A Research Report on Solar Power Investment: The Dawn of Solar Power

By Russell Hasan

Alternative Energy News Source (Altenews.com)

Table of Contents

1. Introduction

Solar power is one of the hottest areas in energy investment right now, but there is much debate about the future of solar technology and solar energy markets. This research report is written with the purpose of analyzing extenstive data to predict solar investment opportunities. Alternative Energy News Source (Altenews.com) has long asserted that there are fortunes to be made from smart investments in renewable energy, and this report examines various ways in which solar power is precisely such an opportunity.

Recently there has been a burst of interest in what is commonly known as "renewable energy," forms of energy that do not become depleted and which are environmentally friendly and producible in most parts of the world. The public is afraid of the very real threat of global warming, as popularized in the documentary "An Inconvenient Truth," and they also want independence from politically unstable foreign oil imports, particularly from the war-ravaged Middle East. The Hubbert's Peak theory of "Peak Oil," which claims that oil resources have peaked and are now beginning a decline that will end in the depletion of global oil reserves, has also gained credibility. This "triple threat" of global warming, energy independence and peak oil has led to an unprecendented focus on renewable energy, which in turn has spurred businesses to concentrate on renewable energy and persuaded investors to put money into renewable energy. There are many exciting opportunities in renewable energy, but there is much confusion that clouds the ability of the investor to find the best opportunities in renewable energy. Two areas of renewable energy that have received a great deal of attention are solar power, which produces energy from sunlight, and ethanol, a fuel substitute made primarily from corn and sugarcane. In previous Altenews reports and articles, including "Ethanol Investment: Golden Opportunity or Fool's Gold?" and "The Ethanol Hype, Quantified," Altenews explored the problems with American corn ethanol. In this report we take a more optimistic approach, investigating various positives that we believe will cause solar markets to expland, solar technology to develop, and solar profits to grow, both in the short term and in the long term. Sunlight is free and plentiful and solar power

emits no pollution, and some have claimed that enough sunlight resources reach the planet in one hour to provide 100% of the world's energy needs for one year. There are also many other data that we feel supports optimisim towards the solar industry.

Below you will find our research report, "Solar Power Investment: The Dawn of Solar Power." In this report we begin with an overview of the solar industry and the history of solar growth. We then examine the shortage of silicon, which is the main raw material for most solar panels, next we review the future of various solar technologies, and then then we analyze solar markets, first in the industrialized world and then in the developing world. We conclude with our acccount of what every investor should know before they invest in solar, where the best opportunities may be, and what kind of strategy a smart investor should employ when investing in solar power.

2. Industry and Growth

The major technological advances that enabled the commercial development of solar took place at MIT in the 1930s, '40s and '50s, under the direction of Professor Hoyt C. Hottel, B. B. Wortz and Austin Whillier, according to award-winning Professor William A. Beckman of the University of Wisconsin's Solar Energy Lab, who is the author of a famous solar power textbook. Since then, the technology was developed by Bell Labs (now Lucent), and then further advancements were made by Japanese electronics companies that undertook solar research. The most widely known commerical use of solar technology is the solar cells that power most simple calculators. However, since the early 1990s, concerns over the environmental impact of fossil fuel energy pollution and a desire to diversify from an energy system dependent upon foreign oil imports have spurred the widespread commercial popularity of solar power. Large solar power plants have been built, a number of which are in southern California. The primary appeal of solar panels is the ability to be placed anywhere where there is sunlight, making them an useful electricity-producing addition to environmentally friendly homes, and a vital part of buildings with no access to power grids. Various national and regional governments, primarily in California, New Jersey, Japan, and Germany, have enacted extensive pro-solar legislation, further helping the spread of solar power. Solar thermal technology, a popular form of which is solar water heating, has become useful for lower-class homes in developing nations. Solar power is known for its ability to dramatically reduce pollution and also for producing reliable, dependable energy. This has resulted in some impressive, and perhaps extraordinary, recent growth in the solar industry.

The growth of the solar power industry in the last 15 years is amazing and should not be ignored. According to Renewable Energy Access, demand for solar has growth by at least 25% every year for the last fifteen years. Clean Edge of Oakland estimates the solar industry at $11.2 billion in 2005, which they claim comes from 55% growth over the previous year, while a DuPont/SEIA report claims that solar had sales of $15 billion in 2005. According to statistics released by Solarbuzz, a solar research group, the amount of megawatts of photovoltaics (the term for electricity-producing solar, as opposed to solar thermal) rose by about 50% from 2003 to 2004, and they estimate that over 300,000 solar systems have been installed worldwide since 1997. Home Power Magazine claims that 156,000 American homes run entirely on solar. The number one solar manufacturer, Sharp of Japan, sold over $1 billion in solar equipment worldwide in 2004, and the other

leading solar companies have also taken advantage of the growing market. What may be most significant is recent growth. MarketWatch of Dow Jones has reported that the solar power industry grew 30% every year from 2000 to 2005, indicating that solar power growth is accelerating, and that solar power is able to compete in modern energy markets.

Not only has there historically been large annual growth in solar for the last fifteen years, there are also forecasts of continued solar growth for the next fifteen years. Clean Edge predicts that the solar industry will climb to $51 billion in 2015. BP has said that they expect solar manufacturing revenue to double from $500 million in 2005 to $1 billion in 2008. They plan to increase their capacity to 200 megawatts per year by the end of 2006 to take advantage of growing solar demand. BP also predicted that the solar industry in Asia may achieve 50% annual growth in 2016, up from 30% in 2006. Photon Magazine, citing Credit Lyonnais Securities Asia, projects that Asian solar panel sales may rise to $36.1 billion in 2010. Backing up these predictions, the Chinese government has announced that they want their solar consumption to go from 20 megawatts per year to 1000 megawatts per year in 2020. Solar power is predicted to become 10% of total worldwide energy in 2030, according to a Time article.

Solar is not just growing, it is becoming more competitive in terms of price also. Solar panel prices fell 60% from 1995 to 2005, according to Time, and another 50% price drop would make solar more competitive with oil and gas. The price at which solar will be better able to compete with conventional energy may be even higher, as factors such as the war in Iraq, the situation in Iran, and Russia's energy takeovers may cause the price of oil and natural gas to rise as the price of solar drops. A German government report has claimed that solar thermal power plants in high sunlight areas can be competitive with oil-based power plants when oil costs $50/barrel or higher, and the price of oil is currently around $70/barrel. Later we will examine the factors that determine solar growth, which include technology, the price of raw material (which for most solar cells is silicon), the demand for off-grid electrification, environmental concerns, and government incentives. Aside from those, the main factor affecting solar growth is its ability to compete with other sources of energy, and if the price of oil remains high it will accelerate solar growth.

At the present time, a comparison of the average cost of solar electricity compared to the price of power grid electricity offered by a major Midwestern utility shows that solar power in America still costs significantly more than traditional power (approximately $0.083/kilowatt-hour from Exelon compared to $3.39/kilowatt-hour based on June 2006 data reported in SolarBuzz). The popular usage of solar power, therefore, depends upon various factors aside from price to achieve mainstream appeal. These include government incentives, the inability to get power from power lines, quantity of sunlight, and environmental appeal. Government programs have a huge impact on solar, as indicated by the fact that solar power has its most widespread usage in Germany, Japan, and California, three areas with extensive government solar incentives. Solar now depends upon government incentives to compete with grid electricity from oil, coal, gas, and nuclear power plants. However, forecasts predict that solar will be commercially viable, and able to compete with the price of oil, in the next ten to twenty years (predictions range from 2016 to 2030). Michael Rogol of Photon Consulting in Aachen, Germany says silicon solar cell manufacturing costs decrease 7 to 10% per year, and there is a lot of research being done to lower the cost of thin-film technology.

This data indicates that solar power, within the last two decades, has a history of strong, steady growth, and industry predictions forecast that this growth will continue, just as strongly and steadily, for the next two decades. The solar market has continuous upward momentum that should spur growth and profits for the next twenty years. Annual growth at the rate of 25% to 55% may continue, making the solar power industry perhaps one of the most exciting opportunities available today. The annual revenue of a 20 megawatt production line has been estimated at $37.5 million to $75 million. However, there are many factors that an investor should consider before investing, which will be presented in the rest of the report.

Now that we have established the potential for growth of the solar energy industry, we will provide a brief overview of the solar industry which will be useful for an investor's general knowledge of solar. To get an idea of worldwide solar usage, the following is a table listing the national solar power usage, from highest to lowest, in 2004. (This data originated from the International Energy Agency, but was configured into this table by Wikipedia.)

