PikeResearch
Cleantech Market Intelligence

Research Report

The New Solar Market

Implications of the Shift to a Demand-Driven Market: Key Differentiators to Watch in 2010 and Beyond

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Section 1

EXECUTIVE SUMMARY

1.1 Solar Market Demand is Recovering after a Difficult 2009

The solar industry experienced the proverbial "perfect storm" of market-changing events in 2009 that redefined the rules of the game and therefore altered the competitive landscape as well. These events have had a strong influence on which companies will lead the industry in 2010 and beyond. Starting in late 2008, the solar market shifted from supply-constricted to demand-driven within a few quarters as a result of four main factors:

- Strong growth in crystalline silicon (c-Si) cells and module production commensurate with rapidly increasing availability of polysilicon at plunging prices.
- Constrained availability of credit and financial uncertainties resulting from the world financial crisis that limited project financing.
- Spain's dramatic demand decline of 2.2 gigawatts (GW) as overly generous feed-in tariffs (FITs) were capped in October 2008.
- The growth of thin film (TF) supply and market share, primarily from First Solar, as cost per watt ($/W) in combination with efficiency became the primary driver of project return on investment (ROI).

In a short timeframe, low-cost modules from Asian (mainly Chinese and Taiwanese) manufacturers grabbed market share from modules made by longtime industry leaders such as Q-Cells, First Solar's value proposition became the most successful in the industry, and reminders of an imminent industry consolidation became frequent.

In the second half of 2009, worldwide financial markets stabilized and Germany once again saved the industry with demand that topped 3.8 GW (including an astounding 1.455 GW of installations in December alone). By 4Q 2009, revenues and margins of low-cost cell and module manufacturers exceeded expectations and indicated the direction of the new solar market. Although little shakeout of market players actually took place, a few companies closed high-cost manufacturing facilities or began to move production to low-cost countries.

Today, in mid-2010, we believe that the new, dramatically lower-cost solar market looks to be set for just short of 43% year-over-year growth in demand to about 10.1 GW. Such growth will be driven by demand from a variety of countries in addition to Germany, but most notably from Italy, the United States, Japan and France. In fact, grid parity for solar-produced power in most of the world's energy markets has likely moved up a year to the 2013 timeframe.

Looking forward, Pike Research expects solar market demand to exceed 19 GW by 2013, a 25% compound annual growth rate (CAGR) from 2010. Demand from the United States, Italy, and China, in addition to Germany's steady demand, will be the primary driver of this impressive growth. Additionally, the new solar market will also be characterized by substantial solar demand growth from a wide variety of smaller and emerging markets.

1.2 Module Oversupply is Likely

As evidenced by the paucity of consolidation in 2009, despite predictions to the contrary, the number of cell and module manufacturers in the new solar market remains unsustainably large. Consequently, gross oversupply is likely until the market is inevitably corrected by the consolidation of weaker competitors. Indeed, according to Pike Research analysis, the solar market is currently supplied by more than 190 major cell and module manufacturers (excluding small companies that make less than 5 MW annually). We have also reviewed company reports on planned capacity and have estimated the capacity of many smaller module suppliers. The result is that total available module capacity by the end of 2010 could reasonably add up to more than 30 GW – an astounding number.

Obviously, with capacity far exceeding demand, many solar module lines will operate at less than (perhaps much less than) 100% utilization. Furthermore, with this much capacity available, module average selling prices (ASPs) will most likely face continued downward pressure, and less competitive companies will probably be consolidated at a faster rate.

Pike Research has diligently analyzed the competitive strength of this large number of cell (for c-Si modules) and module manufacturers (both c-Si and TF). We have sorted this list into three categories, as follows:

- **Tier 1 companies:** Strong, most competitive companies that have demonstrated strength in most (if not all) of the competitive differentiators outlined in subsequent sections of this report.
- **Tier 2 companies:** Existing and often formerly strong solar market competitors, emerging companies with innovative value propositions, and companies more likely (in our opinion) to survive in a consolidating market mainly through restructuring to lower $/W.
- **Tier 3 companies:** Basically, these are the balance of the 190+ list of competitors that will, in our estimation, struggle in varying degrees to survive in the new solar market.

This delineation is dynamic. Some companies will demonstrate strength in the competitive differentiators and grow stronger, while others will fade. Accordingly, Pike Research will update this competitive evaluation on a regular basis.

We anticipate that the 17 Tier 1 companies (identified in Section 3) will enjoy high utilization rates and earn high revenue from the bulk of industry shipments in 2010. Of the 80 companies we have rated as Tier 2 competitors, some will rebuild and others will earn market share through emerging strong value propositions. Still others may weaken and face consolidation. The balance of the 190+ companies will probably face severe ASP declines, resulting thin margins, and greater likelihood of consolidation.

The bottom line: Tier 1 companies alone could supply all of the 10.1 GW of solar demand in 2010. Since this is unlikely, Pike Research expects Tier 2 and 3 companies to continue to win some (but limited) orders and build inventory that reflects hopeful marketing plans or simply company hubris. However, even accounting for reasonable utilization rates and capacity growth (i.e., slower than forecast by companies in many cases), we estimate that module oversupply could reasonably reach 6.1 GW to 8.3 GW in 2010.

1.3 Low Cost per Watt is Now the Primary Differentiator

On what basis did Pike Research select Tier 1 companies? Given the large oversupply and consolidation that we forecast for 2010, which companies will most likely grow and prosper in the new solar market? We suggest that winning companies exhibit excellence in a few key competitive differentiators. Among these, low cost per watt is now the primary differentiator.

While $/W must be considered in combination with module efficiency, it has become the main competitive differentiator in today's solar market. This market is unconstrained by supply and includes many companies that provide high-quality, high-efficiency modules with greater brand recognition and wide presence in key markets. That is, the market for solar module looks much more like a commodity market than it did just 12 to 18 months ago.

Low $/W is achieved in a variety of ways, including:

- Primarily through manufacturing in low-cost (especially labor cost) countries, including Taiwan, Malaysia and the Philippines (not just China)
- Low-cost materials, including cadmium and tellurium for cadmium telluride (CdTe) modules, conductor materials, and low-cost polysilicon (often resulting from re-negotiated long-term contracts)
- Low-cost processing resulting from engineering breakthroughs and process controls
- Advantages of scale

1.4 Module Efficiency and Cost Define Winning Companies

Especially for the growing number of modules to be deployed in utility-scale projects, module efficiency remains a key competitive differentiator. While it is true that the 11.1% efficiency modules from First Solar continue to win major orders from utility projects, this is due to the fact that they are also provided at an industry-leading $/W. However, the number of modules and most of the balance of system (BOS) costs (now nearly as much as the cost of modules in large-scale applications) required for a given project power output is roughly proportional to efficiency. Thus, not surprisingly, higher-efficiency modules are winning a larger share of large commercial and utility-scale projects. Likewise, space- or land-constrained installations often seek higher-efficiency modules to maximize power output.

Looking forward, larger projects will probably consume the bulk of modules in growing markets (e.g., China and the United States), thereby increasing the competitive strength of higher-efficiency modules. While the residential and building integrated photovoltaics (BIPV) markets will likely continue to favor pure cost, trustworthy brands, and architectural compatibility (i.e., invisibility) over efficiency, Pike Research expects module efficiency to continue as a key company differentiator in any ROI-sensitive market segment.

1.5 Moving Down the Supply Chain is Growing in Importance

Again especially for large commercial and utility-scale projects, end customers increasingly prefer one-stop shopping. Therefore, they prefer companies that deliver project development, engineering, permitting services, BOS supplies, financing, and other services instead of just modules. In short, end customer demand for large installations is trending more and more toward the delivery of power – not just modules. Already, First Solar and SunPower have led the way in providing an array of project development services and products. Meanwhile, China's Suntech and Yingli have also developed similar packages. Pike Research looks for most Tier 1 and Tier 2 companies to provide these products and services (increasingly through partnerships) as part of their value proposition in 2010 and beyond as large projects consume the vast majority of modules in growing markets.

1.6 Other Market Differentiators to Watch in 2010 and Beyond

As detailed in Section 3, a few other characteristics of top solar competitors are growing in importance and thus will be indicators of competitive strength in 2010 and beyond:

- Market presence (e.g., brand recognition and sales and marketing) in high growth markets, especially in the United States, China, France, South Korea, and Canada, as well as in a number of smaller EU countries.
- Ability to internally finance a large portion of capacity and technology growth.
- Module (but not cell) manufacturing near or in high-growth markets, sometimes through tolling arrangements, in part to accommodate local content requirements, a growing part of incentives.

