Solar Power Optimization

Some claim our next global conflicts will be for food and water, but the supply of energy will be another source of conflict. The world has a rapidly growing population that is estimated will reach ten billion by 2040. Finding ways to produce energy for our needs and the needs of developing nations could very well turn into a conflict if those demands are not met. Our biggest source of energy is fossil fuel, which according to the European Union Energy Policy, is estimated only to have about 50 years of oil left after peak production (Aguilera, 2008). Fortunately, there are solutions available from cleaner burning of coal, to the controversial use of nuclear power, to renewable sources of energy. One promising renewable technology in this mix that offers great potential is solar power. According to Ecoworld (2006), 8.2-million quads of Btu hit the surface of the Earth a year, approximately 20,000 times what is used by the entire human race. By using a variety of techniques more efficiently, we can employ solar power easily in the mix of power sources to solve the world's energy demands.

The Photovoltaic Effect and Solar Power Today

Power from the sun is harnessed through photovoltaic (PV) solar cells. The sun's rays hit the material on the panel, called semiconductors, which have special properties that allow electrons to flow and move. Containing levels of energy, the sun's rays hit the semiconductors and knock off electrons that paired with the molecules of the material in the panel. This phenomenon in science has been called the photovoltaic effect. A French physicist, Edmund Becquerel, first observed this effect in 1873. The first working solar cell was created with 4.5% efficiency by Bell Labs researchers Pearson, Chapin, and Fuller in 1954 (Bellis, 2011). Very common applications for solar panels are satellites in space since there is a lack of weather that can damage the cells (Toothman & Aldous, 2000). The uses and applications of the photovoltaic effect have expanded and become more adaptable to meet current energy needs.

Today, the most common application of the photoelectric effect is silicon solar panels to be placed on land or on rooftops. The most important material in the panel, silicon, must be synthesized and combined with impurities because pure silicon, whose molecular structure is incredibly stable will not allow electrons to flow easily (Toothman & Aldous, 2000). The goal of a solar panel is to create a voltage for power, and this is achieved when the panel is aligned to have a positive and negative component of connected silicon with impurities. Once the electrons have a difference in voltage and have a path to flow across, a current is created that can be used for power (Toothman& Aldous, 2000). In cases for which large amounts of energy are required, multiple solar panels will be placed in long connected series called solar farms that span several acres. Solar panels can also be assembled on tops of roofs to provide power for individual homes. Even though the process sounds incredibly simple, significant drawbacks exist that prevent the solar revolution from taking over the energy sector in America and around the world.

Drawbacks of Solar Cells

The structure and molecular characteristics of silicon and the photovoltaic effect limit the power that can be harnessed from the sun. For example, the band gap energy is the energy required to knock off the electrons. Because light has many different wave lengths, and thus different energy levels, some photons have too much or too little energy to knock off the electrons in the panel's material. This problem can contribute to around 70% inefficiency. The band gap also cannot just be lowered because it determines the voltage and thus power that can be yielded from the sun (Toothman & Aldous, 2000). Additionally, because silicon, as opposed to a metal, is only a semiconductor, the electrons have a higher resistance and have problems with conducting electricity. One solution is to add conductive metal material to the top of the panel. Unfortunately, covering the top of the panel would limit the sunlight actually hitting the panel, creating obvious problems in harnessing the rays (Toothman & Aldous, 2000). Such difficulties lead to major design problems that create many challenges in implementing this technology on a wide-scale basis.

More importantly, factors that raise the overall cost of maintenance have a greater impact on preventing solar panel expansion. Even though the exact price per megawatt hour is not precise, due to various on-site factors, one reliable source places the price at $396 per megawatt hour for solar panels whereas coal with carbon capture and sequestration is rising to $129, off-shore wind is at $191, and nuclear comes in at $119, all in per megawatt hour (Bailey, 2010). Because solar panels get all of their power supply from the sun, weather has a large effect on their efficiency. Any rooftops with solar panels that have large trees blocking the panels, even for an hour or two, can drastically impact the cost of the project. Very similarly, the angle of the panel aimed at the sun can increase the optimization of energy output. To maximize efficiency, systems in the Northern Hemisphere need to be placed facing south, and, in general, panels should be angled closest to the latitude of that area on the Earth (Toothman & Aldous, 2000). Simple changes such as these lower the high maintenance costs since more energy is yielded.

Costs per energy output, unfortunately, can be misleading related to solar panels because the prices usually do not include the most expensive aspect, the installation. The balance of system cost, including wiring and installation, amounts to nearly half the cost (Hasserjian, 2010). Each panel needs to be installed individually and wired together. The bigger the panel, the more expensive the job can become. This is one reason why the adoption of wide-scale solar power has been slowed. At the simplest level, simultaneous coordination of developers, installers, suppliers, regulators, utilities, and building owners needs to be closely overseen (Behr & Climate Wire, 2010). Especially with a new technology that has really not found a solid method of installation, money can easily be misused and wasted. Additionally, the fact that every house or solar farm is going to have natural conditions unique at each site also leads to rising costs. A uniform method cannot be implemented for solar panels, thus making a large-scale expansion in America extremely difficult. Likewise, the zoning and permits required for each area cause a bureaucratic nightmare. One specific concern is the possibility of electrical islands, small areas in a municipal power grid that are independent systems. The fear is utility workers could be working with electrical lines they think are dead which are actually connected to a residential home’s still live solar panel system that is not mapped out properly (Toothman & Aldous, 2000). Additionally, as the project gets bigger, the total cost will rise with the increasing amount of panels and wiring needed.