Installed PV Power as of the end of 2004					
Country	PV Capacity				
	Cumulative			Installed in 2004	
	Off-grid PV [KW]	Grid-connected [KW]	Total [KW]	Total [KW]	Grid-tied [KW]
Japan	84,245	1,047,746	1,131,991	272,368	267,016
Germany	26,000	768,000	794,000	363,000	360,000
United States	189,600	175,600	365,200	90,000	62,000
Australia	48,640	6,760	52,300	6,670	780
Netherlands	4,769	44,310	49,079	3,162	3,071
Spain	14,000	23,000	37,000	10,000	8,460
Italy	12,000	18,700	30,700	4,700	4,400
France	18,300	8,000	26,300	5,228	4,183
Switzerland	3,100	20,000	23,100	2,100	2,000
Austria	2,687	16,493	19,180	2,347	1,833
Mexico	18,172	10	18,182	1,041	0
Canada	13,372	512	13,884	2,054	107
Korea	5,359	4,533	9,892	3,454	3,106
United	776	7,386	8,164	2,261	2,197

Kingdom					
Norway	6,813	75	6,888	273	0

The same data lists solar use per capital from highest to lowest, in kilowatt per capital, as: Germany (9.62), Japan (8.87), Switzerland (3.12), Netherlands (3.01), Australia (2.6), Austria (2.37), Norway (1.5), USA (1.24). It can be seen that the three big solar users are Japan, the biggest, Germany, the second biggest, and the USA, the third biggest, and that the other countries have considerably less solar usage, although the highest solar usage is concentrated in Europe. The reasons behind solar growth in Japan, Germany and the U.S. will be explained in a later section.

The Solar Energy Industries Association report "The Solar Photovoltaic Industry in 2006" lists national solar manufacturing in 2005 in size from most to least, with Japan (824.3 MW, 45% of world manufacturing), Europe (515.3 MW, 28%), U.S. (154.8 MW, 9%), China (150.7 MW, 8%), and Rest of World (174 MW, 10%).From a variety of sources it has been well established that Japan and Germany have taken the lead in solar usage due to their major pro-solar governmental programs, which date back to over a decade ago.

Solarbuzz data from 2001 lists solar manufacturers in order of size from biggest to smallest as Sharp, Kyocera, BP Solar, Shell Solar, RWE Schott, Mitsubishi Electric, Isofoton, Sanyo, and Q Cells, with the top four companies having over 50% of the market. A 2006 MarketWatch article lists the top two solar manufacturers as Sharp, with 428 MW capacity, and Q-Cells with Sharp and Kyocera are based in Japan, while BP Solar and Shell Solar are multinational companies. A company which previously ranked in the list of top companies, Astropower, went bankrupt during a market downturn in 2002 and its chief assets were acquired by GE. Another company, Nanosolar, in 2006 announced plans to build the world's largest solar cell production factory, in California, and once the plant is completed NanoSolar will join the list of the world's largest solar companies. The solar industry is exciting because there are major established companies, such as BP, GE, Shell and Sharp, but there is room for new companies to achieve considerable growth, as NanoSolar is trying to do.

In terms of technology, there are basically two kinds of PV (short for photovoltaic, meaning producing solar electricity), which are silicon cells and thin-film cells. 90% of all solar panels sold are silicon, but thin-film has become popular due to the recent shortage of silicon. The silicon shortage is the focus on the next section of this report. The other form of common solar technology is solar thermal, which can produce electricity, but because it consists of mirrors and pipes rather than solar panels it is not typically called PV.

Solar panel prices can be viewed in summary. According to Solarbuzz, the average retail price per watt in the U.S. was:

July 2006: $5.44/watt
June 2006: $5.42/watt
Jan 2006: $5.32/watt
Jan 2005: $5.04

Jan 2004: $5.05
Jan 2003: $5.37
Jan 2002: $5.81

Thus, the price has remained fairly steady for the last five years. Mono-crystalline silicon solar cells have the highest price, multi-crystalline silicon solar cells are lower, and thin-film solar cells are the cheapest.

In terms of power output, a solar panel may be 10 to 20% less effective on cloudy days than on sunny days. A one peak kilowatt solar system may produce 1,600 kilowatt hours annually in a sunny region, and only 750 kilowatt hours in an area with less sun. To produce 100 watts a silicon solar panel of 2 feet by 4 feet may be needed, and a 1 kilowatt silicon solar system may need 100 square feet. The area must be doubled for thin-film solar panels. The size requirement of solar panels make them useful for installation on homes or commercial buildings for the purpose of a backup power supply or privately generated environmentally friendly energy, whereas a vast area would be needed for a PV (photovoltaic) power plant. For this reason, most solar power plant technologies are solar thermal.

To get an idea of solar demand by type, the Department of Energy of the United States published data indicating that in 2004, in order of most to least, the use of solar is commercial, then residential, then industrial. Silicon usage far outweighs thin-film usage (with silicon having 90% of the solar market). American solar usage is far more often in grid-connected situations than in off-grid use, but has higher off-grid use than Germany or Japan. There is also a small use of solar for consumer goods, transportation, and water pumping. Approximately 3000 American employees were working for solar companies in 2004, compared to a reported 100,000 solar employees in Germany. Most solar shipments are solar modules that are not part of a complete solar system, as typically the solar equipment is put together by the sales and installation company. Regarding this last statistic, it is known that most solar systems sold are assembled from wholesale parts from different companies by the retail sales company, which typically also installs the system. Depending on the various parts of the system, which are determined by the consumer's needs, the solar panels may be only 50% of the price of the solar system.

As shown in the above data, 90% of world solar sales are silicon solar cells, for which the main raw material in manufacturing is silicon. The rise of silicon has recently been slowed by a shortage of silicon available for solar cell production, and this has had a huge influence on the economics of solar power. For example, an announcement by GiraSolar of the acquisition of several tons of silicon was big news, but would not have been newsworthy if not for the silicon shortage, and several other solar companies have also made announcements regarding silicon supply. The next section explains what investors need to know about the solar silicon shortage.

3. Solar Silicon Shortage:

Silicon is the main raw material in 90% of solar PV cells. The cells require processed silicon. Silicon is made from silica, most commonly found in sand. The most common process to create silicon from silica uses high heat and pollutes, releasing 1.5 tons of carbon dioxide per ton of silicon. According to Professor Beckman and other

sources, most of the silicon that goes into solar cells is not made directly from processed silica, rather it is made from rejects from the computer chip industry, which processes the silica for their computer chips, as the chips require high-grade silicon and solar can use the rejected, lower-grade, cheaper silicon from the computer chip industry. This makes solar silicon of lower grade than the high-grade silicon that the computer chip industry needs. Mono-crystalline silicon, silicon which is cut from a single silicon crystal, is more expensive than poly-crystalline silicon, silicon made of multiple crystals, based on the price of the rejected wafers from the computer chip industry. Silicon is very abundant in nature, in the form of sand, but it has a wide variety of uses, which requires solar manufacturers to compete with many other industries for silicon.

There is a shortage of silicon for solar panels that is driving up the cost of solar and slowing solar growth. What is little understood is that there is not precisely a shortage of silicon as such, rather, the computer chip industry is giving solar companies heavy competition for all available silicon, and they are paying more for silicon than the solar industry can afford to pay, buying up the available silicon and leaving a shortage of silicon for solar manufacturing. Solar panel makers competing with computer chip makers for high grade silicon has led to a state in which silicon sells for $60 per kilogram in long term contracts and $150 per kg in short term contracts. Bloomberg reports that silicon prices have gone from $20-25/kilogram in 2004 to $100-200/kilogram in 2006. The price has gone up so sharply that Phoenix Silicon International, a silicon scrap wafer recycling company which had previously been posting losses, has recently announced record profits and increased orders, despite a $6 price increase per wafer. Solar had grown 30% annually for last five years, but the solar silicon shortage may lower growth to 10% in 2006 and 20% in 2007.

This shortage of silicon has done a number of things. It has slowed solar growth by raising the price of silicon solar cells. It has also led the solar industry to invest in solar research, primarily focused on thin-film solar technology, to find ways to make solar panels without using as much silicon. Research is going into cheaper silicon production and techniques that use less silicon. Thin ribbon technology uses a laser-cut sliver of silicon, which uses half as much silicon as normal. Thin film technology is a term that applies to many different solar technologies, some of which use 1% as much silicon as normal silicon solar cells, some of which use no silicon at all. In general, thin film cells are twice the size of normal silicon cells and are 7 to 10% efficient as compared with a 15% efficiency of normal silicon cells. However, they are cheaper, and since they use far less silicon than normal silicon cells, they are very appealing because of the silicon shortage. It has been predicted that solar companies that use less silicon, such as thin-film technology companies, could escape a supply crunch in 2007 and fare better than silicon-based technology companies in 2007. This has led to investors who like solar into becoming very interested in thin-film and investing a lot of money into thin-film research. This has spurred the creation of Nanosolar, a thin-film solar company that is planning to build the largest solar cell manufacturing plant in the world, employing a patented technology that uses copper instead of silicon, and many other thin-film companies. Furthermore, the prices of solar stocks now go up and down with announcements of the acquisition or loss of stable supplies of silicon. One such instance of this was the public company silicon-based solar manufacturer GiraSolar, which issued

an announcement relating to the acquisition of a supply of solar-grade silicon raw material.

