THOMAS J. STEENBURGH
ALISON BERKLEY WAGONFELD

Nanosolar

It was February 2009, and Nanosolar CEO Martin Roscheisen stopped to talk with a materials scientist as he walked through his company's thin-film solar manufacturing facility adjacent to its corporate headquarters in San Jose, California. Roscheisen was pleased to hear that the latest batch of solar cells produced using Nanosolar's proprietary low-cost, high-speed manufacturing process was performing well in field tests. Nanosolar was on track to have solar modules ready for installation by the end of 2009, and the company was receiving product inquiries on a daily basis from around the world. The company expected to be one of the first solar manufacturers commercializing panels using copper indium gallium (di)selenide (CIGS) technology.

Roscheisen was scheduled to meet with Brian Stone, vice president of product management, later that afternoon to discuss the company's sales and pricing strategy. The Nanosolar executives believed that the company's solar manufacturing process would yield products with lower costs per kilowatt hour (c/kwh) than those offered by other solar companies. In fact, Nanosolar hoped to achieve cost parity with fossil fuel based energy within several years, without the benefit of subsidies. Roscheisen and Stone believed that Nanosolar's cost advantages would allow flexibility with respect to pricing and customer selection; however, the executives were still debating the merits of several different growth plans. On one hand, it made sense for Nanosolar to focus exclusively on the European markets (e.g., Germany, Spain and Italy) that had Feed-in-tariff (FIT) plans with fixed pricing for solar. Those markets would enable solid margins and a steady flow of business. But at the same time, markets with subsidies obfuscated Nanosolar's cost advantage. Perhaps Nanosolar should price aggressively in the United States and try to jumpstart the nascent solar market in America. Roscheisen was eager to talk though the issues with his colleagues, as he knew that Nanosolar's pricing and sales strategy would have ripple effects on all parts of the organization.

Solar Industry Overview

Solar Technologies

Scientists have struggled for decades to establish a cost effective process to convert sunlight into energy. As of early 2009, two broad categories of solar technologies dominated the industry:

Professor Thomas J. Steenburgh and Alison Berkley Wagonfeld, executive director of the HBS California Research Center, prepared this case. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

photovoltaic (PV) and solar thermal. (Nanosolar competed exclusively in the market for photovoltaic systems.) In 2008, solar energy represented approximately 0.5% of all energy consumption around the world. (See **Exhibit 1** for worldwide energy usage by source.)

Photovoltaics represented the fastest growing category of solar energy. All photovoltaic systems involved solar cells that converted sunlight directly into electricity. Solar cells were made out of semiconductors (and other materials) that absorbed energy from light and converted that energy into a current that could be captured and channeled for productive purposes. Individual solar cells were grouped together and packaged in weather-proof cases known as solar modules. Modules were then combined into arrays that could be connected to existing electricity grids or remain "off-grid."

Within the broad category of PV solar electricity, there were many different technologies offered worldwide. The most widely used PV technology relied on crystalline silicon (c-Si) as the key semiconductor material in each solar cell. Solar cells with c-Si were introduced in the 1980s and continued to represent over 90% of installed capacity. This technology used relatively large quantities of polysilicon in thick modules, which was considered efficient relative to other solar technologies because c-Si modules converted approximately 13% to 19% of sunlight into electricity. These efficiencies were considered high, and c-Si was often seen as a desirable product for space-constrained installations.

During the early 2000s, companies began commercializing a new category of PV electricity known as "thin-film photovoltaics." Thin film panels could be manufactured less expensively than c-Si panels because they required substantially less raw material. In addition, thin-film panels were lighter weight and easier to transport. However, thin-film modules were less efficient with 10-15% conversion rates. As a result more panels, sunlight and land were required to generate the same amount of electricity. Within the thin-film PV category, there were several technologies in the market based on the type of semiconductor material used: cadmium telluride (Cdte), copper indium selenide (CIS), copper indium gallium (di)selenide (CIGS), and amorphous silicon. Of these, cadmium telluride had the highest penetration in the field in early 2009, as it was the technology used by the largest thin-film manufacturer, First Solar. There were several CIGS startups (including Nanosolar) that were rolling out their first set of products in 2009.

Solar thermal energy referred to the process of converting sunlight into heat. In small-scale applications such as swimming pools and residential hot water systems, this technology was considered relatively easy and inexpensive to install and operate. At the other end of the spectrum, solar thermal energy was used in utility-scale systems in which sunlight was concentrated via mirrors and lenses in a process known as concentrating solar power (CSP). CSP systems were capital intensive and complex, and the output was typically in the form of heat or steam that could be stored for short periods of the time. The steam from CSP systems could be used to power turbines in electrical plants as a substitute for burning coal to generate steam.

Supply Chain and Customers

The typical PV solar supply chain started with raw materials produced by large silicon suppliers, primarily based in Asia. The silicon was then converted by these suppliers or cell manufacturers into wafers that could be used in cells. Some solar cell companies sold the cells to module manufacturers (primarily located in Asia and Europe), while others made their own modules. Completed modules were typically sold or transferred to retailers or systems integrators that installed systems for residential, commercial or utility customers. (See **Exhibit 2** for estimated 2009 "on grid" solar market demand for residential, commercial and utility projects.)

Residential - Most residential customers purchased panels from a local retailer, and the retailer helped connect those panels into the customer's regional utility. A typical residential system in the U.S. generated two to five kilowatts of electricity and ranged in price from $20,000-$35,000 depending on the size of the system. Most states offered some form of rebate to offset the initial price, and as of early 2009, some of the large installers were starting to provide monthly financing plans in the U.S.. A few companies were starting to make do-it-yourself solar installation kits that could be installed by homeowners, but nearly all residential users required the help of a professional installer to connect the roof top panels into the local electrical grid.

Commercial customers were becoming an increasingly important category for solar manufacturers and installers, as businesses sought to reduce electricity expenses and carbon footprints. Many large chain stores, grocery stores and big-box retailers such as Wal-Mart, Safeway and Whole Foods were experimenting with installing roof-top panels, particularly in states that offered incentives. Some retailers bought their own systems that cost approximately $4 million to $6 million per store, while others partnered with a utility company to share the expenses.[i]

Utilities around the world were experimenting with solar electricity in different ways. Some utilities were building their own solar capabilities while others worked with systems integrators that in turn worked with the solar manufacturers. Systems integrators were particularly important in the European market where they were involved in finding available land, arranging for permits, selecting panels and components, hiring building subcontractors, arranging for financing and ensuring connectivity with utilities. If a solar manufacturer wanted to sell products to utilities in Europe, the company typically developed relationships with system integrators that had a track record in that market. However, company executives predicted that when feed-in tariffs expire, European utilities would ultimately buy panels directly from manufacturers and hire integrators for installation services and mounting hardware. In the U.S., solar manufacturers worked directly with regional utilities such as Pacific Gas & Electric (PG&E), while also starting to develop relationships with the nascent industry of U.S. solar systems integrators. Solar manufacturers also sold directly to regional U.S. firms that marketed solar "solutions" to residential and commercial customers.

Worldwide Solar Production and Capacity

Worldwide demand for solar photovoltaic panels reached 5.95 gigawatts (GW) in 2008, a 110% increase over 2007. [ii] (See **Exhibit 3** for definition of gigawatts and other common solar measurements.) European demand accounted for 82% of the market, with Spain and Germany dominating the European market. (See **Exhibit 4** for 2008 solar demand by country.) The United States represented the third largest market, followed by Korea, Italy and Japan.

Solar cell production nearly doubled from 2007 to 2008, reaching 6.85 gigawatts. Approximately 13% of the production came from thin-film technologies, representing the largest growth area in the industry. Industry analysts noted that the solar industry added significant manufacturing capacity in 2008, primarily in c-Si production lines; however, this happened just as the international economy deteriorated. It became increasingly difficult to obtain financing for energy projects, and worldwide demand for c-Si panels dropped during the fourth quarter of 2008. Inventory levels increased throughout the supply chain, and average selling prices for c-Si modules dropped sharply from October 2008 through March 2009.[iii] (See **Exhibits 5a and 5b** detailing the c-Si supply chain and price trends. Exhibit 18 and 19 from MS Report March 24, 2009) Research analysts believed that many of the c-Si manufacturing companies would suffer as the industry worked through a period of overcapacity and cost improvements. Analysts anticipated that the credit markets would start to thaw during the second half of 2009, and demand for solar panels would resume its growth by the end of 2009. However, Nanosolar still expected that 2009 would represent a market contraction compared to 2008.

Nanosolar Background

Nanosolar was founded in Palo Alto, California in 2002 by two former Stanford PhD candidates, Martin Roscheisen and Brian Sager. (See **Exhibit 6** for management bios.) Roscheisen and Sager were focused on developing the lowest cost manufacturing process for solar energy, based on their belief that when government incentives subsided, the low cost players would win. The founders raised an initial round of financing of $3 million led by Benchmark Capital in late 2002, and they began investigating various technologies that could drive down the prices of solar panels. Roscheisen recalled that the Series A funding was remarkable in that, "Silicon Valley was still emerging from the dot-com fallout, and most investors were wary of investing in manufacturing companies. However, we managed to raise money because our investors believed in our approach to the solar market."