Section 2

WORLDWIDE SOLAR DEMAND

2.1 The Solar Market is Now Demand-Driven

Most people and companies associated with the solar industry know all too well that 2009 was a painful year. It was characterized by a dramatic decline in demand, limited consolidation, and an unprecedented shift from a supply-driven to a demand-driven market. An overview of the major factors that initiated and accelerated this fundamental market change will provide a basis for understanding how the industry will grow in 2010 and beyond. The solar market demand shift in 2009 was primarily caused by the following:

- A rapid change from a shortage of polysilicon (poly) to an oversupply of poly starting in 4Q 2008. Limited poly supply resulted in a restricted supply of crystalline silicon modules and a window of opportunity for some thin film module technologies and processes to develop and take market share from c-Si modules. That window closed in 2009.
- A market-jolting fall in demand from Spain because of an overly generous FIT. Spanish projects consumed about 2.5 GW of solar modules in 2008, but the world's largest demand market fell by about 87% in 2009 due to a cap on FITs instituted by Spain in October 2008.
- Economic uncertainties due to the worldwide financial crisis. This situation limited the ability to finance solar projects, particularly utility-scale projects (at least from 4Q 2008 through 2Q 2009).
- Growth in TF supply, primarily of CdTe modules from First Solar.
- Lack of expected improvements in subsidies to drive new demand in potentially large markets, especially in the United States and Japan. Notably, the solar industry hoped for but saw little real subsidy gain in China despite rhetoric to the contrary.

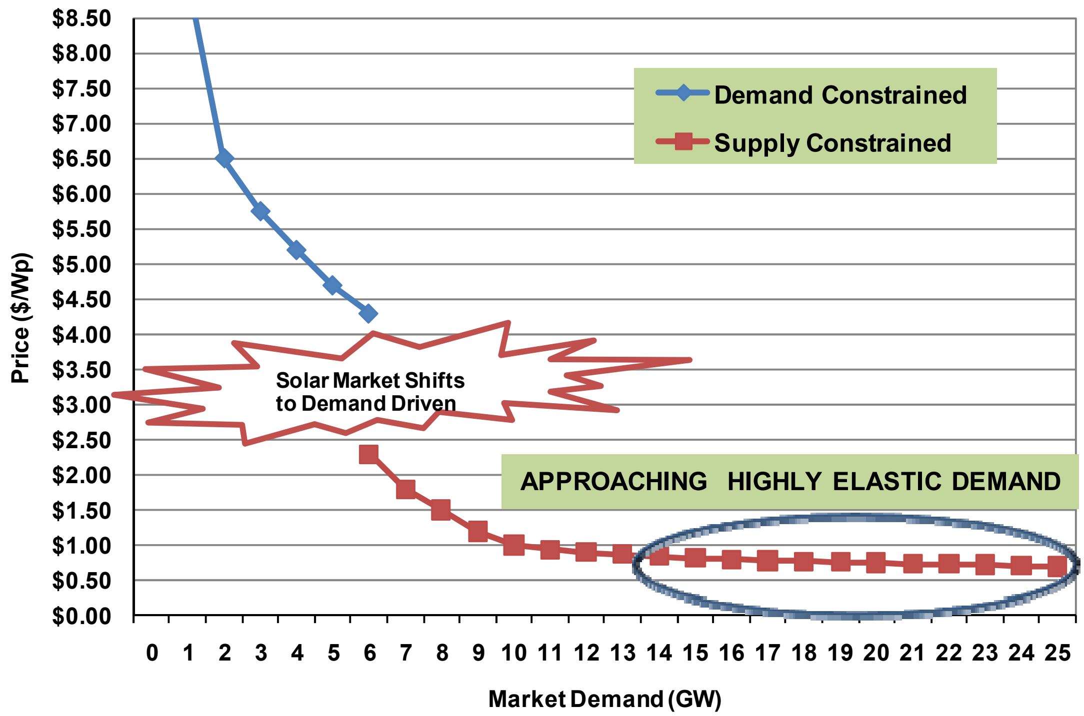
Thankfully for many in the industry, 2009 is over, and Pike Research forecasts that solar demand will grow substantially in 2010. Moreover, we expect the outlook for the solar market to improve dramatically in 2011 and beyond.

An examination of the 2009 market shift that was sparked by an abundance of polysilicon will provide the background for this outlook.

2.2 Dramatic Consequences of the Market Shift

A fundamental postulate of economics suggests that most markets that shift from short supply to abundant supply also shift to high elasticity of demand. As depicted in Chart 2.1, this is what Pike Research believes occurred in the solar market during 2009.

Chart 2.1 Solar Market Demand Shift



(Source: Pike Research)

Two key points from Chart 2.1 should be emphasized. Note the disruption that occurs when a market shifts from supply-driven to demand-driven. Instead of a smooth transition and a continuous price drop that slowly but dependably spurs demand, a shifting market surprisingly (if not shockingly) causes prices to plunge. As a result, market drivers and leaders are redefined. Indeed, this was the case for the solar market in 2009. Many top c-Si module manufacturers were surprised by the rather rapid decline in module prices during 2009. These manufacturers did not forecast, even in late 2008, such a price plunge and the resulting loss of competitive advantage.

Second, note that shifting to a demand-driven market also offers good news for market players in the longer term. Demand in this type of market often becomes highly elastic at a certain price range when new markets open and a product becomes price competitive with and a viable substitute for incumbent products (in this case other types of grid power generation). In the case of the solar industry, electrical power from grid-tied solar installations is indistinguishable from fossil fuel-generated power. Consequently, as the solar power price approaches that of fossil fuel power, which is the definition of grid parity, an enormous amount of worldwide power demand becomes available to drive the production of solar cells/modules.

Many industry observers suggest that an average c-Si module with a cost of about $1.50/W would permit solar installations to produce power at about $0.15/kWh. A cost of about $1.00/W would result in power at about $0.10/kWh. At $0.15/kWh, solar power would be competitive in today's high-power cost areas. However, at $0.10/kWh, solar power would be competitive with most of the world's fossil fuel-generated power. As we describe in Section 4, since the industry is approaching this rough cost range, solar will likely reach grid parity in more and more areas of the world in the next few years. Thus, small price reductions will greatly increase demand, as depicted in the demand curve above.

In summary, as a result of this market shift, project ROI – not the availability of modules – has become the primary demand driver. For solar installations (from residential through large-scale projects) financial return now largely determines which cell/module technologies and what companies will gain market share and earn industry-leading revenue and margins. Since c-Si module supply is no longer constricted by poly availability and TF is gaining market share (primarily CdTe modules from First Solar), module supply has increased dramatically and ASPs have fallen commensurately from about $3.90/W in 4Q 2008 to less than $2.00/W recently.

2.3 Solar Demand Will Rebound to 10.1 GW in 2010

After a dramatic plunge in shipments starting in 4Q 2008, the solar market showed signs of rebound in late 2Q 2009 and enjoyed a recovery (and a strong recovery for the most competitive cell/module manufacturers) in 4Q 2009. Germany led the way, with demand exceeding 3.8 GW in 2009 (a 145% year-over-year gain in demand). The United States, Italy, and Japan also showed strong demand growth. Thus, worldwide solar demand increased by 23%, significantly better performance than predicted by many in early 2009 – despite the huge fall in demand from Spain mentioned above.

With the stage set by the solar market's strong recovery in late 2009, our analysis indicates that the market should take off again in 2010. Indeed, Pike Research believes that solar demand will improve to about 10.1 GW (about 43% growth in demand over 2009). However, several factors have mitigated what could have been an even more stunning market demand spurt in 2010.

Germany's FIT reduction as proposed by its Environment Ministry on January 15 pressed the solar market into turmoil. On top of a planned FIT reduction of 8% to 10% in January, 2010, the Ministry proposed additional FIT reductions of about 16% for rooftop and 25% for open field (i.e., large utility-scale) installations starting in April 2010. Solar stocks plunged. Loud protests from solar-related manufacturers, trade associations, elements of the current coalition government, and workers in Germany ensued.

As a result, the Merkel coalition government eventually proposed a much less severe FIT reduction of 15% for open field and 16% for rooftop installations. These new FITs are proposed to start on July 1. Pike Research believes the net effect will be a rush to complete projects in June, followed by a small drop in demand in 3Q 2010 and a jump in demand in 4Q 2010. Since the FIT reductions will be much less severe than originally proposed and project ROI will return to a respectable 8%+, we expect demand in Germany to grow modestly in 2010 by about 25%.

Solar demand in the United States clearly provides the greatest opportunity for worldwide demand growth. Note, though, that action in support of renewable energy from Congress has been stalled by lengthy debate on healthcare, continued focus on economic recovery, and a myriad of other projects. Still, renewable portfolio standard (RPS) goals, improving utility-scale project ROI, and other incentives in many states have spurred demand growth in the United States and will likely continue to do so through 2010. Eventually, low-cost solar and popular demand for green energy will likely overcome the lobbying and additional influences of coal and other fossil fuel power generators. Combined federal and state incentives will then drive solar demand growth in 2011 and beyond.

Italy's generous FITs could reasonably result in solar demand that approaches 1025 MW and beats the United States for second place in the race for worldwide demand by country in 2010. Despite Italy's proposed FIT reductions in 2011, Pike Research expects solar demand in the country to grow at a CAGR of about 20% through 2013.