The thin-film craze, and everything else related to the silicon shortage, however, should be viewed with caution by investors. It may be thought that the solar silicon shortage will continue for as long as solar companies cannot outbid the high-grade computer chip manufactures for silicon. This is not true, according to most expert opinions. Reuters, Worldwatch, Marketwatch, BP Solar and Elkem Solar have all said that they believe that the solar silicon shortage will be brought to an end in 2008 by increased production of processed silicon. Elkem forecast that polysilicon supply capacity will grow to 70,000 tons in 2008 from the current level of 34,000 tons. MarketWatch of Dow Jones reported that polysilicon capacity may be 76,000 tons in 2010. Norway's Renewable Energy Corporation, the largest manufacturer of solar grade silicon, said it would double production and build a new plant to add 6,500 tons of capacity. Another polysilicon maker, Wacker of Munich, is building a new plant with 2,500 ton capacity. Wacker will go from 5,500 tons now to 9000 tons in 2008. MEMC Electronic Materials, another silicon wafer maker, has announced plans to double its silicon capacity by 2010. China is also boosting polysilicon manufacturing to 10,000 tons annually in 2009. China's silicon production is not as high a grade of silicon as in other countries, but it will also contribute significantly. It is reasonable according to the laws of economics to expect increased demand to lead to an increase in supply and a consequent downturn in price. Investors who are more cautious and less prone to risk could consider the predictions that the solar silicon shortage will end in 2008, and play it safe by forecasting the silicon shortage to end by 2010, when silicon capacity built in 2009 will be producing.

Another way to look at the silicon shortage is from the point of view of the industry competing with solar, which is the computer chip industry. It is generally believed that every year computers become cheaper and are also capable of doing more, and with laptops it is also thought that they become smaller and more portable every year. With these high expectations from consumers, and high growth in the solar industry, the computer chip makers will themselves face pressure from the silicon shortage, and they will have to compete for silicon, and they may not always be able to bid higher for silicon than solar makers. If a variety of potential factors, including computer prices, new technology, and other market factors, were to reduce the ability of computer manufacturers to pay high prices for silicon, then computer chip makers would have to find ways to make more efficient use of their silicon, and that would also greatly reduce or eliminate the solar silicon shortage.

Based on these predictions it is possible to reach certain conclusions. The main conclusion is that investors interested in short-term payoff can take advantage of the solar silicon shortage by investing in thin-film solar. Investors interested in long-term profits, who want to hold their investments beyond 2008 or 2010, should worry less about the silicon shortage and more about advantages in technology and manufacturing methods. Also, a prediction has been made, which is reasonable according to the data, is that in the post-2008 solar industry, once the solar silicon shortage is over, the rapidly growing solar industry will experience a price war in which the most cost-efficient solar technologies will come to dominate the industry. Thin-film companies with cash from 2006-2007 silicon shortage investments will be able to compete in terms of research and

development, but silicon-based solar cells remain the standard, with their smaller size and higher efficiency. The solar silicon shortage has drastically affected the solar market, giving thin film a distinct price advantage in the next two years, but after that there may be a reverse reaction that will restore an advantage to silicon solar. Because of the complexity and change in solar manufacturing and technology, investors interested in a simple investment in solar may be better off putting money into an electric utility company that uses solar power, or a solar retail sales and installation company. However, there are far more public solar manufacturing and technology companies than there are public solar utilities and sales companies, and most of the solar investment activity is in solar manufacturing and technology. An investor who plans to put money into solar power should understand the differences between silicon technology and thin-film technology, which is explained in the next section.

4. Solar Technology

Once the solar silicon shortage ends, the best solar companies will be the ones that can differentiate themselves from other companies on the basis of their technology and the efficiency, utility, and cost-per-watt advantages that their technology has. The area of solar technology research and development is very active, with participants such as BP, DuPont, MIT and CalTech, as well as many solar companies seeking to develop and exploit proprietary solar technology. What follows is first an overview of the basics of solar technology, and then a list of the different solar technologies that investors should know about.

There are two fundamental kinds of solar, photovoltaic, which produces energy from the chemical reaction of a solar cell when hit by light, and solar thermal, which uses the heat from light to either cook, heat water, heat space, or to produce electricity from heat. Photovoltaic solar panels are normally made of either silicon cells or thin-film cells. A normal silicon solar panel is made when a silicon wafer is cut or taken from a recycled computer chip, and then treated with chemicals on the front and metal on the back to make a solar cell. Solar cells are then connected to form a solar panel. A solar power system, such as the kind that could be installed on the roof of a home, is made of the solar panels and various other attachments that depend upon the needs of the consumer. According to Solarbuzz, the solar panels may be as low as 50% of the cost of the system. Solarbuzz also claims that silicon solar panels typically wear out in 20 years, while the other parts of the system may degrade in only 5 years. In predicting the future drops in solar price, an economist would have to look not only at solar cells, but at the other components of solar systems.

Those other components are needed in this way, according to Solarbuzz: a solar system can be grid connected or stand alone, depending on whether the user is connected to a power grid or not, and it can have a battery or not, depending on whether or not the solar system is being used as a backup. If it has a battery, the battery is normally lead acid or nickel cadmium, and has a 75% efficiency. If the solar output is higher than the battery can take, a charge regulator (also known as charge controller and battery regulator) is required, and the quality of the regulator will affect safety and performance. The system can also be “hybrid,” that is, it uses solar and has some other form of fuel as a backup, typically diesel. A solar panel normally produces DC, whereas most power grids use AC,

so when DC (direct current) must be converted to AC (alternating current), an inverter is required. The price of a solar system, aside from the solar panels, depends on the battery, the battery regulator, the inverter, the wiring, and the installation and retail markup. Most solar systems are assembled from various parts by the retail salesman, otherwise known as the dealer, who also typically installs the system. There are three reliable certifications of solar equipment: the US standard, UL, and two international standards, IEEE or IEC.

As mentioned above, the two main types of solar power are photovoltaic and solar thermal. In the US, the vast majority of solar shipments are photovoltaic, according to the DOE. According to International Energy Agency statistics, the worldwide use of solar has more solar thermal than PV. The two most popular types of solar thermal are solar water heaters and solar thermal power plants. Professor Beckman claims that solar water heating is the single most pollution-reducing type of solar equipment, with the potential to cancel as much pollution as a family car produces. The use of solar water heaters has been embraced by China. Solar thermal power plants capture sunlight and use it to heat a liquid that boils up through turbines that spin to produce electricity. IEA argues that for solar power plants, the main constraint is the very large area of land that must be used for large-scale solar electricity production. Solar thermal power plants are the most efficient in terms of the most power for a large area, and three of the most famous solar power plants, SEGS, Solar One and Solar Two, all use solar thermal. All three are in southern California, and they give 354 megawatts of solar electricity to the Los Angeles power grid.

Photovoltaics are ideal for local use, on the roofs of homes and commercial buildings that want environmentally friendly energy, need backup power systems, or cannot connect to a power grid. The two kinds of PV are silicon cells and thin-film cells. The two kinds of silicon cells are mono-crystalline silicon, and multi-crystalline silicon (which is also called polysilicon). Mono-crystalline silicon is cut from a single silicon crystal, and is slightly higher priced and slightly more efficient. Multi-crystalline silicon is made from multiple small silicon crystals, and is slightly cheaper but slightly less efficient. Ninety percent of photovoltaic solar cells sold are silicon cells, as they take half as much space as thin-film and average 15% efficiency compared to thin-film's average 7 to 10% efficiency, but thin-film has become popular recently due to the solar silicon shortage.

Thin-film cells are about half as efficient as silicon cells and use twice as much area, but they are significantly cheaper and use 1% as much silicon as silicon solar cells, and sometimes use no silicon at all. The solar silicon shortage has prompted research and development of many different thin-film technologies. NanoMarkets LC, a research firm, predicts that revenues from thin-film solar cells, including technologies such as amorphous silicon, CIGS, polymers and organic dyes, may be $2.3 billion in 2011. NanoMarkets says that thin-film advantages include flexibility, weight, and ease of integration into buildings and products, but that it is at a disadvantage in terms of price per watt.

US DOE data shows that in America in 2004, there were far more silicon sales than thin-film sales, that there were more multi-crystalline silicon sales than mono-crystalline sales, and that the ratio of multi-crystalline to mono-crystalline sales is going up. In spite of the large majority of the solar market going to silicon cells, the majority of investment and research is going into thin-film, largely because of the silicon shortage.