Roscheisen and Sager spent the first half of 2003 researching different materials, primarily in the thin film category. Roscheisen explained, "We knew thin film was about half as efficient as c-Si in terms of converting sunlight into power, but if the materials were 10x cheaper, then it would still cost less per watt of power delivered." Nanosolar eventually settled on a manufacturing process that involved printing silicon particles on aluminum using a proprietary nanoparticle CIGS ink. Nanosolar believed its printing method would be at least 100x faster at commercial production levels than the vacuum deposition process used by most solar panel manufacturers.

In June 2005 Nanosolar raised $20 million in a Series B financing led by Mohr Davidow Ventures; bringing the total amount raised to $37 million. The company raised another $75 million in 2006 from strategic investors and investment firms, followed by $300 million in 2008 from strategic investors including Advanced Energy Systems (AES) Corporation, a global power company; the Carlyle Group, an investment firm; EDF Energy, a large electric utility based in France; and Energy Capital Partners, an investment firm. The 2008 Series D financing represented the largest financing ever completed by a solar start-up, and Nanosolar management anticipated that it had all the funding it needed to build out the business until profitability. Nanosolar was also supported by the Department of Energy which awarded $35M of R&D grants accelerate the U.S. solar industry's ability to generate electricity less expensively than fossil fuels, termed "grid parity".

An important outgrowth of the Series D financing was the supply agreements signed by strategic investors. Nanosolar's cumulative contractually committed revenue at the conclusion of the Series D was more than $4B in multi-year agreements. This would allow Nanosolar to aggressively ramp production while investigating expansion into new product segments and geographies.

As of March 2009, Nanosolar had approximately 250 employees, nearly all of whom worked directly in technology and manufacturing. About 200 operated in the U.S. cell manufacturing facility while 50 were required in the module assembly facility in Germany. Roscheisen explained, "At this stage, our primary focus is ramping up our production. We have only one sales and marketing executive at our headquarters in San Jose and one in our Swiss operation because we have already sold the bulk of our production capacity for the next couple of years."

Nanosolar Business Overview

Products and Manufacturing

Nanosolar was developing two product types in 2009: Nanosolar SolarPly foil and Nanosolar Utility Panels. The production process for both products started at the company's 200,000 square foot plant in San Jose, California. The first step involved creating the nanoparticle CIGS ink. Next, a custom-built machine printed the ink on rolls of aluminum foil using a fast printing technique called roll-to-roll processing. After the entire roll was covered with the CIGS ink, the foil was treated in a series of heating and chemical processing steps by a set of custom-built machines. The next step involved cutting the foil, either into rectangular cells (approximately one square foot in size) or strips that could be sold as SolarPly foil. Alternatively the foil would be used for Nanosolar's panels.

Nanosolar tested all completed cells and strips to determine their performance characteristics such as voltage, current, and total efficiency. Individual cell performance varied based on the distribution of the CIGS ink as well as the uniformity and consistency of subsequent treatment steps. The company achieved sunlight-to-electricity efficiencies as high as 16% in lab tests with the National Renewable Energy Lab (NREL), and it hoped to achieve efficiencies in the range of 9-11% in its commercial products in 2009.[iv] The rectangular cells were batched based on efficiency, as Nanosolar believed it could sell its modules with higher efficiencies at a premium price. The cells were packaged in stacks of 1,000, then sealed and flown from California to Nanosolar's 500,000 square foot assembly plant in Germany. At the German plant, Nanosolar's cells were converted into functioning modules by connecting groups of 84 cells together in a 14 cell by 6 cell matrix and encapsulating them between two sheets of glass. The glass provided watertight protection, as the CIGS semiconductor would deteriorate in moist environments. Nanosolar had the flexibility to create panels of different sizes, although it planned to start production with panels measuring 2 meters x 1 meter which would represent one of the larger thin-film panels on the market which would provide a competitive advantage in field mounting. Roscheisen shared his thinking about locating the assembly plant in Germany, "Glass modules are expensive to ship, both due to their weight and the careful handling involved. Because the majority of our initial installations will be in Europe, we have decided to keep our costs down by locating the encapsulation step of the process closer to our end users. It can cost a few cents per watt to ship panels around the world." Nanosolar planned to have 700MW of capacity at the completion of its factory build-outs in the U.S. and Germany during 2010.

Costs

From the beginning, Nanosolar focused attention on reducing every cost associated with developing, manufacturing, installing and operating its products. The company developed a method of combining the chemicals in its CIGS ink that allowed it to use aluminum foil as its base because it was $1 per square meter—a substantial discount to materials such as stainless steel (at $15/ square meter) often used by other PV companies. Nanosolar also focused on materials utilization to avoid waste, and the company believed it achieved 95% utilization while competitors were closer to 60-70% utilization. In addition, the company experimented with different types of components used in the "balance of system" (BoS) so that each part of the system was optimized for cost of electricity for the entire operation. For example, Nanosolar's panels were designed to need 25% less mounting equipment, 90% less electronic cabling and 30% less time to install than other leading solar products on the market. Collectively, Nanosolar estimated these cost decisions allowed users to save 25% in BoS costs relative to competitive product offerings. In an average thin-film solar installation, solar modules comprised approximately 50% of costs with the balance of system making up the other 50%.

Photovoltaic solar panels were priced at a cost per watt, and Nanosolar was working toward a target production cost/watt of $0.60/watt by 2010. This cost would be 40% below the lowest cost competitive modules available (~$1.00/watt) in early 2009. The company believed it could hit this target once its plants were operating near capacity and the costs of the capital equipment could be allocated across all of the output. Roscheisen explained, "We had a PhD here that built the most detailed cost analysis model I have ever seen. We evaluate detailed costs like consumable materials and electricity consumption per tool at every step of our manufacturing process. I feel very confident in our ability to achieve our target costs at each growth step of yield and capacity." Capital equipment costs represented less than 15% of Nanosolar's total costs.

Nanosolar sought to provide the lowest "levelized cost of electricity" (LCOE) to consumers based on the total cost of the power plant divided by the electricity generated as measured in kilowatts per hour over 20 years. For example, if a utility wanted to build a 1,000,000 watt (1MW) thin-film project in 2012, it would need to spend $2.00/watt to purchase the panels and the BoS. It would also need to pay for 5 acres of land at $10,000/acre and pay annual operations and maintenance of $7,500 for each of the 20 years. This would add up to $2.2 million for that 1MW project. Nanosolar estimated that the 1MW project would generate 1,850 kWh of electricity the first year, ultimately resulting in 28.9 million of kWh over 20 years assuming a 0.50% degradation in output each year. In this scenario, the LCOE would be $0.053 (cents/kWh). (See **Exhibit 7** for Nanosolar's analysis for thin-film and cSi solar systems in 2012).

Customers

Nanosolar designed its first set of panels for European power generators that sold electricity to mid-size municipalities. These municipalities typically required 1-10 MW of power and purchased this power primarily from coal burning plants.[v] Nanosolar believed this was the "sweetest spot of the market" from a comparative advantage standpoint due to its large panel size and low costs. This utility market was particularly appealing in European countries that had feed-in-tariffs because utilities were required to buy available solar electricity at set prices. This market approach also enabled Nanosolar to focus on one type of product. As Stone explained, "We have one product, ten customers and no more than 30 items in our bill of materials. This strategy allows us to reduce complexity and stay focused. Over time we will develop the sales infrastructure to focus on the commercial market as well."

In December 2007, Nanosolar announced a partnership with Beck Energy, a leading systems integrator in Germany, to build a 1 MW solar farm in East Germany on a former landfill (4.7 acres), ideally generating enough electricity to power 400 homes. Beck was selected as the first customer because it was one of the largest field integrators in the largest market. The project hit some delays related to permitting, weather and construction, and as of late 2008 it was reported in local papers that the project was 50% complete. Nanosolar was also working with Beck Energy on a 10MW PV plant in Germany that was designed to power 10,000 homes. Roscheisen commented on his company's progress in getting product to market, "Our investors and Beck Energy have told us to take our time in refining our production methods and our output. We see no reason to put products in the market until they meet all of our specifications. It is critical that we have 'bankable' products from the very beginning given how difficult it is to get financing today. We are working with Beck to optimize every part of our system before we expand any further." Nanosolar also had plans with EDF and AES, its strategic investors, to build their first projects in Southern France and Eastern Europe respectively.