Similarly, solar demand from a plethora of other EU countries will increase substantially in 2010 and beyond. Led by a modest recovery of solar demand in Spain and significant growth in France and the Czech Republic, installations in the balance of European countries will probably grow to almost 2 GW in 2010. We will also be watching for a growth spurt in the United Kingdom now that a generous FIT has been promulgated. Additionally, Pike Research anticipates that Greece will experience renewed solar growth in late 2010 as its financial difficulties are overcome and installations of solar-generated power increase (solar-generated power has already reached parity with grid power in this country).

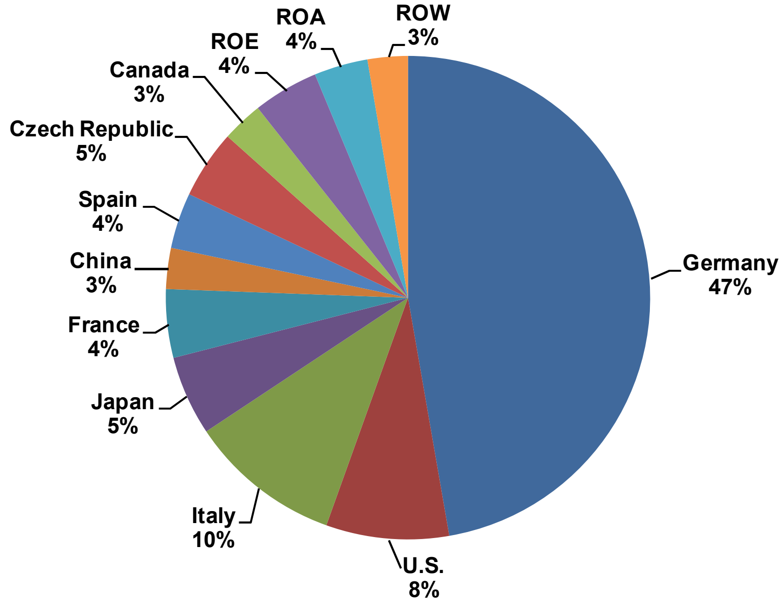
In Asia, Japan has long been the leading market for solar modules – mainly for residential applications. While we expect solar demand in Japan to continue to expand through 2013 at a CAGR of about 30%, Asia's largest growth potential lies across the Yellow Sea in China. Thus far, national incentives for solar installations in China, such as the "Golden Sun" demonstration project, have been limited at best and (to many in the industry) mostly rhetoric. Despite this, improved provincial and federal incentives starting in 2010 will drive solar demand growth to about 275 MW. These incentives will primarily be focused on outlying regions where grid connection is poor. They would also serve as a demand backup for Chinese solar cell/module manufacturers should installations in the EU and the United States fail to consume most of the enormous capacity coming on line with Chinese manufacturers in 2010.

Other Asian countries that will probably expand solar installations in 2010 include South Korea, India, and Taiwan. Despite an economy based on low-cost power from coal and nuclear, South Korean residences could reasonably demand 100 MW to 200 MW in each of the next few years. In India, though the federal government has announced a goal of 20 GW of installations by 2022, the real growth driver for solar appears to be insufficient and unreliable grid power. As a result, Pike Research expects solar demand in India to grow to about 175 MW in 2010. However, demand could reasonably grow to over 250 MW by 2013 as more reliable solar power becomes less expensive.

Finally, Ontario has led Canada in terms of prospects for solar power installations in 2010 through a generous FIT that was initiated in October, 2009. Ontario's FIT requires 50% local content in 2010, much to the chagrin of many module manufacturers in Germany and China. Regardless, we expect several solar companies (notably First Solar, Canadian Solar, and Bosch Solar) to build facilities in Ontario, qualify for the FIT, and drive demand in Canada to reach 275 MW in 2010.

In summary, Pike Research anticipates that worldwide solar demand will grow in an increasingly wider array of countries in 2010, as depicted in Chart 2.2. We expect Germany's share of worldwide demand to shrink to 47% in 2010 (from 54% in 2009) while the United States and Italy take increased share of worldwide demand. Also indicative of broad-ranging growth, demand in the rest of the world and the rest of Asia should increase to about 270 MW and 360 MW respectively in 2010 as the diverse set of countries in these groupings experience new solar installations.

Chart 2.2 Solar Market Demand by Country (MW), World Markets: 2010



(Source: Pike Research)

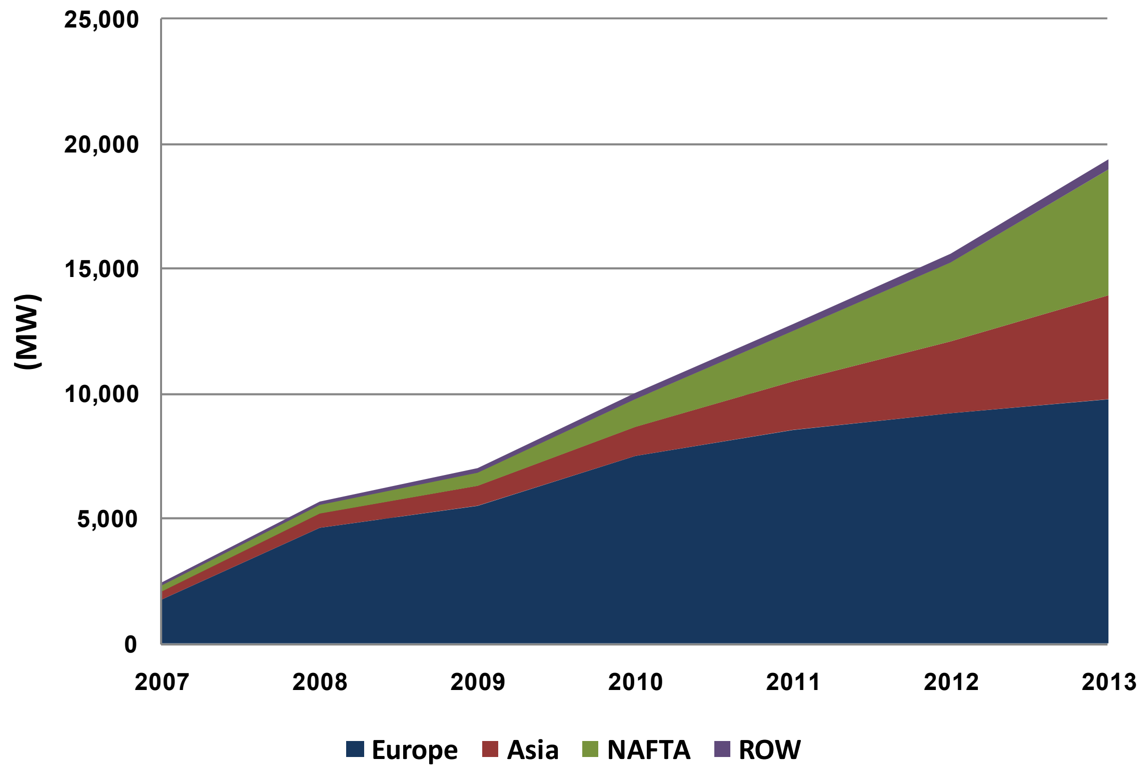
2.4 Solar Demand by Region through 2013

Pike Research estimates solar demand will grow at a strong CAGR of roughly 25% to reach over 19 GW by 2013. We believe that several key factors will lead to this remarkable increase in solar demand, including:

- The enormous but largely untapped U.S. solar market will ramp substantially in 2011 and beyond as states seek to reach RPS goals and the federal government reinstates and adds to solar incentives.
- China's large need for solar power in grid-isolated regions to supply peak power demand and reduce emissions from coal-fired power plants will likely drive a national FIT and other incentives by 2H 2011.
- A much wider array of countries that have stepped up solar demand, most notably Italy, France, United Kingdom, and Canada.
- Grid parity will probably be reached by more than 50% of the world's regions by 2013 as grid power costs continue to climb and solar costs continue to fall.
- Significantly improved project financing availability.

As shown in Chart 2.3, Pike Research expects these factors to increase demand in the North American Free Trade Agreement (NAFTA) region and Asia while the pace of demand growth in the EU slows during 2012 and beyond.

Chart 2.3 Solar Market Demand by Region, World Markets: 2007-2013



(Source: Pike Research)

Section 3

SOLAR MARKET OVERSUPPLY

3.1 Tier 1 Companies Could Supply Entire Market Demand

Due to the shift to a demand-driven market and ample polysilicon supply in 2009, module ASPs have plunged and the competitive landscape in the solar industry has been redefined. The new solar market demands a low-cost structure in order to generate reasonable profit margins in the face of low module ASPs. Yet, module efficiency continues to play a key role in defining which modules are selected for installations because the higher power delivery of more efficient modules translates to fewer modules and lower BOS costs.

This section examines the cell and module capacity and supply of companies Pike Research has found to be most competitive and describes how these 17 companies (listed in Table 3.1) could supply the entire market demand in 2010.