The best example of this is Nanosolar. Nanosolar is a solar startup founded by a dotcom millionaire and using $125 million in venture capital, including investments from the founders of Google, E-Bay's banker Benchmark Capital, and solar specialist Grazia Equity. Nanosolar has announced plans to build the world's largest solar manufacturing plant, in California (although they plan to ship all their solar cells overseas to be assembled and sold in Germany). Nanosolar's plant may have capacity as great as over 25 megawatts. Nanosolar claims that their proprietary technology, protected by multiple patents, will enable thin-film with no silicon that will be as efficient as silicon cells and cost one-fifth their price. The primary appeal of the Nanosolar method, which prints photovoltaic copper ink onto flexible foil, is that it gets around the solar silicon shortage, and it is also believed that flexible solar cells will have greater utility. Nanosolar may stumble when the silicon shortage ends, but it is an example of what solar investors must look for, companies with patented solar technologies that have some form of advantage over competitors. We will proceed to explain the various kinds of solar technologies that are being developed.

Silicon solar cell technology seems to be fairly standard, and most of the technological research is focused on thin film solar. Most thin film consists of a solar absorbing substance sprayed onto a backing, or applied via gas to a backing, or, more recently, of a solar ink printed onto a backing. Thin film is named for the very thin sheet of light-sensitive material that it uses. The thin film technologies differ primarily based on the material that is used. Thin film typically uses 1% or less of the silicon of normal silicon, is cheaper, and is also sometimes flexible, but is less efficient. Thin film is often printed onto foil, making it flexible.

Amorphous silicon is one thin film substance used. Amorphous silicon is silicon in a non-crystal form, with defects in its atomic bonds. A thin layer can be sprayed onto a backing to make thin film amorphous silicon. It is cheaper, but less efficient, than normal silicon, and it only absorbs the visible spectrum of light. Nano-crystalline silicon, also called micro-crystalline, is a kind of silicon that is amorphous but contains small crystals. It is easier to make than normal silicon, absorbs a broader spectrum of light than amorphous, and is flexible.

Three other kinds of thin film are CIGS, cadmium telluride, and CIS. CIGS stands for copper, indium, gallium, and selenium. The chemicals are mixed to form a thin-film PV with up to 14%, or by one report 16.5%, efficiency. It uses a more complicated kind of chemical reaction than silicon. CIGS is known to get better efficiency when concentrating mirrors are used. Cadmium telluride, known as CdTe, is another kind of thin film. It has useful qualities, but has the problem that the substance is toxic. CdTe is also less efficient that silicon, although it is cheaper to manufacture. CIS, a kind of copper chalcogenide film, can be 11% efficient, but is expensive.

Gallium arsenide multijuntion is a kind of thin film designed for high cost high efficiency usage, typically for special industrial use. It is comprised of layers of different thin film materials, each of which absorbs a different spectrum of light. It can be as high as 39% efficient, a number that other solar cells can only achieve in laboratory conditions and not in manufacturing conditions, but it costs $40 per square centimeter.

Two area of thin film research that has received much attention are dye solar cells and organic/polymer solar cells. Dye-sensitized solar cell use an iodide electrolyte between two electrodes, one of which has titanium dioxide and dye. The dye works

similarly to the photosynthesis of plants, and creates an electric current from light. It is cheap and simple to make, but wears out more quickly, as it degrades from UV light. The organic PV/polymers/small molecules class of thin film is made from organic semiconductors, polymers and small-molecule compounds. These have been known to include polyphenylene vinylene, copper phthalocyanine and carbon fullerenes. This type of thin film also degrades from UV light and wears out quickly

The final type of alternative to silicon solar technology that investors should know about is quantum and nano-technology. Quantum dots are a kind of non-silicon semiconductor nanocrystal which may yeild high efficiency. However, it is still in the laboratory development stage. Renewable Energy Access reported that BP Solar and CalTech are trying to develop solar nanorods, microscopic rods of silicon that will increase the surface area of solar cells for better cost efficiency. This technology is also in the development stage.

There are two kinds of PV which are more a modification of existing technology than a new type of technology. The first is transparent PV, intended for use in windows. Transparent PV is still in laboratory development, but the prototypes have reportedly demonstrated poor quality. The second is so-called “black” silicon, in which microscopic dents and bumps across the surface of the PV create a larger surface area that can be exposed to light. It is believed that this will raise efficiency, but is still in development.

An investor who wants to invest in a solar manufacturing company will need to know what kind of solar technology is going to be employed in manufacture, and investors who want to put money into solar research and development companies will also need to understand the technology. What the above review of solar technologies is intended to show is that the different solar technologies each have advantages and disadvantages, and the investor will have to speculate and try to predict which set of qualities will be most appealing to solar consumers. The different factors to consider include manufacturing cost, amount of silicon required, the product’s price per watt, the product’s efficiency, and the product’s flexibility and ease of being integrated into buildings and other products. In general, all of the excitement and attention is being given to thin film research, but silicon remains the most established and widely used solar technology, and investors should not ignore solar silicon companies or research into improving silicon solar panels. Because most solar systems are assembled by the dealer, and most solar dealers operate locally, it is difficult to invest directly in solar sales companies that target a specific region, and the best solar investments may be investments in manufacturing technology. Investors should also heed the warning it is difficult to convert individual lab experiments in a laboratory environment into large-scale production in a manufacturing environment, and difficulties including loss of efficiency have resulted from the change from lab to plant. These costs must be considered when investing in a laboratory stage technology development.

One interesting way to invest in solar is to ignore photovoltaics in favor of solar thermal. As we will examine in another section, much of the market for solar is in developing countries, and both solar water heating and solar power plants appeal to Third World markets. According to Professor Beckman, a solar water heater, a device with a clear front and a backing that causes water to absorb heat from sunlight, is the most pollution-reducing solar technology, and he also claims that solar thermal power plants could be easily replicated in developing countries, to maximize the solar electricity in

countries that are electricity-deficient. A report by the German government on power plants found that solar thermal power plants are favorable and highly efficient, and that an operating solar thermal power plant produces the equivalent of heat from one barrel of oil at a cost of $50, and this will down to $20 in the near future. Solar thermal is often ignored in favor of the more glamorous photovoltaics, but this may change in the future. This section will conclude with a brief account of solar thermal power plant technology.

Solar thermal power plants work when a solar collector heats a liquid that boils, producing steam that goes through turbines, turning the turbines to produce the electricity. The three popular kinds of solar thermal power sources are dish/engine, parabolic trough, and central power tower. A dish/engine system consists of a solar concetrator, the dish, that focuses sunlight onto a receiver that converts the light to heat, and then the engine uses the heat to move pistons. The next two technologies are more popular. In a parabolic trough, mirrors in a parabola-shaped trough focus sunlight into a pipe filled with liquid that heats. One example is SEGS in the Mojave Desert of California, which is reported to be the world's largest solar power plant. With central power towers, a field of sun-tracking mirrors all focus sunlight to a receiver at the top of a tower that heats fluid. Examples include the Solar One and Solar Two solar power plants in California. The success of SEGS, Solar One and Solar Two indicate that in the future, if there is support for solar power plants, then the technology to do that is viable and commerically feasible.

Investors who get excited about specific new solar technologies should have some caution. Silicon remains the dominant technology, there has yet to be a new thin-film solar technology that has become popular, and if the solar silicon shortage ends it will put a damper on the thin-film craze. (The one exception, as will be explained below, is that thin-film is ideal for markets in poor developing countries.) It has also been said in multiple sources that there is high cost and high risk associated with converting solar technology in research lab conditions to the conditions of mass-production manufacturing, the risk being that solar cell efficiency is compromised in favor of manufacturing solutions. There is the possibility that a new technology could take off and skyrocket to industry superiority, but investors should be very careful before they gamble on that happening. It is also reasonable to assume that in the future, solar technology trends will go in two different directions: towards the goal of high efficiency for industrialized wealthy nation markets, and towards the goal of low cost for impoverished developing country markets (these markets will be examined in the next two sections).

In order to see which technologies will appeal to consumers, it is necessary to understand the markets for solar power, which will be analyzed in the next two sections. First we will look at markets in industrialized nations with government support for solar, and then developing nations in need of electrification. It is also worth noting that, according to Professor Beckman, the major factor in the development of solar is not that the technology needs to be improved, rather it is the need for solar government incentives, and some data suggests that this view is correct.