Competitors

First Solar

First Solar was considered the industry benchmark for all thin-film PV companies. Headquartered in Arizona, First Solar was started in 1999. The company reached profitability and went public in 2006. In May 2009, First Solar had a market capitalization of $15 billion, and $1.2 billion of revenues and $348 million of net income in 2008.[vi] (See **Exhibit 8** for First Solar business metrics.) First Solar built panels using thin film Cdte technology through a process that involved silicon deposition directly onto glass. The company produced its first commercial modules in 2005, and it opened its first manufacturing plant in Ohio in 2006. First Solar expanded production into Germany in 2007, and in 2008, First Solar built several large production lines in Malaysia. By the end of 2009, the company expected to have seven facilities that are capable of producing over 1,000 MW of solar panels annually. (See E**xhibit 9** for First Solar's manufacturing capacity and expansion plans). The majority of First Solar's customers were in Europe, although the company had begun focusing on the U.S. market in 2008. First Solar completed two pilot projects for large U.S. utilities in 2008, and it teamed up with Solar City (one of the largest residential providers in the U.S.) to provide residential panels. It was reported in April 2009 that First Solar was providing panels for 60-70% of Solar City's residential customers in 2009, representing the first time thin-film panels were being used in a material way in the U.S. residential market. The CEO of Solar City attributed this shift to the low-cost and attractiveness of the thin black panels made by First Solar.[vii]

In February 2009 First Solar announced that it had reduced its manufacturing costs to $0.98/watt, representing the first time a solar company could produce over 1 MW of product at under $1.00/watt. First Solar announced a manufacturing cost/watt target for $0.65-$0.70 that it believed was achievable by 2012. First Solar was also focused on reducing its BoS costs, primarily driven by increasing its conversion efficiency from approximately 10% to 12%. (**See Exhibits 10a, 10b and 10c** for charts showing First Solar's "path to grid parity.") First Solar's customer pricing was not widely available, though it was believed that buyers paid an average of $2.00/watt to First Solar in 2009.

Nanosolar executives had "a tremendous amount of respect for First Solar," but believed that their company's technology would ultimately make products at even lower price points. In addition, Roscheisen explained, "Most of the large system integrators have worked with First Solar and they have told us that they would love to have another viable company to source panels from. We also believe that there will definitely be room for multiple low-cost players."

Other Thin Film Companies

Several other venture-backed solar companies were ramping up production of their own thin-film products in 2009. California-based Solyndra raised over $600 million since 2005 and started selling a tubular shaped CIGS product in 2008. The company created commercial roof-top systems that were designed to capture more sunlight through round shape modules. As of May 2009, Solyndra had announced over $1.2 billion of signed contracts. In addition, Solyndra received a $535 million loan guarantee from the U.S. government to build a second plant.

Another CIGS company, Heliovolt, had raised close to $150 million since 2005. The company was considered very promising in 2007 and 2008, but it was having a difficult time raising additional financing in early 2009. Miasole, also a California-based CIGS company, had raised substantial financing for its thin-film product offering during 2006 and 2007; however, the company laid off some employees in 2008. One article published in 2008 described CIGS as, "A seductively high efficiency potential technology with very low potential materials costs that has been just over the horizon for a decade or more . . . it has enjoyed a huge influx of capital and increase in the number of programs over the last five years. Similar to other solar thin film technologies, device complexity, effective yield, throughput, and process control issues are always the bugaboo."[viii]

Two large Japanese companies—Sharp Electronics and Sanyo—were building thin-film capabilities based on the amorphous-silicon technology platform. Both companies were building plants in Japan and planned to introduce products in the U.S. and Europe in 2009.

Nanosolar executives watched the developments at each of these other thin-film companies; however, they believed that Nanosolar was best positioned to be the low-cost leader due to its technology and manufacturing process. Nanosolar also believed that the CIGS technology could generate conversion levels that CdTe could not approach due to technical differences between the types of semiconductors. Nanosolar took extraordinary care to protect its intellectual property in order to maintain its competitive advantage. Brain Sager, vice president of corporate development, explained, "In addition to our patents, we have a collective know-how that we protect. Even if we gave someone all of our IP, they would have an extremely difficult time replicating what we do without our key engineers."

c-Si Competitors

Although demand for thin-film products was growing faster than that for c-Si solutions, the c-Si companies were continuing to expand and drive down costs. SunPower, founded by a Stanford scientist in the 1970s, was one of the first companies to commercialize solar products and sold $1.43 billion in 2008. Although the company's first quarter revenues of $214 million in 2009 indicated a dramatic slowdown in sales, SunPower announced a major project with California-based utility, Pacific Gas & Electric, to build the world's largest—250 MW—photovoltaic (PV) power plant. SunPower offered c-Si systems that delivered efficiencies of over 20%; however the expensive raw materials (particularly the silicon) kept cost/watt in the $1.50-$2.00 range. The solar industry was also expecting product expansions in 2009 from several large Asian c-Si companies. China-based SunTech Power reached 1GW of production capacity for its c-Si panels and several industry analysts expected SunTech to be the cost leader in c-Si panels.

Nanosolar believed that in spite of the higher efficiencies in cSi modules, they would not be price competitive with the leading thin-film producers because of the higher material costs. Stone explained, "From what we can tell, c-Si companies could not cover their fixed costs if they priced their panels at less than $1.20/watt." Nanosolar's LCOE analysis indicated that the LCOE disparity of 25% in 2012. (See **Exhibit 7**). However, c-Si technology had a long track record of solid performance, which was an important consideration for companies that were financing solar installations or standing behind the warranties associated with residential or commercial installations. As Randy Bishop, an executive at Verengo Solar Plus (a solar solutions provider in Southern California) explained, "When we install panels at a residential location, we offer a 25-year warranty. We want to reduce our risk of having to replace panels over time, so we tend to stick with the bigger manufacturers such as Sun Power that have years of performance data. If we selected panels from a newer thin-film company we would have to rely on simulations rather than actual performance. We find that most consumers don't have an opinion about what types of panels are on their roof, as long as they perform. "

Policy Factors Impacting Solar Pricing and Demand

Solar companies not only competed with each other, but also with other forms of electricity generation such as coal, wind, and nuclear. In nearly every region of the world, the cost of solar power in 2009 still exceeded the cost of alternatives being used (predominantly electricity generated by burning coal). For example, according to industry analysts, in the U.S. it cost $0.04/kWh to generate electricity from coal, $0.08-$0.10/kWh from wind, and $0.10-$0.12/kWh from gas. By way of comparison, it cost $0.15-$0.35/kWh to produce electricity from solar panels. In 2007 in the U.S., average residential retail prices by state ranged from $.064/kWh in Indiana to $0.241/kWh in Hawaii. The average U.S. household consumed 936kWh/month and paid $99.70/month for electricity, based on an average residential retail price of $0.107/kWh.[ix] Nanosolar believed that grid parity[x] would start with thin-film solar companies matching the costs of electricity generated from gas during peak hours. Stone elaborated:

> Peak energy usage typically happens between 12 noon and 6pm on weekdays. Gas power plants often have to fire up additional plants to cover these hours, and electricity from these plants can cost $0.11/kwh. By the end of 2009, Nanosolar will have products that can be used to generate electricity at the same price levels. It will take several more years of cost improvements to get our costs down to a level that can compete with coal, and hopefully by then we will have better battery storage capacity so that solar can be used 24 hours/day.

Analysts predicted that new technology, cost improvements and economies of scale in the solar industry would lead to grid parity by 2012-2014 in many regions, particularly where it was sunny (~1,800 hours of sun each year) and the costs of alternative sources of electricity were high (e.g., California and Japan). In the meantime, government subsidies and regulations have played a major role in stimulating demand for solar energy. Regulators hoped these policies would give companies a platform to sell solar products, while promoting national energy independence, high tech job creation, and reduction of CO_2 emissions. The countries with the highest solar penetration (Germany, Spain, U.S., and Japan) offered incentives, including feed-in-tariffs, rebates, and investment tax credits.

Europe

Germany introduced a set of renewable energy laws in 2000 (known as EEG) that included an effective solar feed-in-tariff plan. Feed-in tariffs were a mechanism that required utilities to buy any available solar electricity at a fixed price for a time period (typically 20 years). The price was set by policy makers at a level that allowed each of the key players (solar manufacturer, system integrator, finance provider) to make enough profit so there was an incentive to develop more solar power. Pricing was typically set on a schedule that stepped down 5-10% each year to encourage cost reductions by manufacturers. Utilities shouldered the burden of paying above-market rates for electricity by adding an extra fee to the monthly bill of all the customers served by that utility to cover the incremental costs.