Table 3.1 Top Competitors in Solar: 2010

Canadian Solar	Yingli Green Energy	Q-Cells
China Sunergy	Kyocera	SunPower
JA Solar	Sanyo	E-Ton
Solarfun	Sharp	Gintech
Suntech Power	First Solar	Motech
Trina Solar		Neo Solar

(Source: Pike Research)

Many of the toughest competitors in today's solar market manufacture cells and modules in China or Taiwan. Top Chinese companies include Suntech Power, Trina Solar, Yingli Green Energy, JA Solar, Canadian Solar, Solarfun, and China Sunergy (including CEEG PV). Total manufacturing cost for this group, including the cost of poly, wafers, cell processing, and module manufacturing, will likely drop below the $1.50/W level in the first quarter of 2010 and could conceivably reach $1.30/W by the end of the year. Furthermore, these companies (particularly Suntech with its Pluto technology) produce modules that provide very competitive efficiency.

As evidenced by their latest reports, these Chinese companies have grabbed market share, largely at the expense of companies manufacturing in Germany, other EU countries, and the United States. Given their success, the low-cost Chinese manufacturers have also announced combined substantial capacity additions totaling over 2 GW that are scheduled to be operational by the end of 2010.

Top Japanese cell/module manufacturers (Kyocera, Sanyo, and Sharp) have also confirmed plans to grow cell/module capacity by about 830 MW in 2010. Sharp, in particular, is expanding the production of both c-Si and TF modules at its Sakai facility. Sanyo's HIT modules provide very high efficiency, and the manufacturer is driving costs lower to be able to compete with Chinese modules in large-scale installations. As evidenced by sales offices and module manufacturing expansion in the United States and the EU, the Japanese companies are also intent on gaining market share to enable high utilization of their capacity.

First Solar became the world's largest manufacturer of solar modules in 2009 because it offers the best combination of low cost (at less than $0.81/W) and module efficiency (about 11.1%). With its acquisition of Nextlight Renewable Power, First Solar looks to have a pipeline of orders for its modules totaling over 2.2 GW (and possibly more if a project in China comes to fruition sooner than currently expected). As a result, it plans to expand production capacity to reach over 1.3 GW by the end of 2010. According to company reports, First Solar expects to reach reach 2.1 GW total capacity in 2012 to accommodate its expected growth and market share gain.

Q-Cells, the world's largest module maker in 2008, is struggling to survive today as a direct result of the market shift described previously. However, the manufacturer has instituted a plan it has dubbed "Q-Cells Reloaded" that will greatly accelerate its shift to manufacturing in Malaysia (which was already underway). Due to Q-Cells' large scale, improved cell/module efficiency, and other aspects of "Q-Cells Reloaded," the 500 MW of capacity it has planned for Malaysia in 2010 will likely reestablish the manufacturer as a contender and add to its competitive capacity.

U.S.-based SunPower delivers modules with industry-leading efficiency that will top 20% in 2010. As a result, SunPower module orders for large-scale commercial and utility projects have increased rapidly. The manufacturer has not thus far commensurately ramped its module production capacity. However, SunPower intends to quickly make up for its capacity shortfall by adding production in its Philippines facility and purchasing cells and modules through tolling arrangements. In total, SunPower's capacity will probably jump to about 825 MW in 2010.

Any list of top solar competitors should also include low-cost Taiwanese companies. While Gintech, Motech, and Neo Solar primarily manufacture c-Si cells and not modules, their cells are assembled into modules by many companies worldwide and effectively provide low-cost, competitively efficient modules. E Ton, on the other hand, makes both c-Si cell and modules. Combined, these tough competitors from Taiwan will bring 850 MW to 1100 MW of capacity to the solar market in 2010.

The bottom line is that these seventeen top competitors alone will bring 12.0 GW of capacity to the solar market by the end of 2010. More importantly, these top competitors could supply well over the entire 10.1 GW of demand that Pike Research forecasts for 2010. What's more, most of these leading solar companies have clearly expressed their intent to grab more market share. If they are successful, 2010 could very well develop into a struggle to survive for the remaining solar manufacturers (173 companies in total at last count) as module ASPs continue to decline.

Yet many companies outside of our list of the "top 17" solar companies also believe they offer outstanding value propositions and thus will bring additional capacity to the solar market to support their plans for winning market share. Below is a discussion of the cost, efficiency, and other factors that delineate which companies are most competitive.

3.2 Additional Capacity Increases Oversupply

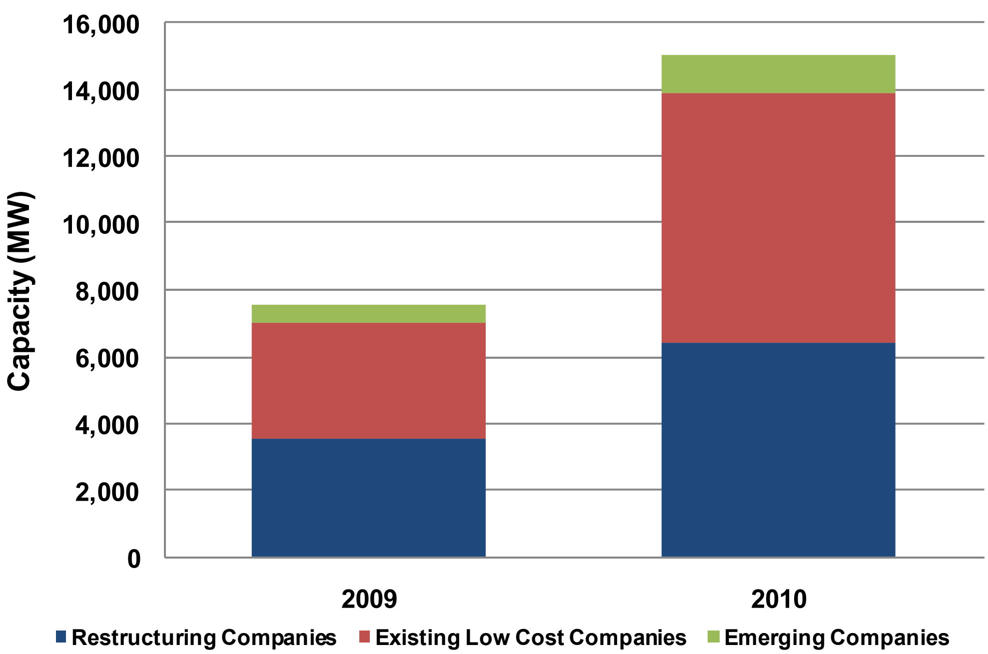
According to Pike Research analysis, the list of second-tier solar cell/module manufacturers consists of 80 companies. These companies could reasonably become top competitors if:

- They restructure, much as Q-Cells did with its "Reloaded" program, and move to low-cost production in new facilities in low-cost locations. Alternatively, they could restructure via tolling arrangements with low-cost cell and module manufacturers (again, primarily in Asia). Companies in this category primarily include former market leaders (e.g., SolarWorld, Q-Cells/Germany, and Mitsubishi) with substantial advantages of scale, proven cell/module efficiency, brand recognition in key markets, and good market share.
- They wrest market share away from the top contenders by proving that their emerging value propositions offer outstanding low-cost efficiency combinations (e.g., emerging companies such as Solar Frontier, Kaneka, Sunovia, and Abound Solar).
- They improve module efficiency and/or market presence to take advantage of their existing low-cost manufacturing. Companies in this category already offer low-cost manufacturing in China or elsewhere in Asia. However, they do not currently enjoy sufficient brand recognition and other market presence in key markets to compete with the top competitors. Notable examples of such companies include LDK/Best Solar, QS Solar Ningbo Solar, and ReneSola.

Because these companies have been, or reasonably could become top contenders, they aim to add capacity to support their plans for gaining market share. As depicted in Chart 3.1, the 80 companies Pike Research has selected for inclusion in our list of second-tier contenders collectively offered about 7.6 GW of capacity to the solar market in 2009 and plan to nearly double that capacity in 2010.

Similar to the group of top competitors, note that the 15.0 GW year-end capacity provided by the 80 second-tier companies alone could provide, if operated at a high utilization rate, well over the 10.1 GW of total solar market demand in 2010.

Chart 3.1 Second-Tier Module Manufacturing Capacity, World Markets: 2009 and 2010



(Source: Pike Research)

3.3 Small Companies Add to Solar Market Oversupply

Prior to the major market shift outlined in Section 2.1, many solar manufacturers using five major types of module technologies and various sources of capital had strategic plans and visions of earning huge returns in the then burgeoning solar industry. Today, many solar cell/module manufacturers that formerly offered promising value propositions are struggling to gain orders and market traction. Many other cell and module makers simply failed to achieve the size and resulting benefits of scale enjoyed by the most competitive companies. Still others could become competitive with the companies listed above but have yet to offer, in Pike Research's estimation, reasonable value propositions that include the required competitive elements.

Of the 93 companies we have included in this list of marginally competitive companies, about half are crystalline silicon cell/module manufacturers that must still reduce costs, differentiate their products in some way, or demonstrate improved scale and market presence. For example, marginal c-Si module makers could improve their product's efficiency to compete with Suntech's 19.7% Pluto-technology cells (if not SunPower's 20%+ efficient modules). Additionally, EU-based c-Si cell/module companies such as Bosch Solar, Isofoton, and Sunways could grow through new capital investment or consolidation to become top competitors.