5. Solar Markets: Industrialized Nations and Government Incentives

In order to forecast solar growth, an investor should understand solar markets. There are fundamentally two markets for solar, industrialized nations with governmnent

incentives, and developing countries in need of electrification. Some areas of the world are sunny, such as equatorial regions, while some areas have less sun, such as more northern areas. Solar resources, or in other words sunlight, are dispersed across the planet. Most areas have enough sunlight to take advantage of solar potential. Sunlight is free, and therefore once the solar equipment has paid for itself, or in other words the cost is exceeded by the savings, solar power is basically a completely free supply of energy. However, due to the high cost of solar equipment, solar does not compare favorably in terms of price per kilowatt-hour with conventional fossil fuels such as oil and natural gas. In situations where electricity from coming from a traditional power plant through the power lines of a power grid is available, it is necessary for there to be government solar incentives in order for solar power to compete with grid electricity in terms of price.

The vast majority of citizens in industrialized nations are grid connected and do not want to pay more for power than they have. Because of the this, the main factor for solar consumption in industrialized nations is the government incentives that make solar more affordable. This idea is proven by the fact that, despite bad sun conditions potentially cutting solar power output in half, there is in general far more solar consumption in cloudy regions with solar incentives than in sunny regions with no incentives. Solarbuzz claims that solar power may cost 3 to 5 times more than grid power, and that a one peak kilowatt solar module may cost $8,000 to $12,000 and make take ten to fifteen years to pay for itself, but that the factors that can enable solar to compete with the grid are high grid rates, government incentives, a sunny environment, being able to sell excess power back through the grid to the utility, and being unable to connect to a grid. This section of this report will proceed to outline the distribution of solar resources across the planet, and then look at the governmental solar incentives in the three primary industrialized solar markets, the United States, Germany and Japan.

According to the Energy Information Administration of the US Department of Energy, the best solar potential in the US is in Southern California, Southern Nevada, Arizona, New Mexico, and Western Texas. Almost all of the American West, Midwest, South, and Southeast has high solar potential. The areas with high solar potential across most of the state include California, Nevada, Arizona, New Mexico, Texas, Florida, Georgia, Utah, Colorado, Oklahoma, and Kansas. The IEA reports that the some of the areas with the best sunlight are Meditteranean countries, in both Southern Europe and Northern Africa, and Australia. India, Africa, the Middle East, and South America all get a lot of sunlight, while Northern Europe, Canada, and Northern Asia have poor quality sunlight. Better sunlit areas can get as much as twice the output from a solar panel as an area with worse sunlight conditions.

Based on these statistics a person would not expect the top two solar uses to be Japan and Germany, but government incentives have resulted in that situation. It has been estimated that Japan has installed as many solar systems in the last decade as the rest of the world combined, and that Japan and Germany have each installed over 100,000 solar systems since 1997. American solar installations are estimated at 100,000 since 1997 by Solarbuzz. The US Department of Energy reports that in 2004, solar power provided 0.06% of America’s energy. Measured in quadrillion Btu, American solar use ranged from 0.063 to 0.066 from 2000 to 2004, and during that same time production from American solar power plants ranged from 0.005 to 0.006. American domestic solar cell shipments have more than quadrupled from 1995 to 2004. Still, American solar usage

does not come close to taking full advantage of the American solar resources, and this is because in America solar incentives at the federal level are deficient and the state governments offer the major solar incentives, which vary from state to state. We will look at American solar incentives, and then look at Germany and Japan.

In America, President Bill Clinton had a national Million Solar Roofs Initiative in 1997, but it was never funded and it did not accomplish anything. Nine years later, President Goerge Bush Jr. announced a Solar America Iniative as part of his Energy Iniative and the 2007 federal budget. Originally set at $148 million to commercialize solar by 2015, it was raised to $170 million with the goal of reducing solar costs by 2010. The American federal solar incentives are incredibly minor compared to what they could be, as shown by the following data. The American state of California spends $3.2 billion on solar power, compared to the American national government spending of $170 million. Also, the Iraq War has cost the USA a total of $400 billion dollars, which can be seen as an investment by the American government in oil imports from the Middle East. Considering this, U.S. national solar spending is inadequate and disproportionately small. The failure of the federal government has left the responsbility for promoting solar to the state governments, some of which has made large commitments to solar, others of which have ignored solar potential.

The area in the United States that has the best market for solar power is California, which combines high quality sunlight in southern California with extensive solar incentives supported by the state legislature and Governor Arnold Schwarzenegger. California has a Million Roofs Initiative, and also has a policy called the California Solar Initiative, with a $3.2 billion budget for installation rebates. California law also forces electric utilities to buy back a percentage of home solar power produced by grid-connected homes, and forces large home builders to offer solar options to customers. It was reported that the California Energy Commission's Emerging Renewables Program and the Public Utilities Commission's Self-Generation Incentive Program caused a 36% solar price drop from 1998 to 2004 in California. The combination of rebates for home solar installation and the ability to sell excess solar power back through the grid has made solar affordable and competitive in California, and California solar is also being promoted by such celebrity charities as that of actor Edward Norton. Two of the world's largest solar power plants (both of which are solar thermal), the SEGS and Solar One, are in southern California and supply a large quantity of solar-generated electricity to the Los Angeles power grid.

New Jersey is the only other state with solar incentives that come close to California's, with rebates that cover over half the price of solar installation, and grid buybacks as part of pollution credits. Over 1000 solar systems have been installed in New Jersey, which is not a high sunlight area, on the strength of state government incentives including the Clean Energy Program and Customer Onsite Renewable Energy rebates. This is another example of proof that government incentives can compensate for low sun areas in promoting and commercializing solar power. Only California and New Jersey allow rollover of grid buybacks to the following month. To summarize other state solar incentives, 17 states, including New York, Massachusetts, Illinois, and Rhode Island, have solar rebate programs, while 35 states plus the District of Columbia allow solar grid buybacks. It has been claimed that after California and New Jersey, the region with the best state solar incentives is New England. There have also been several reports of solar

power plants being built in Florida. In general, however, the best area in the United States for solar, the only state that combines ample sunlight resources with billion-dollar solar incentives, is California. California should be viewed as the number one solar market in North America.

Solar incentives in countries outside of America are clustered mainly in Japan and Germany, although Italy did enact a 10,000 Roofs Program in 2001 to offer subsidies for solar installation. Japan enacted legislation to promote solar in one way, with installation rebates. According to one report, in 1994 Japan created a 70,000 Roofs Program offering a 50% rebate, with an original budget of $18.3 million. They also created the New Sunshine Program in 1992 to require utilities to allow grid buyback of home excess solar power. The Japanese government felt that their program was a success, as the 70,000 roof goal had been met, and they reduced the rebate to 15%, in 2003, but raised the budget up to $186 million. Another source offers similar, but slightly different, numbers. This report claims that Japan's solar spending averaged $115 million per year from 1996 to 2006, and that rebates now cover 10% of installation cost. This source also claims that Japan's government support for solar has caused a 75% drop in solar prices (partially due to advancements in technology and installation methods), that solar power usage has increased by a multiple of 35, and they further report that Japan wants half of all new homes built in 2010 to be solar.

Japan now leads the world in both solar technology, solar manufacturing, and solar installation. A valuable lesson can be learned from the example of Japan. Japan combined several factors, including an absense of domestic fossil fuel resources, large government incentives for solar use, and multiple domestic electronics companies working on solar, to take the lead in PV research and PV usage, despite the cloudy climate. This not only supplies Japan with domestically produced reneable energy, decreasing its foreign oil and gas imports, it also puts Japan in a position of global solar industry leadership, which enables it to export solar products to other countries to help its trade balance. As the demand for renewable energy grows, this investment will be of increased benefit to Japan. As such, government incentives for solar can be seen as a public investment in the environment, energy independence, and economic growth, and it shows that any government with a political desire to promote solar does have the effective means to do so.

Germany went about promoting solar in a different way, focusing on making solar cost-competitive by increasing the price at which home solar users could sell their excess energy back through the grid to utilities. Germany, in 1998, created a 100,000 Roofs Program, which offered favorable loans for PV installation, and ended in 2003 when target was met. However, their most influential program was the Renewable Energy Sources Act, also called the Feed-In Law, which mandates that German power utilities had to buy back excess electricity through the grid at a very favorable price. This enabled Germans to finance their solar purchases with grid buyback money, and promoted a robust growth of solar usage among Germans. This had led the German solar industry to grow, with active German solar research and multiple solar manufacturing companies, and Germany is now the number two leader in solar power. Germany has also taken a lead in solar thermal development, which is an increasingly important and underappreciated aspect of solar technology.