Germany instituted a plan with a 20-year price schedule starting with payments of EURO.30 ($0.42) kWh of utility power, declining at 8% each year. These policies were so effective that Germany increased its percentage of total power generated from the sun from approximately 0% in 2000 to approximately 1% in 2009. The German government announced a goal of getting 27% of its electricity from renewable sources by 2020, and much of that was expected to be solar. In 2009, the average German consumer was expected to pay an incremental EURO.20 ($0.28) per month to cover the premium paid for solar electricity over the cost of alternative sources of electricity.[xi]

Spain introduced its own feed-in-tariff in 2007, which also stimulated major investments in solar energy in Spain. The policies in Spain differed from those in German in two key ways: the rates paid to solar energy providers were set at a comparatively high level and Spain capped the total amount of solar energy that could qualify for the high rates. This resulted in a major rush of applications and projects, causing Spain to reach its cap in eight months. Spanish officials estimated that the country added 3 gigawatts of solar power in 2008, three times more than it planned.[xii] In late 2008, Spain adjusted the rate it offered to solar providers and capped the program at 500 MW, hoping to reduce the frenzy created by the previous set of policies. This policy change was difficult for companies that focused on Spain during 2007 and early 2008 when they were suddenly unable to finance projects in that country. As Tom Werner, CEO of SunPower explained, "If you look to Spain with its feed-in-tariff, Spain was #1 in the solar market. It's now going to be the 10th or 15th, and the difference is policy change. There was a gold rush, and now almost all the solar installers are gone."[xiii] John Woolard, CEO of BrightSource Energy, expanded, "You have to have the confidence that whoever is backing the feed-in-tariff won't change the rules on you. The rules changed in Spain and you have unfinanceable projects. You need a long-term policy to match the long-term horizon for building a power plant."[xiv]

France announced a plan to increase renewable energy from 10.3% in 2005 to 20% by 2020, and the government instituted a 20-year feed-in-tariff plan with tariff increases pegged to inflation starting at EURO.30/kWh ($0.42/kwh) for ground-mounted utility projects. France also implemented an income tax credit for individuals as well as additional subsidies for PV systems integrated into buildings. In May 2009, France announced plans to build 300MW of solar capacity by 2011.

Italy announced plans to reach 3GW of solar capacity by 2016, primarily relying on feed-in-tariffs (modeled off of Germany) to provide growth. The country offered tiered feed-in-tariff rates at EURO.42/kWh ($0.59/kWh) for utility projects. Rates were scheduled to drop 2% each year for 20 years, and Italy capped the incentives at 1.2GW. Italy also offered bonuses for schools and public health centers as well as municipalities with less than 5,000 residents.

United States

U.S. federal policy makers were considering feed-in-tariffs in early 2009, but most analysts believed it was unlikely that the country would adopt a national plan for at least several years, if ever. Roscheisen advocated for a national plan because he believed it would provide, "predictable compensation to any renewable energy generator in the form of long-term power purchase contracts, creating a streamlined administrative national framework that makes developing renewable energy projects and manufacturing new technologies highly investable for entrepreneurs and private capital alike." He continued, "Currently, developing utility-scale renewable energy projects requires dealing with hundreds of private and public utilities all operating under strikingly different state regulatory requirements, and often requiring substantial upfront investments just to respond to requests for proposal."[xv]

Although there was not a consensus around a national plan in 2009, there were a few regions in the U.S. that implemented their own feed-in-tariff plans with mixed success. California introduced a plan in 2006 capped at 250MW for systems with a maximum of 1.5 GW of capacity, and pricing was based on the time of electricity delivery (peak vs. off-peak). The state revised the plan several times by increasing the caps and altering pricing mechanisms; however, usage remained low. Industry experts believed that the California prices paid to solar providers were set too low, and for too short a period of time, to make it attractive for investors to finance and build new solar projects. In Gainesville, Florida, regulators approved a feed-in-tariff plan modeled after Germany with prices set for 20 years at $0.32 per kilowatt-hour. (It typically cost around $0.15 per kilowatt hour to produce electricity from gas-fired turbines in Florida.) The plan was announced in February 2009, and by early March the regional utility group already received enough applications to reach its 4GW cap for 2009. The utility expected it would charge consumers an extra $0.74 each month to pay for the solar power it planned to purchase through the feed-in-tariff plan.[xvi]

Analysts anticipated that investment tax credits in the U.S. would play a bigger role than feed-in-tariffs in stimulating demand. The U.S. Emergency Economic Stabilization Act of 2008 included a 30% investment tax credit for business and residential solar investments through 2016 that allowed individuals and companies to use solar capital expenditures to offset tax liabilities. Analysts expected this tax credit would stimulate new solar installations, particularly for long term projects that required spending over multiple years. U.S. utilities were also able to qualify for tax credits under the new laws, leading to hundreds of applications for new solar projects in late 2008 and early 2009. In 2008, approximately 192 MW of solar capacity was added by U.S. utilities, with Pacific Gas and Electric Company in California representing 44% of the total. Many utilities doubled their solar capacity in 2008.[xvii] First Solar purchased a company, Optisolar, in March 2009 primarily for its utility project pipeline. (See **Exhibit 11** for a news article about First Solar's purchase.)

In addition to federal support, most state governments also offered solar incentives such as rebates and loans to reduce the price of solar installations on rooftops. California had one of the largest programs (known as the California Solar Initiative) with the goal of one million solar roofs by 2016, up from 52,000 in early 2009.[xviii] The state allocated $2.167 billion for these programs, 79% of which represented direct incentives to consumers from 2007-2016.[xix] Forty-two of the states also offered "net metering," that allowed solar operators to sell back to the utility any electricity they didn't use. Twenty-six states passed laws that required a certain portion of electricity be from renewable sources by specific years ranging from 2010-2025, as detailed in **Exhibit 12**. Utilities planned to reach these targets through a combination of buying and operating their own solar projects, contracting with third parties to buy solar electricity, and contracting with commercial and residential solar users.

Several analysts predicted that the United States would be the biggest market for solar energy by 2012 when the lower solar prices could make grid parity a reality in select locations. In addition, there were discussions in the country about a possible "carbon tax" that would increase the price of other forms of energy production, making solar relatively less expensive. For example, producers of electricity from coal might have to pay a tax of $0.01-$0.02/kWh, raising the effective price of electricity from coal to approximately $0.06/kWh.

Japan

Japan imported the majority of its energy sources, resulting in some of the highest prices for electricity in the world. Japan started investing in solar energy in 1993 with subsidies for rooftop solar installation, and the country continued to invest in solar capabilities and usage, resulting in 1% of Japanese households using solar electricity in 2008. The Japanese government announced in 200[9] that it wanted to more than double its solar capacity from 2GW in 2008 to 4.8GW in 2010, and there were discussions about a plan in 2010 that would require utilities to purchase surplus solar electricity at approximately $0.50/kwh.[xx]

Nanosolar Sales and Pricing Strategies

Nanosolar was in the process of determining its own sales and pricing strategy in the context of the different incentives in place around the world. As of early 2009, Nanosolar planned to stay focused on the utility market for the next several years, but it envisioned offering residential and commercial products by 2011. (See **Exhibit 13** for the estimated size of the worldwide utility market for 2007-2013.)

Europe

When the company made the decision to build its assembly plant in Germany in 2008, it believed that Europe would be its primary market for the next several years. Stone explained, "The European markets have been predictable for manufacturers and systems integrators. We know that the utilities will buy the electricity in Germany at a price that allows everyone to make some profit."

As of early 2009, Nanosolar had signed contracts with several system integrators in Europe that covered projects to be installed by 2015. For its first few projects, Nanosolar opted to price its panels just below the prices set by First Solar. Roscheisen commented, "We are still in the process of determining just how inexpensive we can make our panels. We know that we can match First Solar's pricing, so we decided to start at a level that already has acceptance in the market." Prices were quoted to customers in terms of cost/watt, and Nanosolar could charge more for the panels with the highest efficiency cells as these panels reduce the customer's installation hardware and labor costs. Customers such as Beck arranged bank financing to buy panels from Nanosolar and set up solar farms. The typical formula for solar project investors was to take a 9% to 11% unlevered IRR and get 70% to 80% bank financing at 5% to 6% to arrive at a high double digit equity IRR. Once a project was up and running, a systems integrator could hold on to the asset and receive payments from the local utilities for the electricity. Alternatively, systems integrator could choose to sell the plant and the corresponding revenue streams. Roscheisen believed that investing in solar farms in countries with reliable feed-in-tariffs was like investing in government bonds given the low levels of risk involved.

Within Europe, Nanosolar maintained that it was indifferent as to the specific location, provided there was a reliable pricing schedule for electricity. The company believed that Germany, Italy, and France would be the most likely markets for 2009-2011 due to the stable pricing levels in those countries and Nanosolar's existing relations with European power companies. Nanosolar's assembly location in Germany allowed for ground transportation to each of these countries, and the company believed it could be price competitive in all of the countries.

United States

Nanosolar was approaching the United States with a bit more caution than Europe. Unlike in Germany, most state and federal incentive plans did not provide long term pricing guarantees. As a result, Nanosolar was concerned that state incentives could change every year or two based on local interests, making it difficult for large scale systems that relied on outside financing. Roscheisen explained, "Investors in solar projects need a predictable policy framework that allows them to calculate returns over 10-20 years. There is some concern in the U.S. that local governments will change the rules based on the lobbying efforts of 'green collar workers' in the region. We can't build a business in which we can get wiped out by regulatory action." Nanosolar also found that the U.S. did not have the same set of experienced system integrators that could help Nanosolar go to market. Furthermore, most of the integrators were localized to specific states, making it more difficult to establish deep partnerships unless Nanosolar wanted to focus on only one or two states. Nanosolar was in the process of evaluating potential partnerships for the U.S., including those with the utility companies that were becoming project developers.

