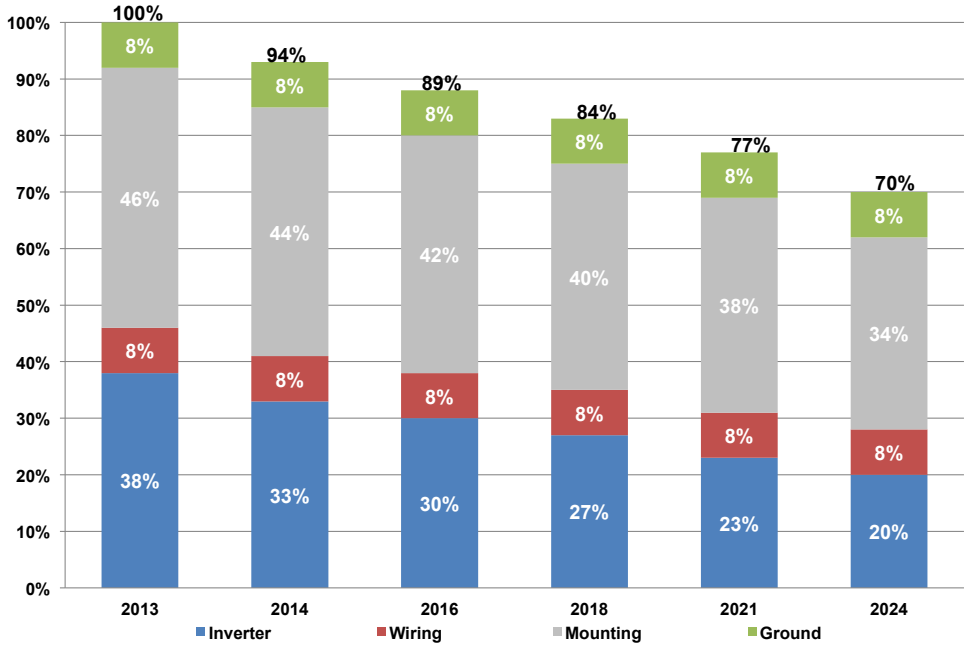
Exhibit 8: Relative BoS Cost Development in the U.S. (2013 = 100%)



Source: International Technology Roadmap for Photovoltaic

provide inverters that work smarter and reduce costs throughout a project's lifecycle.

Inverters play a crucial role in any solar energy system and are often considered the brains of a project. An inverter's basic function is to "invert" the direct current (DC) output into alternating current (AC). There has been a large movement away from central inverters and towards 1,000 volt (V) three-phase string inverters in the U.S., particularly in the rapidly expanding commercial solar market. Three-phase string inverters have become important in rooftop solar because they allow for greater economies of scale with repeatability, inventory turns, simplicity in system design, and system diagnostics and monitoring.[19]

Installation of a 1,000V inverter results in higher voltages relative to a traditional 600V inverter. Higher voltage equates to lower installed costs, greater inverter efficiency, less system power loss and a reduced number of BoS components. With an approximate 0.5 percent efficiency gain due to lower line loss, compared to a 600V inverter, total energy yield improves which translates directly into a more profitable project.[20]

Increasing penetration of PV on the grid is galvanizing utilities to maximize the functionality of inverters and driving development of "smart" inverters. Smart inverter manufacturers are providing greater functionality and better services that complement the core purpose of the inverter: power supply.[21] Smart inverters can provide plant-level control, as opposed to simply inverter-level control, through integrated monitoring – a cornerstone of smart inverter technology.[22] To optimize the grid in an environment of higher PV penetration, utilities will request frequency and curtailment response more often from grid-tied PV plants. Moving forward, this makes integrated monitoring via smart inverters a critical component of any solar asset.

Uncertainty: Trending Downward

Financing for the solar market is increasingly migrating to more risk-averse debt investors who are underwriting long-term cash flows that require more certainty. However, the industry lacks robust historical data on long-term reliability and performance for PV systems.

In an effort to provide more clarity around PV system performance, the National Renewable Energy Laboratory (NREL) recently published data from 1.7 GW of installed capacity (50,000 PV projects) in the U.S. ranging in size from 0.5 kW to 25 MW (with a median of 6 kW). At 1.7 GW of capacity – 13 percent of total U.S. PV capacity at the end of 2013 – these projects can reasonably be viewed as a representative cross section of the U.S. PV market.[23]

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During the study, systems were monitored for the first four years of operations. Data collected suggests these systems produced on average 2 percent – 5 percent more energy than their projected targets.[24] This study is an important step towards reducing investors' uncertainty around the production capability of PV systems.