Another main factor in solar growth in industrialized nations is the trend of "green building," which is becoming increasingly trendy and popular. A green building is a building that is designed to be environmentally friendly, by reducing waste, using appliances that use less energy, better insulation to keep heating and cooling costs down, using green power sources such as sunlit rooms and roof-mounted solar panels, and most of all by being energy efficient and reducing energy demand. Green building's growth will directly influence solar grwoth, both because integrating solar power into green buildings is common, and also because energy efficient buildings with reduced electricity needs can typically get 100% of their electrical needs fulfilled from solar panels on a normal-sized roof, as opposed to non-green buildings that can only meet approximately 75% of their needs with on-site solar power. Also, solar equipment is often cheaper to install when it is integrated into a newly built building as opposed to being added to an already constructed building. Because green building has been shown not just to be environmentally responsible, but also to significantly save money in energy costs, we can expect the green building trend to continue in homes, commercial buildings, and factories.

Two conclusions for investors can be reached on the basis of this data. First, much of the industrialized world has large untapped solar potential because their governments do not offer solar incentives to make solar competitive, and if in the future a country enacts legislation to promote solar power and offer solar incentives, then the investor should look for solar companies positioned to be able to take advantage of that newly created market. Italy may become such a market, Spain is active in solar, and other European and Mediterannean countries are also candidates. Switzerland and Austria have also enjoyed some success with solar use. France is relying heavily on nuclear for its power, while Britain is seriously considering new nuclear plants as well as more coal. As pollution from coal, as well as oil, and the storage of nuclear waste becoming issues, these countries may turn to solar as an emissions-free power source, and the success of British Petroleum's BP Solar department could also help that. Russia is seeking a dominant position in world energy production and is agressively pursueing that goal, and solar may become a part of that strategy down the road. Canada has passed some solar incentives, and the Canadian north has the unique situation of longer days in spring and summer, which means more sunlight each day (although their winter days are also shorter). And lastly, spread across much of the southern United States is untapped solar potential that could raise U.S. energy independence and lower air pollution.

Second, because most solar modules are assembled, sold and installed by local solar dealers, it is difficult to invest in a specific retail market. Instead, the investor must look at manufacturers whose sales are directed towards that market. This may change, however, as solar retailers grow and consolidate, and also due to internet retail solar sales. Another thing that may change this is the recent development of utilities specializing in selling solar power over the grid to consumers who want green power (such as SunEdison of Baltimore). If such utilities can grow and compete with rival oil-based and nuclear-based utilites, this would enable direct investment in specific regions. Solar companies that are taking advantage of solar demand in California, Japan, and Germany have high growth solar markets to sell to, and these markets should remain strong for the foreseeable future. As the majority of solar manufacturers target Germany and Japan, one might say that California is the solar market with the highest untapped

demand and potential future growth, which is one reason why NanoSolar's decision to build solar panels in California and then assemble and sell them in Germany may not be the best plan, as it leaves the California opportunity open to competitors.

We conclude this section by mentioning that in a few instances in industrialized countries, solar power can compete with conventional power in terms of cost. The German government recently issued a study claiming that solar thermal power plants could compete with oil-fired power plants if the price of oil is $50/barrel or greater (and it is around $70 as of the date of this report), and that in the future solar power plants will be able to compete with $20/barrel oil. The study noted that the deserts of the Middle East have extraordinary sunlight resources, such that 1 square kilometer of Mideast desert could produce the energy equivalant of 1.5 million barrels of oil per year. The study indicated that collaberation between Europe and the Middle East could help to develop desert solar plants. The study concluded that such Mideast desert solar power plants could provide 100% of Europe's energy demand in 2050 while cutting energy-related CO2 pollution by 70%, and that the world's deserts receive enough sunlight resources to meet 100% of world energy demand. Critics of solar power often say, in response to claims that solar power could meet all global energy demands, that you would have to cover whole countries with solar panels to get that power. This is highly misinformed, as the most efficient solar power plants are not made of photovoltaic solar panels, they are solar thermal power plants, made of mirrors and pipes, which can be the size of a typical power plant and produce as much electricity as a typical power plant when placed in a sunny area. Furthermore, when the "Peak Oil" scenario, the depletion of global oil reserves predicted by Hubbert's Peak, reduces the oil resources of Middle East countries, those countries may turn to their solar resources to maintain their dominance in world energy markets. This can be seen already in Dubai of the United Arab Emirates, which has become a center for solar research including research into solar thermal power plants.

6. Solar Markets: Electrification of Developing Countries

In the majority of cases in industrialized countries, the public has access to electricity supplied to their building from a power utility company, via power lines that connect the building to a power grid. The power companies may produce their electricity from oil-burning power plants, coal-burning plants, natural gas-fired plants, or nuclear power plants. In these situations, in order for solar power to be practical in economic terms, it must be able to compete with the price of electricity produced from the so-called "conventional" sources, oil, coal, nuclear etc. If solar is significantly more expensive than oil power or nuclear power, government incentives are required to make solar power cost competitive, since the free market will not support solar power. However, in the majority of cases in developing countries, the rural areas do not have access to power lines, and in the urban areas the supply of grid power is often unreliable and subject to regular blackouts. In these conditions, if solar power is cheaper than the cost of connecting and installing power lines, or if solar power is more reliable than the conventional power grid, then solar power can achieve widespread demand in free market conditions.

In fact, it has been shown that in most cases solar power installation is cheaper than the cost of bringing power lines to rural villages, and it is also more reliable than the power grids in many Third World cities. Thus, developing countries are an ideal market

for solar power, and this market is underappreciated and full of untapped potential. To get an idea of the size of this market, consider our claim that most of the people in the developing world could easily become solar power consumers, and then consider the population statistics. The population of India is estimated at 1.1 billion, China is believed to have 1.3 billion, and both countries are expected to have significant population growth in the future. Africa has an estimated population of 840 million, while South America is estimated at 371 million. To look at one country as an example, we can consider Bangladesh, in southern Asia, which has a population of approximately 130 million. This means that once solar companies target these markets effectively, there may be over 3 billion new solar customers. A more conservative estimate from the International Energy Agency claims that there are currently 1.6 billion people worldwide without electriricy, and that half of those cannot get access to power lines, for a potential solar consumer market of 800 million people. There are, of course, some obstacles to this, like the poverty of the people in these areas, but there are ways to overcome those obstacles, such as microcredit loans. Once the solar industry takes advantage of the developing countries market, solar sales will accelerate considerably. The fact that solar power makes sense financially for 3 billion of the world's inhabitants hints at the future growth potential of solar, which already has a history of high growth. A DuPont report claimed that in 2005 over four-fifths of the world's PV systems were used in grid-connected applications, indicating that the off-grid PV market is unexplored territory ripe for being targeted.

The analysis of developing markets can be divided into two groups, the industrializing China and India market, and the many other developing areas with slower growth, an example of which is Bangladesh. In regards to China, the world's largest country (in terms of population) and India, the world's largest democracy, these two countries combines several unique factors, including: rapid economic growth and industrialization, economic stimulation from international trade and jobs due to outsourcing and manufacturing, national governments that engage in extensive public programs, and majority percentages of the populace living in low-income rural areas far from cities and with no access to power lines. The combination of these factors make China and India the most ideal solar markets in the developing world. In fact, much of the rise in the price of oil has been due to forecasts that the rapid industrialization of China and India, and their resulting thirst for oil, will put strains on world oil supplies in the future. There are also grave concerns over the quality of air in China and India, which is being poisoned by industrialization-related air pollution. This is in part due to pollution laws that are less strict than in the West, and also from the extensive burning of coal and oil for power plants. An ideal solution to help these two problems is renewable energy, and the governments of both China and India recognize that solar power could be a major help to them.

The Chinese government has announced a plan to spend $1.21 billion dollars to help install solar power systems to electrify the rural areas of western China. Western China is a vast area with hundreds of millions of people, and for most of them it would be cheaper to give them solar panels than to bring in power lines. The Chinese electrification market has amazing potential and governmental support. One Chinese company has reported that the Chinese people are now using over 30 million solar water heaters to heat their water, and this supports our previous claim that solar thermal water heaters are one of the best and most underappreciated solar devices, being a cost-effective way to save

electricity and prevent pollution. The President of India has also announced that solar power is a high priority for his government, and that he wants 55 MW from solar power and 25% of all power to be renewable within 25 years. In the Indian capitol city of New Delhi, a law has been proposed that would require every commerical building in the city to use solar power.

The Chinese and Indian villages can benefit from on-site installation of solar panels onto their buildings, but there is also potential to provide more reliable electricity to Chinese and Indian cities from solar power plants. One German company is planning a 50 MW solar power plant in the Mongolia region, and with China's thirst for energy, and the Chinese government's ability to invest in energy, we believe the market would support multiple solar power plants. It has been suggested by Professor William Beckman that solar thermal power plant designs, such as SEGS of California, could easily be applied to China or India, and both countries have the sunlight resources and the financial resources to build solar power plants. The more that the China and India economies grow, the more attractive pollution-free, highly reliable solar power plants will become.