Assuming Nanosolar did enter the U.S. market in 2010 or 2011, the company faced an important set of decisions with respect to pricing. Although Nanosolar believed it could enter the market as the low-cost provider, it was not sure that would be best for Nanosolar or the solar industry's development in the U.S. For example, if Nanosolar priced close to its cost, it could encourage states to remove subsidies earlier than they had planned. This would limit Nanosolar's ability to generate profits and could set up the U.S. market with thin margins. However, if Nanosolar entered the U.S. market at higher price points, it could find itself competing against hundreds of companies, potentially enabling others to achieve the economies of scale that Nanosolar sought for itself.

Other Parts of the World

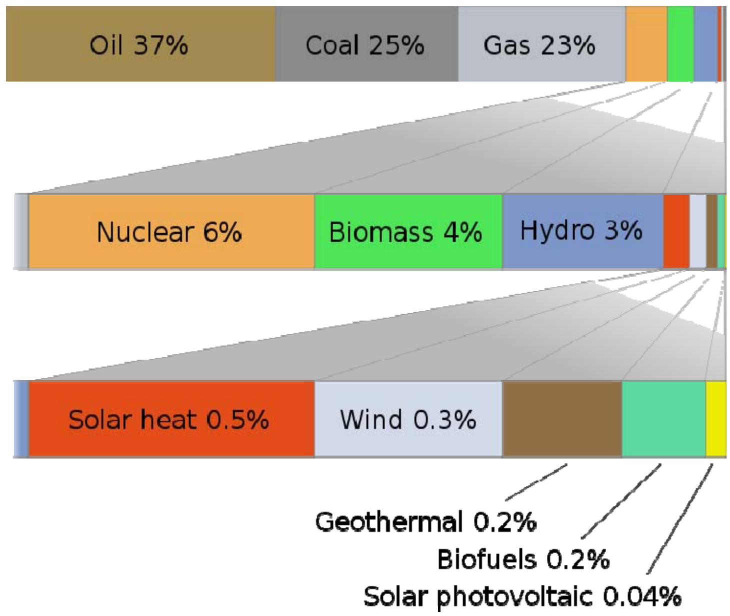
Nanosolar believed that it would eventually be a supplier to countries beyond Europe and the U.S., such as Japan, China, and India. These markets were in the process of developing feed-in tariffs, and market sizing estimates were expected once the tariffs were defined.

Conclusion

Roscheisen was looking forward to his meeting that afternoon with Stone. He was optimistic that Nanosolar's manufacturing would be ramped up by the end of 2009, and he wanted to map out his company's sales strategy for 2010 and beyond. It was tempting to stick with the European markets as long as feed-in-tariffs were still in place. As Stone said, "If you could sell all your panels into a market that would pay $0.30 or more for your electricity, why would choose a market that only pays you $0.15?" However, it was difficult to stay out of the U.S. market altogether. First Solar was announcing new projects on a weekly basis, many of which were now in the U.S. In 2008, First Solar appeared to be focusing on the residential market through its partnership with Solar City, but it had recently acquired a U.S. company that had contracts with utilities for several projects in the Southeast U.S. Nanosolar was watching the market leader carefully to see how it planned to price its products in the U.S.

In addition to discussing pricing and entry strategies during the meeting, Roscheisen also wanted to revisit the topic of first mover advantage. The management team had agreed during the last strategy meeting that early mover advantages were minimal in this business, as the market would evolve dramatically over the next decade. Roscheisen explained, "The market will commoditize based on 'cost per watt.' Athough early product introduction will enhance 'bankability' for producers, all companies that achieve bankable status will ultimately have to compete on 'cost per watt.'" Nevertheless, Roscheisen wanted to think about what Nanosolar might be missing if it chose to enter the U.S. at a slow pace. As Roscheisen returned to his desk, he thought about the enormous potential for Nanosolar. The worldwide solar PV market was expected to grow at a compound annual rate of 50% for the next four years,[xxi] and Roscheisen wanted to make sure that Nanosolar was poised to participate in that growth.

Exhibit 1 Worldwide Energy Usage (Consumption) by Source (data from 2006)



Source: Wikipedia chart, data from: REN21 2006 global status report on renewables and the BP 2006 Statistical review

Exhibit 2 Estimated On Grid Solar Market Demand (2009)

2009 GLOBAL SOLAR PV MARKET				
MWs	**Residential**	**Commercial**	**Utility**	**Total**
Germany & Eastern Europe	900	750	400	2050
Spain & Portugal	75	175	500	750
Italy & Greece	100	100	300	500
United States & Canada	125	200	150	475
Japan	350	100	-	450
France	50	75	150	275
Korea	25	50	150	225
Emerging (China, India, Middle East, Australia)	50	75	50	175
Total Market Size	1675	1525	1700	4900

Source: Nanosolar estimates.

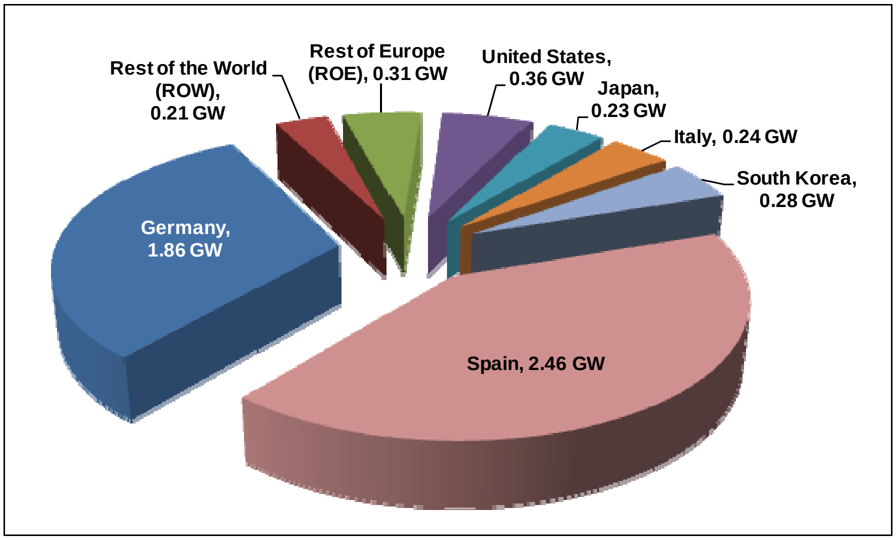
Exhibit 3 Common Solar Definitions and Measurements

- Watt = unit of power
- Kilowatt (KW) = 1,000 watts
- Megawatt (MW) = 1,000,000 watts
- Gigawatt (GW) = 1,000,000,000 watts
- Kilowatt-hour (kWh) = 1,000 watt hours; measure of how electricity is purchased from a utility
- $/kWh or cents/KWh = how electricity is priced on a retail level
- $/Watt = how solar panels are priced. Calculation is derived by determining cost per sq. metere and dividing that by power generated per square meter.
- Average US monthly electricity consumption in kWh: Residential: 936 kWh; Commercial: 6,408 kWh; Industrial: 107,907 kWh
- In Southern California, one GW of electricity is enough to power up to 650,000 homes. [a]

Source: Energy Information Administration, Electricity FAQs, http://tonto.eia.doe.gov/ask/electricity_faqs.asp, accessed June 2, 2009.

[a]Nichola Groom, "First Solar Buys Rival Utility Project Pipeline," Reuters, Marcy 3, 2009.

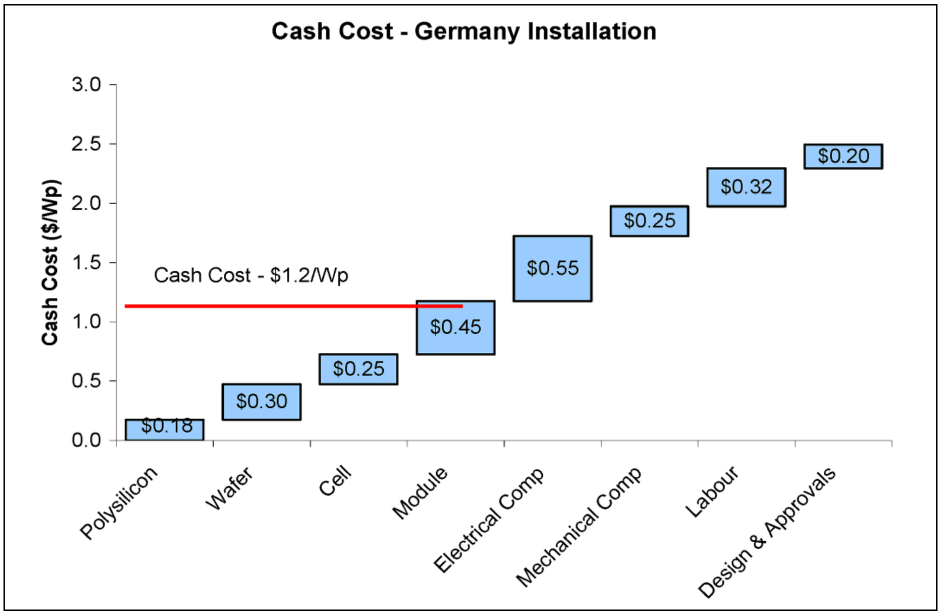
Exhibit 4 Solar Demand by Country (2008)