Pike Research has also included 19 copper indium gallium selenide (CIGS) TF module producers in this list of marginal competitors. The physics of CIGS technology is impressive and offers a theoretical efficiency advantage relative to CdTe TF modules. Once considered the shining stars of TF solar technology and venture capital firms (which provided most of the investment) CIGS companies have struggled to reduce costs to be competitive with First Solar's CdTe TF modules. Pike Research believes that depositing the four elements of a CIGS module has proven to be much more complex and difficult to uniformly process relative to the CdTe process of First Solar. This has resulted in higher processing costs and lower throughput per line for CIGS modules, a competitive disadvantage not likely to be readily overcome. Consequently, we anticipate only about 5 CIGS companies will survive in the next few years.

Approximately 25 amorphous silicon (a-Si) TF module producers are also, in our estimation, in danger of consolidation or closing. In addition to a-Si modules from vintage companies such as Schott Solar, EPV Solar, and Bangkok Solar, several companies manufacture a-Si modules from equipment supplied by Applied Materials (i.e., on its Sunfab line of equipment). Even though a-Si modules are relatively simple and inexpensive to make, they only provide about 6% efficiency for single-junction (i.e., one current-producing set of layers) modules and 7% to 8% efficiency for two-junction modules. Thus, in order to compete with modules made by the top competitors on an installed cost basis, a-Si modules would have to be sold at a very low price. In fact, unless a-Si modules could be produced with about 10% efficiency, they are unlikely to provide competitive returns for large-scale projects and require too much area for small-scale projects.

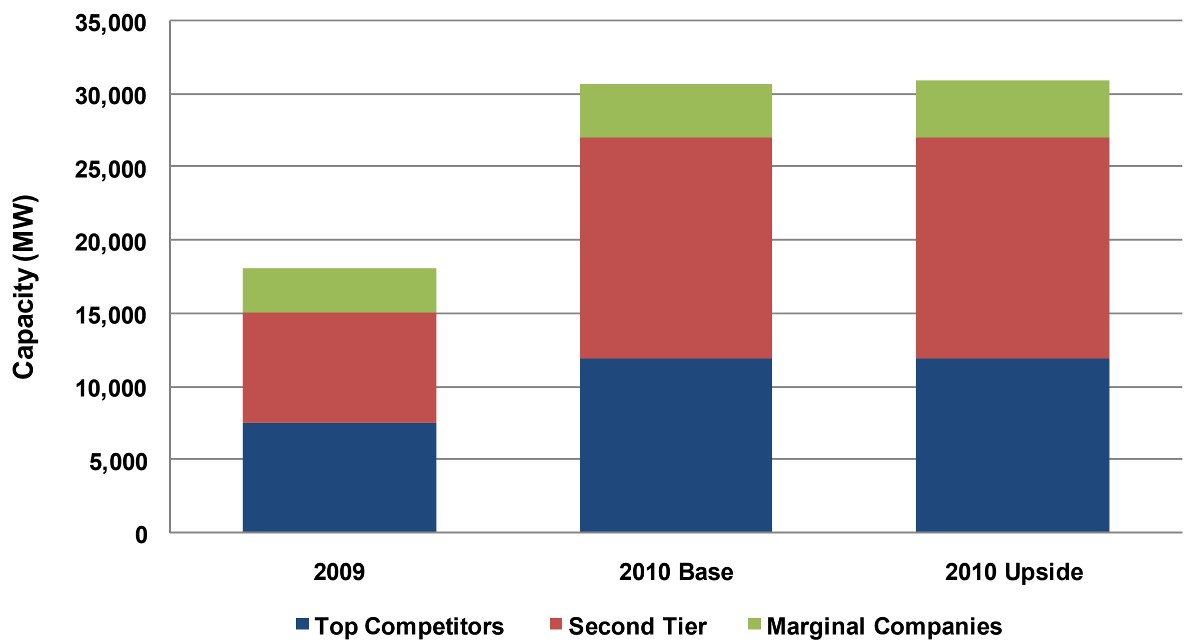
Two U.S. companies are part of this group of marginally competitive companies. The UNI-SOLAR division of Energy Conversion Devices makes solar tiles that easily mount on many types of roofs and blend into architectures of buildings. Consequently, UNI-SOLAR offers a competitive value proposition for a niche market. However, UNI-SOLAR's tiles deliver low efficiency (about 7%), but still cost more than most c-Si modules. As a result, UNI-SOLAR faces a difficult future. Despite this, it plans to add capacity in 2010. The other company, Evergreen Solar, produces modules that are based on a unique technology called string ribbon that looked to be competitive with c-Si technology when polysilicon and wafer costs were high. Today, though, Evergreen has realized that it must manufacture modules in China in order to compete. The manufacturer has accordingly closed its U.S. production in favor of toll manufacturing in China.

According to our research, these 93 companies brought about 3 GW of capacity to the solar market in 2009. Although expansion plans by these often financially struggling companies are difficult to define precisely, Pike Research estimates they could add 1 GW of capacity in 2010 based on expectations of market growth, assumptions of improvements in company value proposition, and management hubris.

3.4 Large Oversupply in 2010 is Likely

One needs only to add Pike Research's anticipated capacity of the above three categories of solar cell/module manufacturers (30 GW) and compare the sum to our forecast solar market demand (10.1 GW) to realize that the solar market will most likely be oversupplied in 2010. We have summarized our forecast of solar market capacity in Chart 3.2.

Chart 3.2 Total Solar Manufacturing Capacity, World Markets: 2009 and 2010



(Source: Pike Research)

Historically, though, companies do not operate at a 100% utilization rate. In fact, 2009 saw very low utilization rates for many solar manufacturers. Industry sources report rumors of utilization rates approaching 20% to 30% in the first quarter of 2009 for several marginally competitive solar manufacturers.

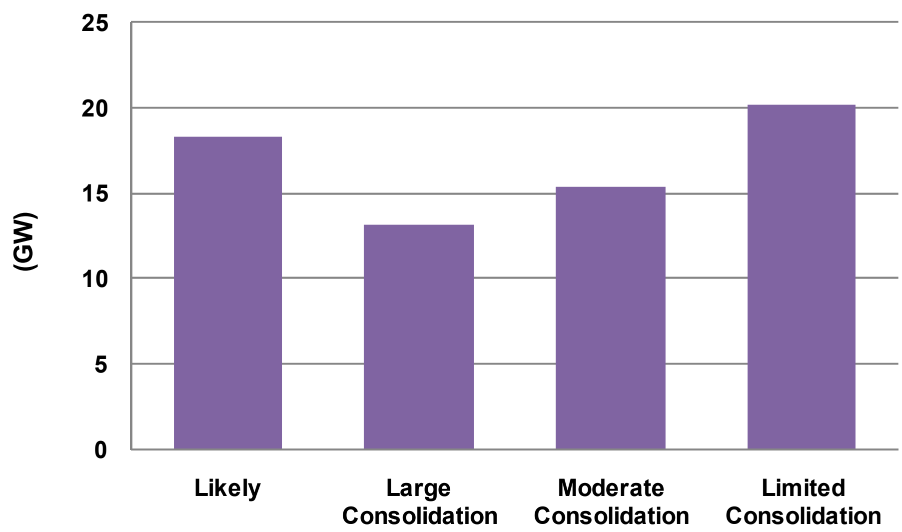
However, given the conditions in the new solar market, the most competitive solar manufacturers listed above could reasonably win an increasingly large portion of solar demand (i.e., take market share) and therefore experience high utilization rates at the expense of less competitive companies. The semiconductor market, for example, saw utilization rates of the most competitive companies' 300 mm fabs approach 100% in good times. Meanwhile, older 200 mm lines barely managed to stay in business, with utilization rates as low as 30% to 50% in some cases.

Recent reports from many of the top competitors in the solar industry indicate that their manufacturing lines will indeed be fully utilized. Suntech Power, SunPower, Trina Solar, and Yingli, for example, mentioned that their production was "sold out" and that they would rapidly ramp capacity in 2010 to accommodate this large demand.

If the most competitive companies are taking market share, what will be the fate of the less competitive companies? We anticipate many companies will close or be consolidated into larger, more competitive companies in the next few years. The most difficult question, though, is: How fast and to what degree will consolidation happen?

Based on Pike Research's analysis, we have assessed likely utilization rates for each of the three levels of competitors listed above. We have assumed a variety of consolidation scenarios in order to calculate total supply in the solar industry in 2010. Chart 3.3 depicts likely total solar supply for 2010, as well as total solar supply under different and less likely industry consolidation scenarios.