Investors should also consider the potential solar demand in the rest of the developing world, outside of China and India. These countries, in which the majority of villages are in remote rural areas with no power grids, contain situations in which solar power is a cost-effective electrification solution. As indications of this, it has been reported that the Philippine government is giving out 15,000 solar modules for rural electrification, and that solar power is being used to electrify 200 rural villages in Nigeria, and is also helpful for providing power to schools in Uganda. However, the poverty and stagnant economic growth in most developing countries is a major factor that must be considered. To get an idea of the real solar potential in these markets, we can look at an example, the country of Bangladesh.

It has been reported that in Bangladesh, over two-thirds of families do not have access to power lines. With a population estimate of 130 million, that is 87 million people in rural villages in need of electrification. The Bangladeshi government has stated that 70% of the population lives in areas that are too remote for power lines to be brought in. Furthermore, while there are no power grids in most of the country, the power grid of the capitol city of Dhaka is unstable, unreliable, and prone to regular blackouts. The total potential solar consumer demand may be 130 million people.

However, the Bangladeshi people and their government have turned to solar power to aid electrification. Efforts have led to 80,000 solar-powered homes in Bangladesh, but that is minor compared to the need for electrification. The main obstacle to solar growth, which is widespread among Third World countries, is that the majority of the people do not have the money to afford to buy and install solar panels. In fact, the cost of solar installation is almost equal to the average yearly income. In these cases solar power is the most affordable energy source, but there is no money to invest in it. There are two prominent ways through which this obstacle can be overcome, after which the developing countries solar market will become viable.

There are two primary solutions that will enable the developing country solar market to be taken advantage of. The first is microcredit loans, either from the national government, World Bank, NGOs, or private banks. The Grameen Bank of Bangladesh pioneered microcredit loans, very small loans to poor people with the goal of improving

the standard of living and with an organized system to promote repayment. It has been shown that microcredit loans can finance solar installation for poor rural villagers, because the monthly repayment is similar to what those people would otherwise pay for their energy needs. Because solar power is actually the most cost-effective method for electrification in these cases, the loans can be justified. The phenomenon of "globalization," the continued outsourcing of jobs in manufacturing and technology from the industrialized world to the developing world, has spurred growth in India and China, and its influence may spread. If globalization continues, it will make the electrification of developing countries more profitable by creating jobs in impoverished areas that have electricity. Third World globalization-related economic growth will cause more demand for power and a demand for more reliable power. The governments in these countries are often unable or unwilling to provide solar incentives, so solar must be funded in other ways, and the activity of organizations such as the Grameen Bank and the World Bank perform this function. One main factor to look for in solar markets is to see in which countries there is international aid going towards solar electrification. In the case of Bangladesh, a combination of Grameen Bank microcredit loans and government renewable energy spending are helping to continue solar electrification. In addition to microcredit loans, spending by international charities can also help fund Third World solar purchases.

The second solution is solar power technology specifically designed to be cheap and affordable for rural villagers. It is clear that thin-film, which is cheaper than silicon but takes up more space than silicon, is idea for rural electrification in areas where people have plenty of land and not very much money. Because of its suitability for the developing country electrification market, it may be the case that the current trend in thin-film research towards higher efficiency with the intent of competing with silicon panels is not going to be as profitable as thin-film research focusing on lowering the cost of thin-film. In fact, silicon is not as well suited for developing countries as is thin-film, and one strategy would be for thin-film companies to ignore the silicon-dominated industrial markets and focus on developing super-cheap thin-film for Third World electrificiation. Emerging thin-film technologies that are extremely low cost but require large areas for installation may end up becoming the dominant thin-film technology when the developing world solar market is targeted.

There are also two groups, both originating from MIT research, which have developed extremely affordable solar thermal equipment using parabolic trough design for the purpose of the electrification of poor villages. These solar thermal designs incorporate spare parts, from cars, plumbing pipes and other sources, which are available and cheap, as well as new technology such as sun-tracking devices, and they use mirrors to heat liquid which then can be used to power a motor, instead of photovoltaic solar panels. The result of the use of non-solar parts is that these modules cost significantly less than a typical solar module made from solar-designed parts. There may be significant progress in super-cheap solar technology designed for the poor developing world electrification needs, and with 3 billion potential customers this technology has an attractive market. It has been reported that $200 solar modules are being sold in Uganda, and some people want to bring the cost of Third World solar equipment down to $100 per unit. Strangely, much of the work being done on this is through charity organizations, even though a super-cheap solar technology could possibly make millions if it could

achieve manufacturing costs lower than the prices that rural villagers can afford to pay for solar. These systems, currently targeted for African use, could significantly lower the solar module installation cost in Bangladesh, bringing solar electrification within the reach of millions more consumers.

To conclude the analysis of worldwide solar markets, we can look at information about American solar equipment exports issued by the U.S. DOE. In 2004 the vast majority of exports went to Germany with 41%, the next highest destination was Hong Kong with 11.5%, and every other country received minimal exports of under 4%, with India, China and Bangladesh all receiving 1% or less. Obviously, the two main solar markets, Japan and Germany, have their needs met by Japanese and German solar manufacturers. Aside from targeting solar growth in California, solar companies have two promising paths to pursue. The first is to market high-end high efficiency silicon solar modules to promising industrialized markets such as Italy, Spain, Austria, and Switzerland, as well as Canada and New Jersey, and anywhere else where there are solar government incentives. The second is to target developing country poor rural village electrification needs in places such as Asia, Africa, and South America with super-cheap solar modules backed by microcredit loans. In both cases there are high potential export markets waiting to be exploited, and the first companies to branch out from the Japan-Germany-California market and explore new markets may be able to achieve some superiority in emerging solar markets. Altogether, the analysis of global markets supports the conclusion that the solar industry has the ability to maintain its 15 year history of high annual growth with what will probably be another 15 years of high annual growth. As renewable energy becomes more popular with the public, with investors, with businesses and with governments, solar may emerge as one of the stars of the renewable energy trend.

7. What Investors Should Know About Solar

We shall finish this report by listing and then summarizing the conclusions of the report that are important for solar investors to know about before putting money into solar stocks. The topics covered include solar industry growth trends, the solar silicon shortage, silicon technology, thin-film technology, solar-thermal technology, research-state technology, industrialized markets dependent upon government incentives, and developing markets with a demand for off-grid electrification. At the end of the report will be recommendations and a detailed plan of action for investors considering solar power stocks.

Here is the list of this report’s conclusions:

List:

1. Solar power is hot. The solar industry has a 15 year history of 25% annual growth.
2. The solar silicon shortage will probably end some time from 2008 to 2010.
3. Silicon solar technology has the majority of the market, and when the silicon shortage ends it will see even higher growth, particularly in the industrialized nations market.
4. The silicon shortage has created a thin-film craze, and thin-film technology may be overvalued. However, cheap thin-films are well suited for the developing countries market.

5. Solar thermal technology is underappreciated and undervalued, and solar thermal power plants and solar water heaters may see high growth in the future, in both industrialized and developing nations.
6. A new solar technology may become popular in the future and one day challenge silicon for industry dominance, but it is diffuclt to move technology from laboratory to factory, and solar R&D investments are high risk gambles.
7. Industrialized nations depend upon government incentives for solar growth. Japan, Germany, and California have taken the lead as primary solar markets, with several other countries close behind. Silicon is the best technology for these markets.
8. Developing countries hold potentially 3 billion new solar customers for whom solar power is the most cost-effective method of electrification. Once the financing for poor people in need of electrification is arranged, these will become vast and untapped markets for solar sales. Thin-film and other super-cheap designs can best take advantage of these markets.
9. A careful and knowledgable investment in solar power could produce significant profits. Solar growth may show short-term growth and, as the silicon shortage ends and more countries are opened up to solar sales, the industry may achieve even higher growth in the long-term.

Summary and Recommendations:

Solar power has grown 25% every year for the last 15 years, 30% annually for the last five years, and there is every reason to expect this rate of growth to continue for at least 10 to 20 more years, as markets in both developing and industrialized nations open up to solar sales. There are two main factors in solar growth. The first is the situations that make solar able to compete with conventional energy sources, which in industrialized nations consists of government incentives, and in developing countries consists of the need for electrification in areas that cannot become grid-connected. The second is the availability of sunlight resources. There is no cohesive solar policy in the E.U. or U.S. or the rest of the world, but individual country and state efforts can have huge effects, as for example in California, New Jersey, Germany, and Japan. In something that is hard to believe, government support matters more than sunlight resources, even though sunlight quality can make a 50% difference in power generation. This can be seen with Germany and Japan, which have more solar usage than the desert area of Arizona, New Mexico, and West Texas, which has much better sunlight resources. It is reasonable to suppose that when solar growth comes to hot, sunny areas, it will become a significant player in the energy industry

Once solar becomes more popular and goes from something at the fringe of the energy industry to something that is mainstream, financial analysis will view sunlight not as a weather phenomenon, but as a natural resource, according to which the sun is an enormous reserve of “sunlight resources.” In terms of economic analysis sunlight is perhaps the most underappreciated energy-related resource, because it is free, it is present in every part of the world at every hour of daylight, there are enough resources to meet global world energy demand, and the resource is renewable and cannot be depleted through human usage. Some solar advocates claim that enough sunlight falls on the planet in one hour to meet global energy demand for one year. Although this claim is unconfirmed, it has been said by many scientists and industry experts that solar panels

can meet most of the typical daily energy demand for a solar-equipped building. In the case of energy-efficient “green buildings,” which are becoming more and more popular, the decreased energy consumption means that in most cases, roof-mounted solar panels can fulfill the total energy demand for the building.