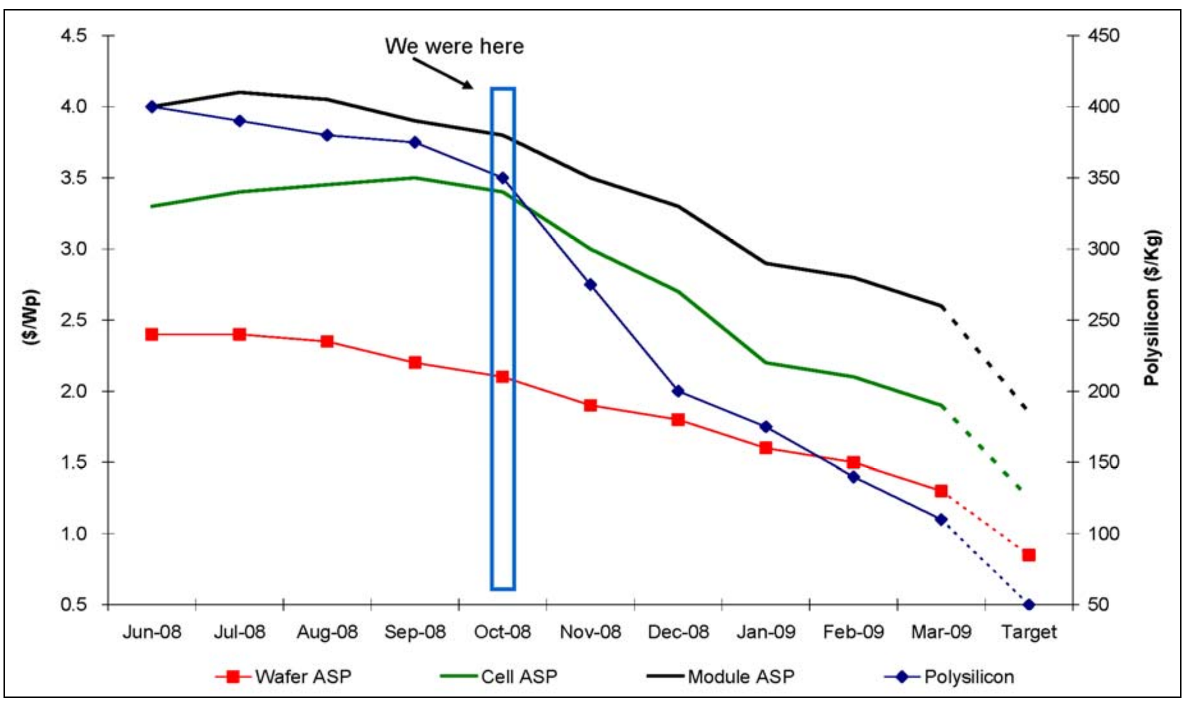
Source: Solarbuzz, http://www.solarbuzz.com/Marketbuzz2009-intro.htm, accessed June 2, 2009.

Exhibit 5 c-Si Supply Chain and Price Trends

c-Si: Cash Cost



Recent ASP Trends



Source: Morgan Stanley Research. Sunil Gupta, Andrew Humphrey, Nick Allen, "Solar Devices—Dislocation: Industry Reset," Morgan Stanley Global Research, March 24, 2009, p. 10.

Exhibit 6 Management Bios

Martin Roscheisen, Chief Executive Officer

Martin Roscheisen has been Nanosolar's chief executive officer since the company's inception in 2002. Prior to Nanosolar, Roscheisen was the entrepreneur behind three information technology companies, each ultimately acquired by their respective industry leader and together delivering $1.2 billion in shareholder value. An Austrian citizen born in Munich, Martin Roscheisen got his Silicon Valley apprenticeship as a teenager during a year at Xerox PARC. He received advanced engineering degrees from Stanford University and Munich Technical University, and holds a doctorate from Stanford University's School of Engineering.

Brian Sager, Vice President of Corporate Development

Brian Sager managed the company's government programs, its intellectual property portfolio, and its relationships with customers in the United States. Prior to co-founding Nanosolar, he led a high-growth biotechnology practice at Ernst & Young where he advised companies on corporate finance issues, R&D portfolio management, and technology licensing. Brian Sager earned a Ph.D. in Biochemistry from Stanford University and did his postdoctoral work at Harvard University.

Brian Stone, Vice President, Product Management

Brian Stone is the vice president, product management at Nanosolar. His responsibilities include leading the company's product management and North American sales activities. Prior to Nanosolar, Brian spent three years in various executive roles at SunPower and PowerLight Corporation. Brian's roles included utility-scale power plant sales and channel sales management in North America, and global marketing and product management as the company's Vice President, Marketing. Prior to SunPower, Brian was the General Manager, Siebel Public Sector at Siebel Systems, Inc. Brian earned an MBA from the Haas School of Business, UC Berkeley and a BA in Economics and International Relations from the University of Pennsylvania.

Exhibit 7 Nanosolar's Pricing Analysis for Thin-Film and cSi solar Projects in 2009 and 2012

Levelized Cost of Electricity =
(over entire lifetime of power plant)

	2012 Estimated $/w Price	
	c-SI Fixed Tilt	**NS Fixed Tilt**
Panel	$1.75	$1.00
Balance of System	$1.00	$1.00
Total	$2.75	$2.00
Annual O&M (per 1MW)	$7,500	$7,500
Land Required (Acres per 1MW)	3.5	5
Total Cost	$2,935,000	$2,200,000

kWh (DC) Generated (1MW, Southwest U.S.)	**c-SI Fixed Tilt**	**Fixed Tilt Thin Film**
Annual kWh per 1 kW peak installed	1,850.00	1,850.00
Annual Degradation	0.50%	0.50%
20 Years kWh	28,941,180	28,941,180

20 Year LCOE w/out 30% ITC (cents / kWh)*	$0.101	$0.076
20 Year LCOE w/ 30% ITC (cents / kWh) *	$0.071	$0.053

* Does not account for financing cost of capital

Source: Nanosolar estimates.

Exhibit 8 First Solar Business Metrics

Key Quarterly Financial Data ($ in millions, except gross profit and net income per share data), (unaudited)	**Q1'08**	**Q2'08**	**Q3'08**	**Q4'08**	**Q1'09**	**Q1'09 (Y/Y)**	**Q1'09 (Q/Q)**
Net sales	$196.9	$267.0	$348.7	$433.7	$418.2	112%	-4%
Gross profit (%)	53.0%	54.2%	56.1%	53.9%	56.3%	3%	2%
Research and development	4.8	7.7	10	11	11.7	144%	7%
Selling, general and administrative	28.7	43.6	49	52.7	49.3	72%	-7%
Production start-up	12.8	4.6	6.3	8.8	6.2	-52%	-29%
Operating income	58.1	88.7	130.2	161.3	168.1	189%	4%
Income tax expense	18.6	24.2	33.8	38.8	5.1	-73%	-87%
Net income	$46.6	$69.7	$99.3	$132.8	$164.6	253%	24%
Share count—Diluted	81.6	82.0	82.4	82.5	82.6	1%	0%
Net income per share—Diluted	$0.57	$0.85	$1.20	$1.61	$1.99	249%	24%
RONA[a]	16.8%	17.0%	19.6%	22.4%	27.4%	65%	22%
Stock-based compensation expense	10.9	15.5	17.3	15.2	15.2	39%	0%
Capital expenditures (cash basis)	74.6	160.3	95.7	128.7	86.4	16%	-33%
Cash and marketable securities	$709.0	$661.2	$729.4	$821.8	$811.6	14%	-1%
Supplemental Data (unaudited)							
Average foreign spot exchange rate (€/USD)	1.50	1.56	1.51	1.32	1.31	-13%	1%
Free cash flow	(11.3)	(101.1	41.6	74.6	(22.7)	101%	130%
+ Purchases of property, plant, and equipment	74.6	160.3	95.7	128.7	86.4		
= Net cash provided by operating activities	63.3	59.2	137.3	203.3	63.7		
MW produced	79.4	114.1	136.5	173.6	219.5	177%	26%
Line run rate	45.0	48.0	49.3	47.7	49.4	10%	4%
Conversion efficiency	10.6%	10.7%	10.7%	10.8%	10.9%	0.3%	0.1%
Core cost per watt produced	$1.12	$1.09	$1.01	!0.93	$0.90	-20%	-3%
Stock-based payment cost per watt (manufacturing)[b]	$0.02	$0.03	$0.03	$0.02	$0.01	-50%	-50%
Ramp penalty (cost per watt)[c]	$--	$0.06	$0.04	$0.03	$0.02	0%	-33%
Total cost per watt produced	$1.14	$1.18	$1.08	$0.98	$0.93	-18%	-5%