The NREL data provides a glimpse at system performance but does not address long-term reliability. Information provided by the International Energy Agency (IEA) with respect to long-term reliability shows c-Si panel degradation has a mean value of 0.8 percent/year and a median of 0.5 percent/year.[25] The majority of these reported rates, 78 percent of all data, are below a rate of 1 percent/year.

Furthermore, it has been observed that the confidence among manufacturers has increased over time, with some of them giving a guarantee of 10 percent degradation over a period of 12 years and 15 percent over 25 years. This is evident from the increase in guarantee period being provided by module manufacturers. Prior to 1987, a typical PV module warranty lasted 5 years, since then warranties have increased to 25 years and will likely cover 30 years by 2015.[26] However, even with robust warranties in place, acceptable returns on investment for all solar assets rely heavily on adequate operations and maintenance (O&M) programs.

The number of solar PV installations entering the post-warranty stage is driving the solar O&M industry. Furthermore, the growing sophistication in investment models, leading to assets changing hands or being sold is promoting the PV O&M industry. Subsequently, financiers will drive O&M best practices and influence the development of standards as they become more active in this maturing market sector.[27]

The largest U.S. O&M players are vertically-integrated solar firms, while independent O&M providers are growing in number and market share. Inverter companies are eyeing O&M as a new revenue source, and traditional engineering, procurement, and construction (EPC) firms are developing O&M specific divisions as they complete warranty period O&M contracts.[28]

Installation is the biggest factor in determining how much maintenance a system will need. Minor install oversights can become major maintenance headaches down the road. Individual residential projects have a difficult time justifying robust preventative programs. As a result, the strategy becomes largely reactive and response is based on a combination of critical mass and customer complaints.[29] Commercial projects typically have revenue streams that justify a stronger preventive maintenance strategy.

Making Cents of All This

Maturation of the U.S. solar industry is rapidly developing, which is evident in the strong demand growth and rush of capital entering the solar space. Over 70 percent of new U.S. electric generating capacity in Q1 2014 came from solar.[30]

Global corporate financing, including venture capital/private equity, debt and public market financing in the solar sector totaled $6.3 billion in Q2 2014.[31] Debt financing alone brought in over $9 billion during H1 2014 through 27 transactions with solar companies located across the globe *(see Exhibit 9)*.

Increased supply of capital is reducing the cost of capital across the industry. According to Sol Systems, market clearing prices for projects indicate that investor's hurdle rates for financeable large commercial and small utility projects have dropped 100-200 basis points since the end of 2013.[32] However, questions remain as to how the U.S. solar industry will fare with diminishing obligations for renewable portfolio standards (RPS), changes to net energy metering, and expiration of the 30 percent ITC.

RPS policies exist in 29 States plus the D.C. and eight more states have non-binding goals. The vast majority of state RPS requirements have been met with wind (88 percent). However, solar has played an increasing role in meeting RPS mandates since 2010. Future RPS requirements, though less than previous additions, still equate to approximately 3-5 GW per year through 2020 and 2-3 GW per year through 2035.[33]