Methods of Lowering Costs

Fortunately, there are many simple ways to lower the costs of maintenance and installation for solar panels. One way to reduce the entire cost dramatically is to have one company manage the entire process of manufacturing, installing, and maintaining the solar panels. Currently, the industry has many different companies that specialize in many different components. Given such specialization, individuals or different companies are likely to pay higher prices for each individual part than they would if they were able to purchase all parts together. The most promising example of this achievement involves Siliken Renewable Energy, a Spanish manufacturer of solar panels reported by Alberto Cortes and Ricardo Silla. This manufacturer coordinates the entire process from silicon purification to collecting the real-time data coming from its panels. Siliken has received high recognition for providing the best advertised-to-actual performance ratio for the panel output (Cortes & Silla, 2009). Another great benefit of handling the entire process is having a greater working experience with the technology. The Spanish company has standardized its entire business system to reduce the cost of the product and achieve more optimized outputs. The largest solar field, built in 2008 in Cuenca, Spain, stands as one of its greatest achievements. Likewise, Siliken has created its purification process to be 40 percent cheaper than Siemens' process, the traditional method (Cortes & Silla, 2009). By eliminating the multiple middlemen, Siliken has driven down the costs and gained more accurate outputs of energy.

Even though there are many parts in the market making the process very confusing and costly, having the right design makes a huge difference. Using the resources and unique characteristics of each area is key for creating the most effective energy-saving system. Barbara Jorgensen (2009), who has reported in great detail about the solar panel industry in America, claims that the "broad base of products can be mixed and matched for optimum performance." Not every panel is the same, and using certain ones in different climates yields different results. Crystalline silicon cells have a much higher resistance when in hotter climates like Los Angeles. Thin film panels produce five to ten percent more electricity (MWh/year) under these conditions (Hasserjian, 2010). Similarly, crystalline panels work much better in direct sunlight while thin film panels work better in cloudier climates (Hasserjian, 2010). Jorgensen (2009) goes on to report that the ill effects of weather and other kinks in the flow, like shade or malfunctioning parts, have been dramatically reduced with National Semiconductor's power optimizer, which attaches to the panels to increase the harvest of the rays. Simple considerations like this are what cause dramatic drops in price for solar energy.

The other big factor to consider related to the exposure of actual output is the general cost trends all technologies go through. With every new technology that is introduced, the initial cost is high, but with more and more capital flowing through the industry, the price declines. National Semiconductor's power optimizer provides a great example of this trend. The more time the technology has to develop, the easier and more adaptable it will be across the globe.

However, the world does not need to wait for this change to happen. Solar power need not be limited to developing countries, for it can be woven into a current municipal infrastructure. For example, Jorgenson (2009) mentions that Germany, one of the world's largest industrial countries of the world, which used fossil fuels exclusively in the past, currently has 50% of the world's solar capacity. Germany, as a leader in the global market, is a positive example of how solar energy can be used on a large scale across an entire country. The technology will become more and more developed while prices continue to drop. And, luckily, there are enough resources available to begin large-scale production of solar panels with methods known to reduce costs.

Pete Behr and Climate Wire (2010) have reported that Robin Schaffer, the "senior vice president of sales and marketing for SunLink Corp., which has installed 150 megawatts of mounting systems," has said, "We don't need technology breakthroughs … We just need the effort and cooperation among industry participants to get there” (n.p.). Behr and Climate Wire (2010) note that a variety of methods exist to improve costs and efficiency: better module and array “designs to withstand high winds; standardized permitting; streamlined manufacturing; more ‘tool-less’ installation automation to limit on-site labor, and improved direct-to-alternating-current conversion instruments” (n.p.). All of these solutions require practice to streamline. The Rocky Mountain Institute has filed a report concluding that the average cost per watt of $3.50 or more can be cut in half and the back-end cost of installation of $1.60 to $1.85 can be lowered 60 to 90 cents (Behr and Climate Wire, 2010). Thomas Rooney, president and CEO of SPG Solar, the second-largest solar installer in California, has said that a one-megawatt project which would have cost $8 million and taken 14,000 worker hours two or three years ago, would now be $5 million and only require 4,000 worker hours (Behr and Climate Wire, 2010). The savings of $3 million alone is worth noting, but the lowering in labor cost, at the most minimal rate of $10 per hour, is an additional $100,000. These methods of price reduction are proven and make it very possible for more solar power to be harnessed.

Solar panels are expensive. Having a low 30% efficiency yield to begin with, this source of energy does not come easily. Current models of successful solar panel companies can be seen in Silikin in Spain and in various companies in America. While subsidies are currently needed to make the cost of solar power competitive, the process can be optimized in simple ways to yield more energy and to lower the costs of installation. If smarter applications of the technology are employed, cheaper renewable energy can be used and the dependency on fossil fuels can be drastically be lowered. For example, large solar farms must be engineered carefully because the distance from where the energy is being consumed and where it is being created depletes the actual amount of electricity that can be used. Utilizing smaller, individual, and more manageable systems, like panels on commercial buildings and residential homes, we can optimize electricity. Even having half of commercial districts and residential homes in all of America using solar panels would have a huge impact on fossil fuel dependency and CO_2 emissions. Likewise, giving time for this technology to develop will yield new breakthroughs that could raise the 30%

efficiency rate or increase optimization. This has historically been the trend of all new technologies, and there is no reason to doubt that it will not happen with solar panels either. Solar energy has great potential and is ready to use on a large scale.

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