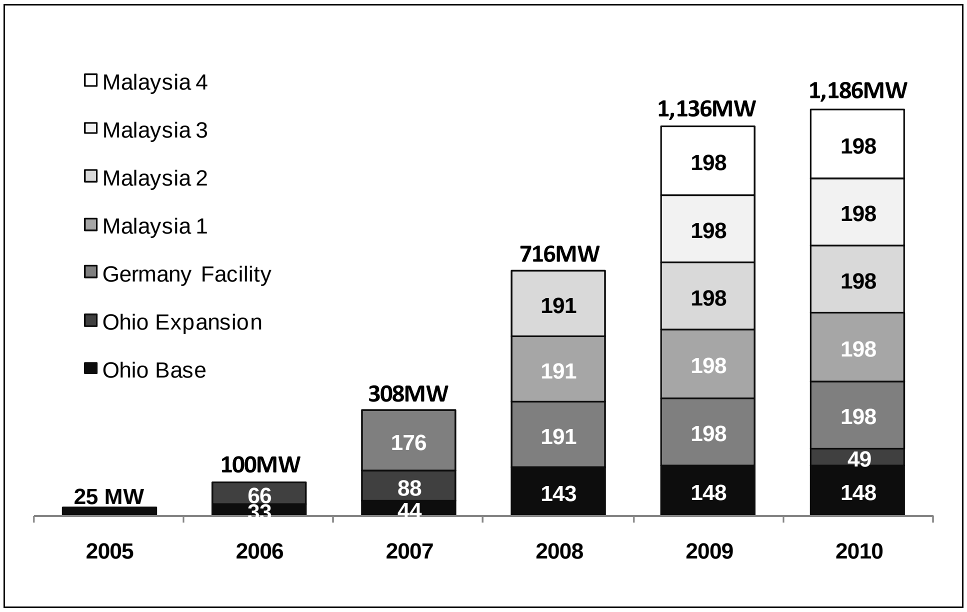
Source: First Solar Corporate Overview, Q1 2009. Page 30.

[a]RONA = 4 quarter rolling NOPAT/4 quarter rolling NET ASSETS (where NET ASETS = Assets – Non-interest-bearing liabilities)

[b]Represents stock-based payment costs associated with factory labor.

[c]Ramp penalty start-up costs consist primarily of fixed production labor and overhead spending associated with production below normal capacity utilization in a new production facility.

Exhibit 9 First Solar's Manufacturing Capacity and Expansion Plans

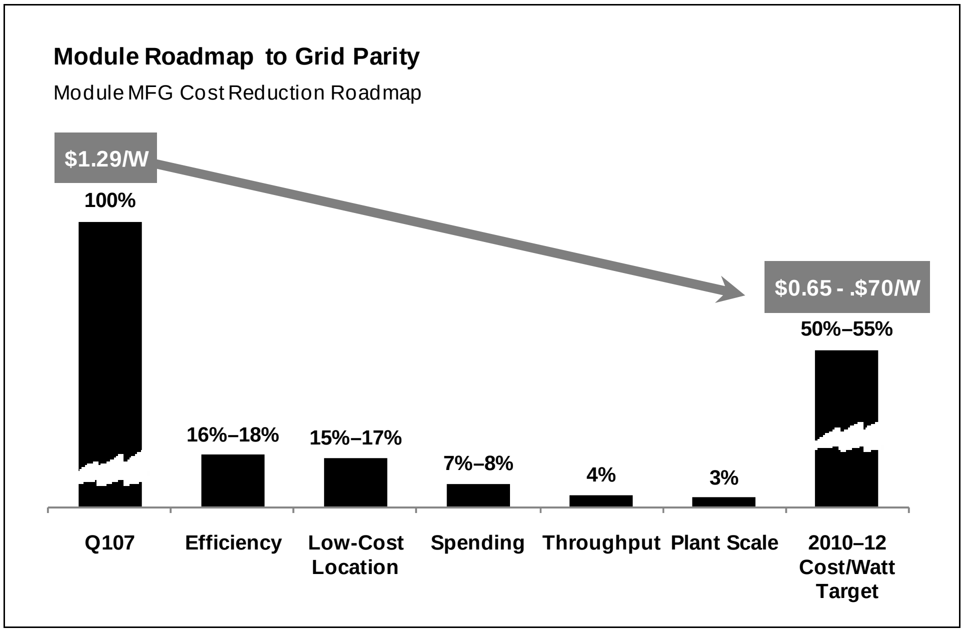


Source: First Solar Corporate Overview, Q1 2009. Page 7.

Note: 2005 and 2006 based on Q407 run rate; 2007 based on Q407 run rate; 2008 based on Q408 run rate; 2009–2010 based on Q109 run rate.

Exhibit 10 First Solar's Path to Grid Parity

A.



B.

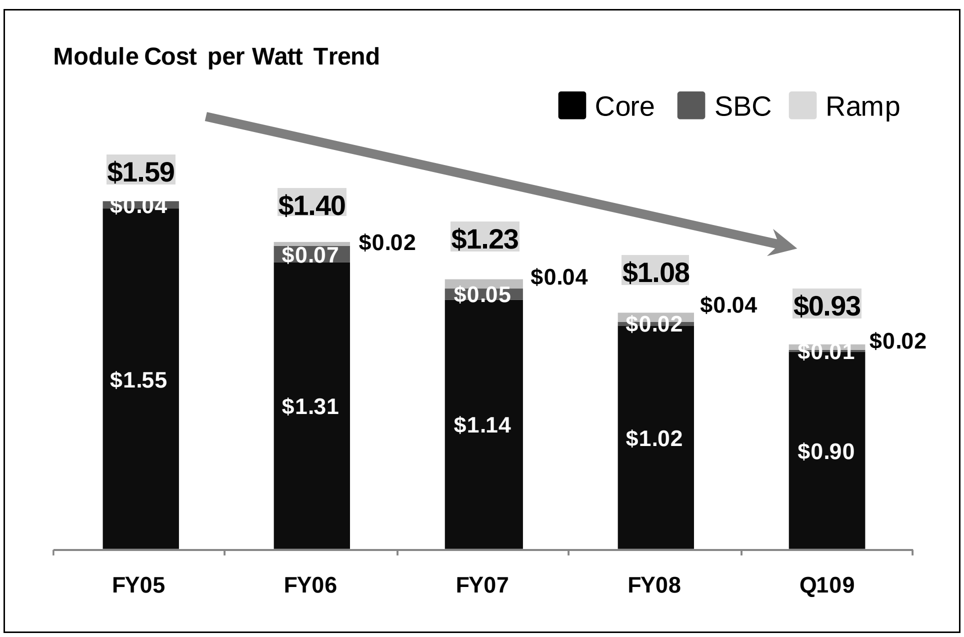
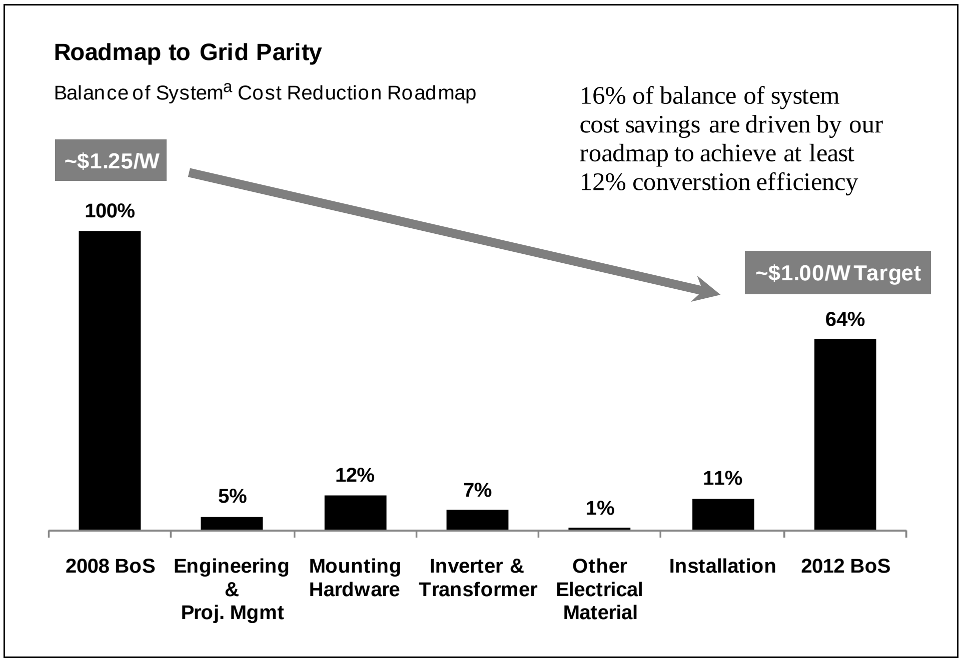


Exhibit 10 (continued)

C.



Source: First Solar 1Q 2009 Update, http://media.corporate-ir.net/media_files/irol/20/201491/CorporateOverview.pdf, accessed June 2, 2009. Pages 18-21.