Chart 3.3 Total Solar Supply, World Markets: 2010



(Source: Pike Research)

Note that Pike Research expects total solar supply to exceed 18 GW in 2010. This forecast is based on the following conclusions:

- We believe that the top competitors we have listed will indeed take market share and fill available capacity to greater than 90% utilization in the first half of 2010.
- Because of high utilization in the first half of 2010, top competitors will execute manufacturing line expansion plans as already announced, thus adding significant additional capacity in 2H 2010.
- Not to be outperformed, emerging companies with a competitive advantage will also win capital support and add capacity.
- Likewise, existing competitors with advantages of scale and, in many cases, readily available sources of capital, will also probably continue to add capacity (much of which could be in Asia).
- Similarly, many cell/module companies with an existing advantage of low-cost manufacturing could reasonably expand production, particularly in China, where capital for new production that will employ people seems to be more available.
- Many marginally competitive companies have devised plans for improvements in product performance (particularly efficiency), market share gain, and bolstering their presence in growing markets (primarily the United States, Italy, and EU countries). While these plans are sometimes unrealistic, they will in many cases spur investment in new manufacturing capacity.
- Because admission by management that their company is struggling is often difficult, even poorly competitive companies will maintain capacity and even add capacity on occasion.

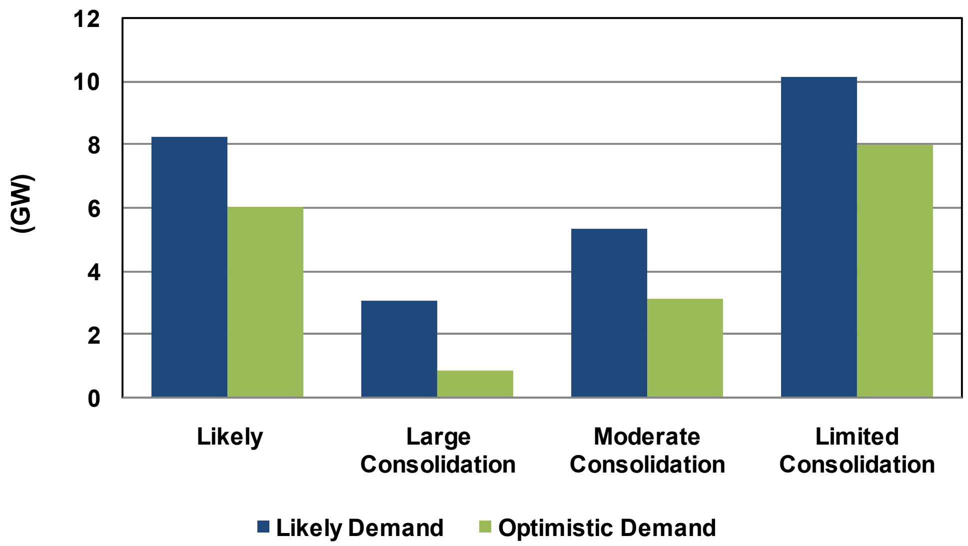
We have also examined total solar supply in other less likely conditions in the case that the consolidation of marginally competitive companies is more or less severe than expected. Pike Research has estimated total solar supply if the consolidation of marginally competitive companies is:

- Much larger than we currently expect, driven by a more severe demand decline in 2H 2010, primarily in Germany, Italy and the United States.
- Moderately larger than we currently expect, again driven by demand decline that is larger than we believe will actually occur.
- Limited or less than we currently expect. As evidenced by the small number of companies that actually left the solar market in 2009 (a very difficult year) this scenario has a reasonable probability of recurring in 2010.

As stated previously, Pike Research forecasts that worldwide solar demand will probably be about 10.1 GW. It is possible, however, that demand could exceed 12 GW. Given the above supply scenarios, a reasonable question that is often asked is: How much inventory will be built in 2010?

As shown in Chart 3.4, Pike Research believes the most likely scenario is that the solar industry will grow finished goods inventory (FGI) and work in process inventory (WIP) by 6.1 to 8.3 GW in 2010. Under the different supplier consolidation scenarios described above, inventory growth could possibly grow by between 0.9 and 10.1 GW. However, the odds of the latter inventory expansion are, in our estimation, relatively low.

Chart 3.4 Total Solar Supply, World Markets: 2010



(Source: Pike Research)

In any case, we forecast that the solar industry will experience very large inventory growth in 2010. Such growth will most likely lead to inventory cost write-downs that will result in negative margins and increased chances of further consolidation in 2011 and beyond.

However, the solar industry will emerge from 2010 with a much stronger supply chain and prospects of reaching grid parity in many regions by 2013. In fact, Pike Research expects solar projects to be justified by reasonable ROI with a few incentives by 2014 at the latest and as early as 2013 for much of the world.

Which companies and technologies will survive consolidation and lead solar industry growth in 2010 and beyond? Pike Research analysis suggests that several market drivers have determined company/technology success in the past and will likely continue to do so in the future. Moreover, a few new market drivers will increasingly define which companies and technologies offer the best value propositions and therefore which companies will grab market share in 2010 and beyond. We discuss these market drivers in the next section.

Section 4
COST PER WATT

4.1 Low Cost per Watt is Now the Primary Competitive Differentiator

In the new solar market unconstrained by poly supply, low-cost manufacturing (generally measured in cost per watt) has become the major factor in determining competitiveness and market leadership. One key point must be emphasized with respect to $/W: cell and module efficiency must be considered in combination with low $/W to derive total installed $/W (and consequently project ROI). Single-junction a-Si thin film modules, for example, provide very low $/W but only deliver about 6% efficiency. Relative to the 11.1% efficiency CdTe modules produced by First Solar, about 60% more single-junction a-Si module area is required to generate the same power output of an installation. In addition, for large installations, a-Si installations would require about 40% to 60% additional BOS costs. Thus, though low $/W is the major factor in determining the competitiveness of a technology or company, it must not be considered alone.

First Solar enjoyed phenomenal growth and became the world's largest solar module manufacturer in 2009 – largely as a result of its industry-leading low $/W (currently at $0.81/W and projected to drop to $0.75/W by the end of 2010). Moreover, the market share gain earned by low-cost Asian module manufacturers in 2009 provides ample evidence of how important low $/W has become.

Low $/W cell/module manufacturers offer several common competitive differentiators, including:

- Manufacturing in low-cost countries, including Taiwan, Malaysia and the Philippines, as well as most of China
- Low-cost materials, primarily low-cost poly
- Lower-cost, better controlled processes (termed non-silicon cost in the case of c-Si module manufacturing)
- Economies of scale

4.2 Low-Cost Countries Lead the Way

A quick review of the world's leading solar cell/module manufacturers demonstrates the importance of manufacturing in low-cost countries. Pike Research analysis and estimates of module shipments in 2009 reveal that 13 of the top 17 cell/module companies manufacture largely in low-cost countries.

First Solar, the industry's largest module producer, manufactures modules in Ohio and in Germany and intends to add lines in France and China in the next 2 years. However, the bulk (about two-thirds) of its production is in Malaysia. Similarly, U.S.-based SunPower manufactures c-Si modules in the Philippines and through tolling agreements with Jiawei in China. Suntech Power, Yingli Green Energy, JA Solar, Trina Solar, and a few more of the solar market's lowest-cost manufacturers produce c-Si modules in China. These manufacturers are taking advantage of China's low labor cost, favorable tax structure (often enjoying no tax at all), and readily available low-cost capital.

Taiwan, home of many of the world's largest and most cost-effective semiconductor fabs, has now developed a thriving solar manufacturing industry. Motech and Gintech, two of the solar industry's largest cell manufacturers, are based in Taiwan and enjoy low-cost labor, buildings, and infrastructure, as well as capital availability. Additionally, E Ton, Neo Solar Power, and DelSolar make cells and/or modules in Taiwan. In short, Taiwan looks to have gained ground in 2009 as a leading contender for cost-effective solar manufacturing.

Q-Cells, the number one solar manufacturer in 2007 and 2008, started manufacturing in Malaysia in 2008. To reverse enormous losses (an astounding €1.356 billion net margin loss) in 2009, Q-Cells announced plans (as part of its "Q-Cells Reloaded" program) to greatly accelerate the move of manufacturing from Germany to Malaysia in order to regain competitive $/W.

Of the top 17 manufacturers, Sharp, Sanyo, and Kyocera produce cells/modules in a relatively expensive country, Japan. However, they too are moving to reduce $/W in other ways to compensate for a labor cost penalty.

As further evidence of the importance of low-cost manufacturing, Evergreen Solar closed its string ribbon silicon module production in Devens, Massachusetts in favor of making modules through a tolling arrangement with Jiawei Solar located in Wuhan, China. This move is not surprising since Evergreen's module cost, as reported by industry sources, topped $2.20/W in 2009.

One final note with respect to low-cost manufacturing: prospects of tax and other financial incentives that require local content (such as the new FIT in Ontario, Canada) could drive some manufacturing to higher-cost countries, including the United States. Moreover, increasing sentiment to "buy American" and political pressure to spend tax dollars only if such expenditure adds U.S. jobs could also force some solar manufacturing to move to the United States. Recent moves such as Suntech's establishment of a facility in Goodyear, Arizona, Canadian Solar's new facility in Ontario, and Yingli's rumored facility in Austin, Texas, underscore the likelihood that some solar manufacturing will be driven to the United States and Canada.

Pike Research analysis suggests that producing modules (but not c-Si cells) in the United States or Mexico will increasingly make sense. C-Si modules are bulky, heavy, and fragile relative to cells. Consequently, c-Si modules cost more to ship than c-Si cells. We expect this factor to drive companies to open new module manufacturing facilities or possibly execute toll manufacturing agreements with contract manufacturers in the NAFTA countries. Similarly, module production in facilities located in low-cost EU countries has already started and will probably grow in 2010 and beyond.