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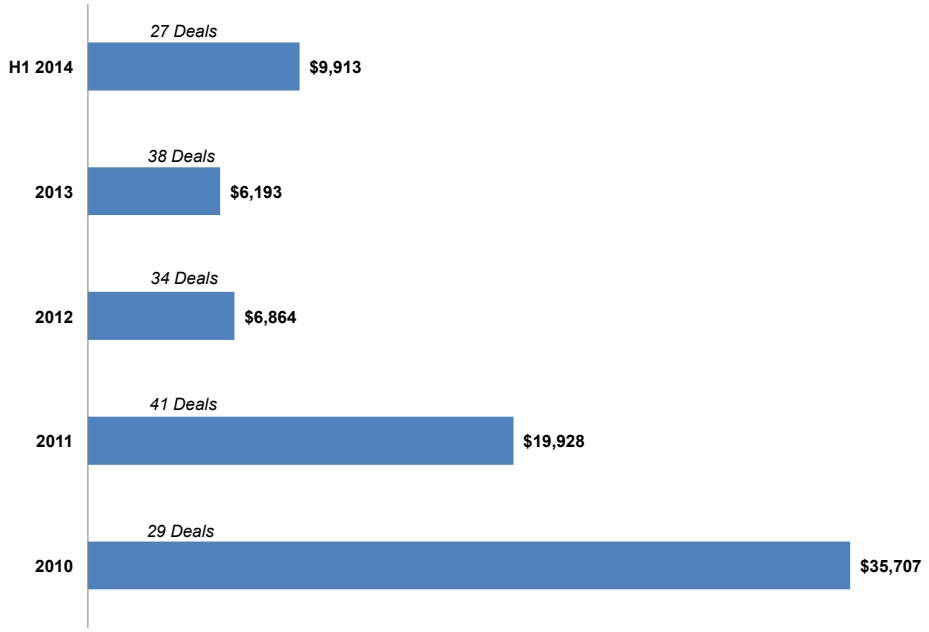
Exhibit 9: Global Solar Debt Financing 2010 – H1 2014
($ Millions)



Source: Mercom Capital Group

Net energy metering policies will remain in constant flux as utilities and regulators wrestle with the best way to incorporate distributed energy onto the grid and into business models. Some states have decided to implement a "value of solar" tariff in lieu of net metering, while other states have attempted to block pro net metering legislation. Net energy metering policies, along with fixed rate charges to solar customers, will likely be scaled back as utilities expand further into the distributed generation sector.

Reduction of the ITC from 30 percent to 10 percent could make utility scale projects that sell wholesale energy, less competitive than the growing distributed generation asset class. Securitization of distributed solar assets is gaining momentum and recent market activity supports the long-term nature of this asset class. Financial innovation, such as securitization, will likely reduce the cost of capital for distributed solar projects to rates only utility-scale projects could historically justify.

Assuming a developer can access capital at 6 percent and sell electricity at $0.08/kWh, utility-scale projects will have to be built at around $1.20/W to break even, given a 10 percent ITC.[34] This represents approximately a 35 percent reduction from today's average utility-scale all-in costs. However, this is not unprecedented considering average costs declined over 30 percent from Q1 2012 to Q1 2014.[35] The challenge is that module prices will likely decline at a slower rate over the next two years, relative to the prior two years. Beyond 2016, it is likely utilities will focus on smaller scale community solar projects that can take advantage of higher retail electricity rates. Furthermore, this allows utilities to market modules or kWh directly to their customer base and guard against encroachment by third party solar providers.

It is clear that retail electricity rates will become critical for solar projects in a post ITC world and will drive growth in the distributed sector. All-in development costs with a 10 percent ITC can be established for distributed projects, assuming cost of capital is around 6.5 percent and retail electricity rates stay consistent into 2017, and PPA rates track retail rates. According to analysis by GTM Research and Sol Systems, commercial projects will require a rate of $1.52/W and residential projects will require a rate of $1.89/W to be economical after 2016.[36] These project development rates assume average residential electricity rates of $0.125/kWh and commercial electricity rates of $0.103/kWh.

Currently, residential rooftop projects are being installed for around $3.00/W, and small rooftop commercial projects are being installed for $2.50/W.[37] Therefore, by 2017 average residential and commercial all-in development cost will have to decrease by 50 percent and 25 percent, respectively. From Q1 2012 to Q1 2014, both residential and commercial all-in costs declined by

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approximately 25 percent. It seems the residential sector will be under the greatest pressure to reduce system costs. The industry's ability to scale manufacturing and installation while reducing the cost of capital will determine growth of the distributed sector, particularly for residential projects.

Conclusion

Growing interest in the U.S. solar industry from risk-averse investors is helping push solar into the mainstream. Financiers' ever-growing need for greater certainty of solar assets' long-term performance will instill a market discipline across the entire solar value chain, rewarding companies that deliver on performance and reliability. Greater certainty around the performance of solar assets will promote the flow of capital into the space and reduce the industry's overall cost of capital, bringing down the levelized cost of energy (LCOE) for PV systems. This is a vitally important fact given the sector will be entering an environment of declining government incentives.

CoBank's Knowledge Exchange Division welcomes readers' comments and suggestions. Please send them to KEDRESEARCH@cobank.com.

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