Exhibit 11 News Article: First Solar Buys Rival Utility Project Pipeline
By Nichola Groom
(Reporting by Nichola Groom; Editing by Andre Grenon)

LOS ANGELES (Reuters)—First Solar Inc said on Monday it would pay rival OptiSolar $400 million in stock for its pipeline of solar projects, including a major installation for California utility PG&E Corp and other nascent deals that will rapidly expand the company's presence in the U.S. utility market.

The deal, which First Solar Chief Executive Mike Ahearn called a "watershed acquisition" for the company, includes 1.3 gigawatts (GW) of solar development projects being negotiated with Western U.S. utilities and 136,000 acres of strategic land rights that have the potential to deploy up to 19 GW of additional solar projects.

In Southern California, one GW of electricity is enough to power up to 650,000 homes.

The addition of projects already at various stages of development will "catapult us into a whole new league," Ahearn said on a conference call to discuss the deal.

"This package, in total, we think would be very hard to replicate at all, and certainly not without many years of work," Ahearn added.

The deal between First Solar and OptiSolar, expected to close in the second quarter, comes as the global credit crisis had dried up funding for many renewable energy projects. California utilities, however, have been a bright spot in an otherwise gloomy solar market because they must comply with a state mandate to produce 20 percent of their power from renewables by 2010 and then 33 percent by 2020.

Utilities also benefit from a 30 percent tax credit for building solar installations.

"Although this position is not guaranteed, buying an existing pipeline increases the likelihood of becoming the preeminent solar energy provider to the U.S. utility market and potentially boxes out other competitors at a time when the industry is capital constrained," Piper Jaffray analyst Jesse Pichel said in a note to clients.

Going forward, the projects included in the deal will incorporate First Solar's cadmium telluride solar panels rather than Hayward, California-based OptiSolar's amorphous silicon panels. Both technologies are photovoltaic, meaning they use the sun's rays to generate electricity.

Both also fall under the category of "thin film" solar, meaning they are cheaper to produce than traditional crystalline silicon panels. The downside is that thin film panels produce less electricity than silicon-based rivals, making them less effective in small spaces such as residential rooftops.

Cheaper thin film panels have scored big deals with price- conscious utilities, however.

Last year, OptiSolar made headlines when it secured a deal to build a 550-MW solar power plant in Central California for PG&E's Pacific Gas & Electric. As part of the same announcement, SunPower Corp, a maker of silicon-based panels, inked a deal to build a 250-MW plant nearby.

Then, at the beginning of this year, privately-held OptiSolar cut 300 jobs, or half its workforce, and halted the construction of a manufacturing plant because it could not secure the funding it needed to expand. That lead the company to "entertain a partner," Ahearn said.

First Solar executives said the deal would add about $70 million to 2009 revenue, but would decrease earnings per share for the year by 35 cents to 40 cents a share.

The deal is expected to add to earnings "modestly" in 2010.

First Solar shares rose about 2.9 percent to $107 in extended trading following the announcement. The stock closed at $103.97 on the Nasdaq after falling $1.77, or 1.7 percent, in regular trading.

Source: Nichola Groom, "First Solar Buys Rival Utility Project Pipeline," Reuters, Marcy 3, 2009, http://www.reuters.com/article/GCA-GreenBusiness/idUSTRE5225W420090303?sp=true, accessed July 13, 2009.

Exhibit 12 U.S. State Requirements for Electricity from Renewable Sources (2010–2025)

State	Total Generation (2007), ('000 kWh)	Requirement	By When
Arizona	104,392,528[a]	15%	2025
California	490,795,218	20%	2010
Colorado	205,960,167	20%	2020
Connecticut	53,756,522	23%	2020
Delaware	7,182,179*	20%	2019
D.C.	81,467*	11%	2022
Hawaii	11,960,090	20%	2020
Illinois	197,795,429	25%	2025
Iowa	89,007,047	105MW	--
Maine	30,196,422	30%	--
Maryland	252,759,444	9.5%	2022
Massachusetts	79,574,968	4%	2009
Minnesota	70,259,509	25%	2025
Montana	348,007,286	15%	2015
Nevada	65,130,407	20%	2015
New Hampshire	46,536,608	25%	2025
New Jersey	66,303,400	22.5%	2021
New Mexico	27,632,793	20%	2020
New York	1,418,258,950	25%	2013
North Carolina	322,801,400	12.50%	2021
Oregon	867,839,634	25%	2025
Pennsylvania	435,900,727	18%	2020
Rhode Island	8,175,579	16%	2019
Texas	350,862,367	5,580MW	2015
Washington	2,076,777,949	15%	2020
Wisconsin	130,525,091	10%	2015

Source: Vishal Shah, "Solar Energy Handbook," Barclays Capital, May 1, 2009, p. 130

[a]Does not include hydro.

Exhibit 13 Estimated Ground/Utility PV Market by Country

	GLOBAL UTILITY MARKET (>1MW)						
Source: SolarBuzz, Nanosolar estimates	2007	2008	2009	2010	2011	2012	2013
- Germany & Eastern Europe	110	150	400	450	500	650	850
- Spain & Portugal	300	2,000	500	300	375	500	750
- Italy & Greece	5	100	300	450	500	600	750
- France	5	25	150	200	250	300	350
- U.S. & Canada	25	30	150	200	350	500	750
- Korea	50	100	150	100	200	250	300
- Japan	-	-	-	-	-	-	-
- Emerging Markets (China, India, ME)	5	25	50	250	400	575	750
Total Market Size (MWs)	500	2,430	1,700	1,950	2,575	3,375	4,500
Aggregate Growth Rate	67%	386%	-30%	15%	32%	31%	33%

Source: Solarbuzz, Nanosolar estimates

---

[i] Stephanie Rosenbloom, "Giant Retailers Look to Sun for Energy Savings," *The New York Times*, August 10, 2008, http://www.nytimes.com/2008/08/11/business/11solar.html?em, accessed May 15, 2009.

[ii] Data in this section is from the Solarbuzz 2009 market report. http://www.solarbuzz.com/Marketbuzz2009-intro.htm, accessed April 28, 2009.

[iii] Sunil Gupta, Andrew Humphrey, Nick Allen, "Solar Devices—Dislocation: Industry Reset," Morgan Stanley Global Research, March 24, 2009, p. 10.

[iv] NREL's "rule of thumb" is that any technology, PV or otherwise, will likely ultimately yield ~80% of its laboratory results in a production environment as the manufacturing process reaches steady state.A lab works on very small scales and lower processing speeds. The faster speed of manufacturing over a much larger surface area will always yield less efficiency.

[v] According to a DRI Germany Report, Germany's electricity market had annual power consumption about 550 TWh and generation capacity of 125 GW, half of which was coal fired, 17% nuclear, and 18% gas-fired.

[vi] Based on stock prices on May 15, 2009.

[vii] Ucilia Wong, "First Solar Panels Big with Solar City Customers," April 17, 2009, Greentech Media.

[viii] Neal Dikeman, "Who will make CIGS work for the solar sector?" CNET news, July 8, 2008, http://news.cnet.com/8301-11128_3-9986200-54.html?tag=mncol;title, accessed May 19, 2009.

[ix] Source: Energy Information Administration, Electricity FAQs http://tonto.eia.doe.gov/ask/electricity_faqs.asp, accessed June 2, 2009.

[x] Grid parity referred to the situation in which each incremental watt of electricity from PV solar energy cost the same to produce as an incremental watt of energy from other sources of electricity currently being used.

[xi] Vishal Shah, "Solar Energy Handbook," Barclays Capital, May 1, 2009, page 41.

[xii] Ucilia Wong, "Spain Installed More Than 3GW of Solar in 2008," Greentech Media, http://www.greentechmedia.com/ articles/spain-installed-more-than-3gw-of-solar-in-2008-5545.htmlaccessed April 28, 2009.

[xiii] Ucilia Wong, "Spain: The Solar Frontier No More," May 29, 2009, Greentech Media, http://www.greentechmedia.com/
articles/read/spain-the-solar-frontier-no-more/, accessed June 2, 2009.

[xiv] Ibid.

[xv] "Feeding in Renewably Energy Breakthroughs," George Sterzinger, Executive Director, Renewable Energy Policy Project, and Martin Roscheisen, CEO, Nanosolar, January 21, 2009, Nanosolar Blog, http://www.nanosolar.com/blog3/

[xvi] Kate Galbraith, "Europe's Way of Encouraging Solar Power Arrives in the U.S.," *The New York Times*, March 12, 2009. Page B1.

[xvii] Solar Electric Power Association, "Top Ten Utility Solar Integration Rankings: Results of the 2008 Utility Solar Electricity Survey," May 2009, page 7.

[xviii] Los Angeles Time Editorial, "California's Solar Push," May 22,2009, http://www.latimes.com/news/opinion/la-ed-solar22-2009may22,0,5723.story

[xix] http://www.gosolarcalifornia.org/csi/index.html

[xx] Vishal Shah, "Solar Energy Handbook," Barclays Capital, May 1, 2009, page 134.

[xxi] Vishal Shah, "Solar Energy Handbook," Barclays Capital, May 1, 2009, page 1.