4.3 Low-Cost Materials

With poly spot price dropping from a high of about $400/kg in 2Q 2008 to less than $50/kg in 1Q 2010, many c-Si cell manufacturers enjoyed substantially reduced materials costs in late 2009. However, most c-Si manufacturers also negotiated long-term, take-or-pay poly contracts in 2008. These contracts made business sense at the time when wafers and poly were expensive. Today, though, the contracts carry a price penalty (some pundits say price "hangover") in light of the poly cost plunge that started in late 2008. Therefore, one recent competitive differentiator is a company's ability to renegotiate poly contracts and drive to the lowest blended poly cost (i.e., weighted average of contract poly cost and spot poly cost).

Pike Research analysis found that blended poly cost varied widely by company in 2009 and will continue to be a major cost differentiator in 2010.

Even with low-cost poly, however, the most competitive c-Si cell makers have developed processes that are capable of handling thin (160-180µ or even thinner) wafers while maintaining low breakage rates. Pike Research investigations found that companies such as Yingli, Suntech, and SunPower have gained competitive advantage through a low-cost poly and wafer supply and thin wafers.

Additionally, the most competitive c-Si cell processes, according to Pike Research's industry sources, use narrower conductor metal lines on the top (sun-facing) surface of cells. These leading processes reduce the cost of conductor pastes (second only to poly cost) that are screen-printed on the front and back surfaces of cells in conventional c-Si processes. They also improve cell efficiency because fewer of the sun's photons are reflected by the metal lines and reach the cell's power-producing p-n junction. Other leading low process cost manufacturers are now employing entirely different methods of forming cell conductors. For example, an increasingly used process deposits a very thin, narrow conductive layer on the surface of the cell and then forms the bulk of the conductor using an inexpensive plating process.

In TF manufacturing, cadmium and tellurium (the base materials for CdTe processes such as those of First Solar and Abound Solar) are inexpensive when compared to the base materials required for CIGS processing. Cd and Te are available from low-cost mine tailings. True, great care in handling elemental Cd must be taken since it is a known carcinogen (though the compound CdTe most likely is not).

4.4 Low-Cost Processes

Probably the largest differences between current CdTe processes and CIGS processes are process uniformity and throughput. Although CIGS technology inherently offers higher efficiency as a matter of physics (because it provides a larger band gap) the process of uniformly depositing layers for CIGS modules is much more complex. In addition, control of the interactions between the four CIGS elements has proven to be much more difficult than originally expected. As a result, CIGS module makers have struggled to attain uniformity sufficient to reach efficiency targets while at the same time achieving throughput that could drive processing cost to be competitive with CdTe processing. This CIGS process uniformity and control issue alone could result in the closure or consolidation of many of the twenty-plus CIGS module manufacturers.

In the case of c-Si manufacturing, the most competitive manufacturers have:

- Increased throughput per line via many process improvements and engineering breakthroughs
- Adopted semiconductor-process-like controls to shrink yield loss and minimize bottlenecks
- Reduced $/W by using low-cost manual labor instead of expensive machines for certain processes such as loading/unloading of process tools and connecting cells in series to form strings of cells (known as the "stringulation" process when a process tool is used)

The measure of low c-Si process cost is commonly termed "non-silicon cost" or the total cost to produce a cell and module excluding the cost of poly, ingots, and wafers. Pike Research's analysis indicates that non-silicon cost varies widely between c-Si companies and therefore is a significant competitive differentiator. Companies with the lowest non-silicon cost include Trina Solar and Yingli Green Energy. These companies currently boast of industry-leading non-silicon costs. Pike Research forecasts by company, however, suggest that these process cost leaders will probably face competition from other companies in 2010.

4.5 Economies of Scale

The cost advantages from large-scale manufacturing are straightforward. Large solar companies are able to manufacture many more MW of cells/modules to dilute fixed costs more effectively than small solar companies. Additionally, large companies have more clout when negotiating materials contracts, broader market presence, larger R&D budgets, and access to specialized people, tools, and other similar benefits.

4.6 Cost Measurement

Today, the gold standard for measuring project return is levelized cost of energy (LCOE). Not surprisingly, LCOE is referenced by companies with the most competitive cost/efficiency combination, as well as in trade press articles, webinars, and other discussions of project ROI. LCOE has become the de facto standard measure of ROI for power generation from different solar technologies and, more importantly, for large commercial and utility-scale solar projects.

Fundamentally, LCOE is:

- The net present value of all costs of installing and operating a solar project (or other energy producing project) project DIVIDED BY:
- All of the energy (electricity in the case of solar projects) generated by the project during the project's life (generally 20 to 25 years)

LCOE provides the best way to compare the ROI between technologies, financing options, and project plans IF module costs, BOS costs, development costs, interest rates, tax rates, system maintenance and degradation, and a host of other assumptions are included and reasonable. In short, "the devil is in the details" with respect to LCOE calculations.

Consequently, careful attention to details and assumptions must be made when depending on LCOE to weigh options or project returns. Similarly, accepting the LCOE claims of a cell/module maker or as derived for a given project requires careful scrutiny of assumptions. Pike Research recommends that such scrutiny be performed by a competent, independent third party.

Section 5

MODULE EFFICIENCY

5.1 The Importance of Efficiency

Module efficiency is the key measure of module performance. Basically, it measures how much electrical energy is generated per amount of solar energy impinging on the front surface of the module. As noted previously, module efficiency and cost per watt must be considered together for a given application when assessing which modules will provide the best value for the application.

For example, space-constrained applications often require high-efficiency modules (even at higher cost) because the application needs maximum power output per module area. On the other hand, utility-scale and large commercial projects with large acreage usually consider project ROI as the main criterion for selecting a module provider. In this case, low-cost modules with good (but not the highest) efficiency are often designed in. Yet, high-efficiency modules with modestly higher cost are also often selected for utility-scale projects because they require less land and BOS costs for a project power output.

5.2 Efficiency of Today's Modules

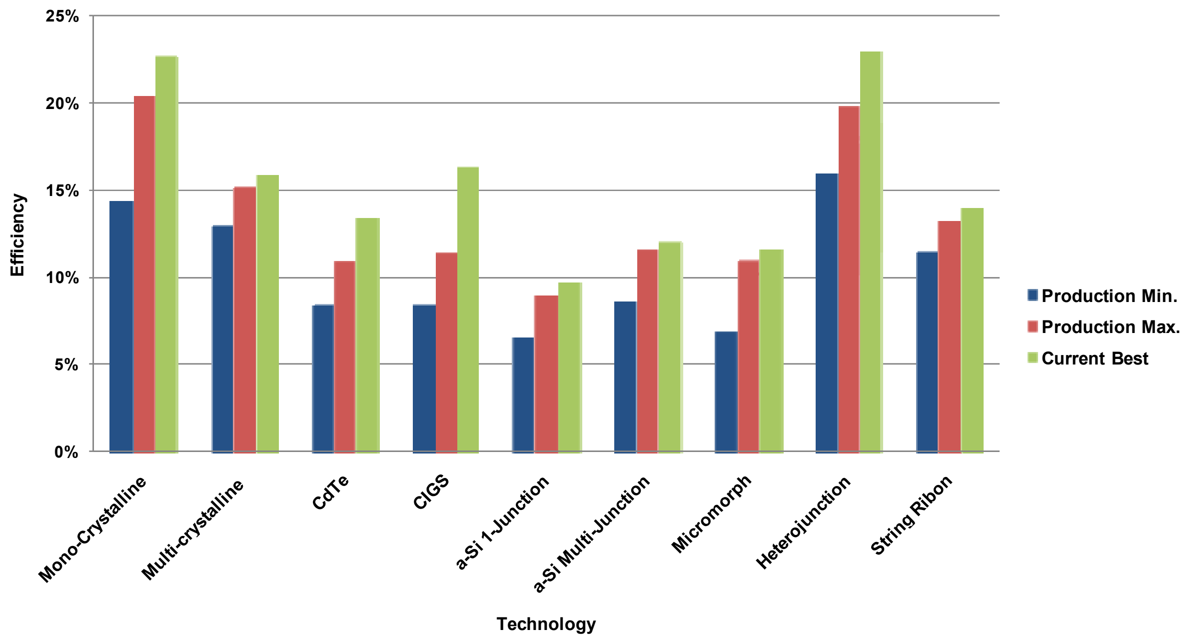
Module efficiency varies widely by technology. The solar industry was founded on c-Si technology, and c-Si processes have improved substantially over the course many years. Not surprisingly, c-Si technology provides the highest efficiencies of modules in large-scale production. Thin film technologies include CdTe, CIGS, a-Si, and a few other technologies with tiny market share or that are in development. Two other hybrid technologies that feature a combination of crystalline and thin film technologies provide promising module efficiencies and should be considered in any review of module efficiencies. These include micromorph technology (based on a process developed by Oerlikon) and Sanyo's HIT (heterojunction with intrinsic thin-layer) technology. Finally, a unique technology from Evergreen Solar called "string ribbon" should be considered because it features an interesting c-Si-like technology that employs extruded silicon cells rather than wafers.