The primary factors for solar growth include the end of the solar silicon shortage, demand for rural off-grid electrification in developing countries with populations that need to be electrified, concern over global warming, concern over air pollution in industrializing nations such as China and India, new technologies, government incentives, and the rising popularity of green building. These trends may give solar power the highest rate of growth out of all the energy sources in renewable energy, which would be in line with solar power’s historical growth.

Professor Beckman of the University of Masion-Wisconsin’s Solar Energy Lab has told Altenews that he believes that the main obstacle to solar growth is not a need for more efficient solar technology, rather it is a need for more government incentives. Government rebates can reportedly drop solar prices by 36% (in California) to 75% percent (in Japan), and new technology developments and the end of the silicon shortage could further cut the price of solar significantly. As the price of solar power goes down, it becomes better able to compete with oil, coal, natural gas and nuclear, and when the costs become similar the unique attractive qaulities of sunlight resources may push solar into the mainstream energy market. In terms of efficiency, typical silicon panels have 15%, while thin film gets 8%, and new technologies may be as high as 30%.
Thin-film is ideal for remote rural electrification, as it is cheaper than silicon but uses more space. However, thin-film has worse cost per watt than silicon, according to NanoMarkets, and Beckman claims that for economic decisions the cost per watt matters more than the solar cell efficiency, so silcion will probably maintain industry superiority, and the end of the solar silicon shortage will make that more likely. The thin-film investment craze may be short-term whereas silicon investments are long-term. The one technology that is most likely to rival silicon is solar thermal, which is well-suited for large solar power plants as well as for home water heating usage, and which can be configured into super-cheap designs for poor villages.

A variety of factors have caused Japan, Germany, and California to take the lead in worldwide solar usage. Japan has no domestic oil resource but does have domestic sunlight resources, and Japanese government rebates made solar competitive, This combined with the high number of Japanese electronics companies capable of solar research to develop Japan into the world leader ins solar use, solar manufacturing and solar technology. In Germany, rebates started solar growth and it is continued by the grid buyback mandate Feed Law, which mandates that solar power users can sell their excess energy back to the utilities through the grid at very high prices. Germany has taken the secondary world solar leadership position, and is the world leader in solar thermal technology. California combines great solar resources in southern California with government rebates and mandated grid buybacks to make solar competitive, and California solar spending exceeds the American national solar spending. Japan and Germany show what an extreme positive effect government spending on solar can have, and if government spending were combined with areas that have vast sunlight resources, such as southwestern U.S. deserts, then solar power could see extreme growth.

In addition to industrialized markets, there are developing country markets with ample sunlight resources and a need for off-grid remote area rural electrification. In these cases the cost of solar is lower than the cost of bringing power lines to villages, so solar is able to be cost-competitive. These areas include Central and South America, India, China, the rest of Asia, and Africa, and the economics of solar electrification combined with govermnent support, such as in China, or microcredit loans, such as in Bangladesh, will open these markets up for the solar industry's sales. Solar growth, which has already grown steadily every year for fifteen years, could make huge leaps of growth in the future, fueled by both industrialized and developing nations.

In conclusion, based on a variety of data from many different sources, it is clear that the solar power industry is poised to continue its historical high annual growth. Various qualities make short-term solar growth likely, and factors such as the end of the solar silicon shortage and sales in new markets may push solar power into the realm of conventional power generation, on the oil, coal and nuclear. Because of this, solar stocks have the potential for significant sustained growth, and solar investment may indeed be, at this point in time, the very best area in renewable energy to invest in. According to Altenews's conclusions, a solar investment strategy could be multifaceted and include multiple components. A strategy may:

A. Seek to take advantage of the end of the silicon shortage and the demand for high-end solar equipment in industrialized nations by investing in silicon-based solar manufacturing stocks.

B. Exploit the undervalued potential of solar thermal by targeting solar thermal stocks. Note that while Japan is the world leader in solar technology, Germany is said to be the leader in solar thermal. Solar water heaters are underappreciated and have potential for worldwide growth, but what may post the biggest solar returns, in terms of the quantity of electricity produced, may be solar thermal power plants.

C. Take advantage of opportunities in thin-film, by avoiding thin-film solar research and manufacturing stocks that are held up by the silicon shortage-induced thin-film craze, while at the same time investing in super-cheap thin-films that may appeal to developing nations. However, claims by thin-film researchers that their thin-film is equal to or better than silicon cells must be evaluated (based upon laboratory data and taking into account the difficulty of going from laboratory conditions to factory conditions) before making an investment decision.

D. Targeting specific regions, such as high growth potential California, China, India, and other European nations such as Italy, Spain, Austria and Switzerland, as well as New Jersey and other American states with incentives, and to a lesser extent the already filled markets of Japan and Germany.

E. Seek out and invest in companies that are seeking to develop and sell super-cheap solar equipment to developing countries, with the primary markets being China and India, followed by any other market that can arrange microcredit loans.

F. Investors interested in high risk in exchange for high returns may try to find an area of laboratory-stage solar research and predict which future solar technology will be the next big thing, but this is not a strategy for sustained returns. Current solar technology is adequate to most needs and a new technology must have a significant advantage to be marketable.

G. The trends in solar markets (industrialized and developing) indicate that in the future, solar technology will develop towards the goal of high efficiency for industrialized nations, and the goal of low cost for developing countries, and finding the best technologies that will either maximize efficiency or minimize cost may be the best strategy in solar research investments. The cost-per-watt of the manufactured solar product must also be looked at before investing.

A comprehensive and regularly updated list of solar power stocks can be found in the Altenews list of stocks (www.altenews.com/stocklist.htm). In passing we can mention some public solar companies, first saying as a disclaimer that we do not endorse any of these companies, nor do we offer any specific recommendations regarding investing in any of these companies. Some of the big companies are Q-Cells of Germany (Symbol: QCLSF.PK), Sharp of Japan (SHCAF.PK), Kyocera (KYO), BP's BP Solar divison (BP), and GE, which owns most of Astropower's assets, (GE). Other silicon-based solar makers include GiraSolar (GRSR.PK) and SunPower Corp. (SPWR). Some thin-film companies are Evergreen Solar (ESLR) and DayStar Technologies (DSTI). One public thin film company that claims to be able to make cheap thin film photovoltaics is Ovonic, which trades as Energy Conversion Devices (ENER). Two silicon suppliers are MEMC (WFR) and Renewable Energy Corp. of Norway (REC.OL). Two public utilities that are involved with solar power are FPL (FPL) which owns the SEGS power plant, and SoCal Edison, a subsidiary of Edison International (EIX), which buys SEGS energy and distributes it to customers. Solar Millenium AG (SMLNF.PK), a solar thermal company, has a solar power plant project in China. Ascent Solar (ASTIU) is a high-end solar R&D company. NanoSolar, which plans to build the world's largest solar cell factory using proprietary thin-film technology, is funded by private capital including prominent investment banks, as is SunEdison, which runs a utility that specializes in selling solar power. China Himin Solar Energy Group, which is currently private, is a major solar water heater seller in China, and Dawn Solar Systems (which the title of this report is unrelated to) sells solar water heaters in the United States. This list is intented to give a general overview of the types of companies out there, and does not reflect upon the quality of any of these companies. There are many other solar investment opportunities, and there are sure to be more in the future as the solar industry continues to grow.

More information about solar power can be found in the solar power page of the Altenews website (www.altenews.com/solar.htm). There is extensive information and analysis regarding renewable energy investment in our research reports, editorials, interviews, news headlines and other features, as well as a list of solar power stocks in our list of stocks, all of which is available free to the public at Alternative Energy News Source (Altenews.com). Other online sources of information about solar power (none of which are officially endorsed by Altenews) include SolarBuzz, Wikipedia, the ISES, ASES, and SEIA organizations, RenewableEnergyAccess.com, RenewableEnergyStocks.com, and Photon Magazine. Links to these and other solar websites and be found on www.altenews.com.