Additionally, module efficiencies vary significantly within each technology category depending on the particular process employed by a company. Crystalline silicon module efficiencies, for example, currently vary from 12% to almost 20% depending on the wafer types used (semiconductor-like mono-crystalline or multi-crystalline) and on the process used to form conductors. Some companies enjoy advantages of scale and can afford the R&D to advance the efficiency of their cells/modules. Other companies are able to deliver only average or typical efficiencies in the cells/modules that they produce. Interestingly, several companies provide "target efficiencies" or goals for improvement of efficiency in the next few years instead of specifying a specific efficiency for their modules.

Pike Research has summarized the current range of efficiencies that are currently offered by technology in Chart 5.1. Based on a review of modules by company for a given technology, Chart 5.1 provides a minimum and a maximum efficiency commonly available from modules in large-scale production. Note that solar cells that do not meet a minimum efficiency standard are often scrapped or sold at a low price for inexpensive consumer applications such as patio lights.

In addition, based on a search of leading companies for each technology, we have provided the "current best" or target efficiency for the technology that could reasonably be reached in the next year or so.

Chart 5.1 Module Efficiency by Technology



(Sources: Pike Research and company reports)

Several salient points from Chart 5.1 should be mentioned. First, even though the basic physics of CIGS technology provides a potential efficiency advantage over CdTe technology, this advantage has not been realized in actual production modules. Also note that a few one-junction a-Si modules in production feature 9% efficiency; the vast majority, however, continue to provide only about 6% efficiency. In the case of mono-crystalline modules, maximum efficiencies are generated by SunPower's modules, which use semiconductor-like processing to form conductors on the back side of wafers so that no sunlight is reflected by topside conductors. Lastly, Evergreen's string ribbon technology modules only deliver 11.5% to 14.0% efficiency and therefore must be manufactured at much lower cost in order to be competitive.

5.3 Module Efficiency Alone Does Not Define Which Modules Win Orders

Given the picture of module efficiencies in Chart 5.1 above, one could reasonably believe that mono-C and Sanyo's HIT modules should be taking market share and winning revenue at the expense of TF modules. Yet, this is not the case. CdTe modules (particularly the 11.1% efficiency modules from First Solar) have taken market share from c-Si modules. Meanwhile, HIT modules, though they continue to hold promise, have not yet penetrated ROI-sensitive markets. This is because the $/W of the two high-efficiency technologies is substantially higher than the $/W of CdTe. In short, the $/W of those two technologies overwhelms their efficiency advantage when project returns are calculated.

Additionally, multi-junction a-Si module manufacturers suggest that another efficiency-like measure of module performance measure is as important as traditional efficiency. Multi-junction a-Si cells are designed so that they absorb a broader spectrum of sunlight and thus are capable of generating more kilowatt-hours (kWh) for a given module rating (watts generated at peak sunlight conditions, or Wp). As a result, multi-junction module makers rate module performance in kWh/kWp.

Finally, residential and BIPV applications frequently require other cell and module features that supersede efficiency as a differentiator. Given their limited financial resources, homeowners will often choose the lowest-cost modules or solar shingles for power generation at the sacrifice of efficiency. In addition, for many residential and BIPV applications, eye appeal and solar modules or tiles that are invisible to the casual observer (i.e., because they blend into the architecture of a building) are primary differentiators – with efficiency a secondary concern. A few companies, such as Global Solar and UNI-SOLAR, have recognized BIPV as a lucrative solar market niche and have focused their products and resources exclusively on BIPV.

Section 6

SUPPLY CHAIN INTEGRATION

6.1 Delivering Power, Not Just Modules

First Solar is a leader in moving down the supply chain to supply power, not just cells or modules, in order to increase revenue and market share. This is exemplified by the manufacturer's acquisition of Optisolar, a developer of utility-scale projects, Turner Renewable Energy, a provider of engineering, procurement, and construction services (EPC), and now Nextlight Energy as mentioned above. First Solar also partners with providers of financing and many utility-scale project developers and systems integrators such as EDF, enXco, and Juwi. The net result is that First Solar offers a complete package (i.e., one-stop shopping) to a utility company or independent power producer (IPP).

Similarly, SunPower acquired U.S.-based Powerlight in 2006, and Solar Sales in Australia in 2008, to enter the business of solar project engineering and development. These acquisitions, as well as SunPower's project financing deals with Wells Fargo and a few credit unions for residential projects, have enabled the manufacturer to provide an attractive package of capabilities and resources that have driven its revenue growth.

6.2 Providing "One-Stop Shopping"

Especially for large commercial and utility-scale projects, providing one-stop shopping for the end user will increasingly become a significant competitive differentiator. Companies that offer their customers (especially utilities) not only solar modules, but also project development services, supplies of BOS components, permitting services, and financing provide a complete package to bring projects to reality. Such a complete package obviates the customer's need to provide these services themselves. This compelling value proposition enhancement will become a key indicator of competitive success.

Pike Research expects other module manufacturers that move down the supply chain and add project development partners, EPC, and financing partners to join First Solar and SunPower as companies that will grow in revenue and (eventually) margins. Suntech Power and Yingli Green Energy have reportedly led the way for Chinese module manufacturers in moving down the supply chain, and we anticipate many of the most competitive companies will do likewise.

Section 7

EMERGING COMPETITIVE DIFFERENTIATORS

7.1 Market Presence in Large and Emerging Markets

In the past, a strong market presence in Germany, Japan, Italy, and (at least for a year) Spain was generally sufficient to ensure strong revenue growth. In the new solar market, however, the most competitive cell and module manufacturers must, in Pike Research's view, establish strong brand recognition and sales/marketing teams in Italy, the United States (particularly California), China, France, South Korea, Canada, and many smaller EU countries. Notably, strong market presence also builds residential customer confidence and substantiates the trustworthiness of warranties.

7.2 Strong Balance Sheets and Internal Financing of Growth

As demonstrated by recent reports from First Solar, Suntech Power, Trina Solar, and Yingli Green Energy, the most competitive companies tend to be able to finance a substantial part of their growth through capital available from internal sources. While this differentiator is often related to the scale advantage of larger companies, a few smaller companies have also been able to succeed via internally financed growth.

7.3 Module Manufacturing in NAFTA and Low-Cost EU Countries

In addition to Suntech's new facility in Goodyear, Arizona and Yingli's reported plan for a new facility in Austin, sources indicate that other companies are planning to build modules in the United States, Mexico, and Canada through tolling agreements with ODMs, as well as company-owned manufacturing lines. Manufacturing modules (but not cells) close to end markets makes sense because it enables a company to reduce the costs of shipping the bulky modules, facilitate the customization of modules for an application, and meet the local content requirements (such as in Ontario, Canada's latest FIT) anticipated for many future incentives, especially in the United States.

Additional leading module manufacturers are also reportedly considering manufacturing in Poland or other low-cost EU countries to reduce shipping costs and avoid potential moves, especially in Germany, to restrict or limit modules imported from outside of the EU. Pike Research will be watching for additional indicators of this move to build modules close to end markets, as we believe this will be a market differentiator in 2010.

Section 8

ACRONYM AND ABBREVIATION LIST

Amorphous Silicon	a-Si
Average Selling Price	ASP
Balance of System	BOS
Building Integrated Photovoltaic	BIPV
Cadmium Telluride	CdTe
Compound Annual Growth Rate	CAGR
Copper Indium Gallium Selenide	CIGS
Cost per Watt	$/W
Crystalline Silicon	c-Si
Engineering, Procurement, and Construction	EPC
European Union	EU
Feed-in-Tariff	FIT
Finished Goods Inventory	FGI
Gigawatt	GW
Heterojunction with Intrinsic Thin Layer (Sanyo)	HIT
Independent Power Producer	IPP
Kilogram	kg
Kilowatt-Hour	kWh
Kilowatt-Peak	kWp
Levelized Cost of Energy	LCOE
Megawatt	MW
Micron	μ
Millimeter	mm
Mono-Crystalline	mono-C
North American Free Trade Agreement	NAFTA

Original Design Manufacturer	ODM
Polysilicon	Poly
Positively Doped-Negatively Doped	p-n
Renewable Portfolio Standard	RPS
Research and Development	R&D
Rest of Europe	ROE
Rest of World	ROW
Return on Investment	ROI
Thin Film	TF
Venture Capital	VC
Watt	W
Watt-Peak	Wp
Work in Process	WIP

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SOURCES AND METHODOLOGY

Pike Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Pike Research's analysis is primary research gained from phone and in-person interviews with industry leaders, including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Pike Research's analysts and the firm's staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Pike Research's reports. Great care is taken in making sure that all analysis is well supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

Pike Research is an independent market research firm whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. The firm is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

NOTES

CAGR refers to compound average annual growth rate, using the formula:

CAGR = (End Year Value ÷ Start Year Value)$^{(1/steps)}$ – 1.

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2010 U.S. dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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