Undergraduate Research Journal
University of California, Merced

"The Power of the Sun Gods": Future of Solar Energy

Javier Chaname

University of California,

Merced

Author Notes

Questions and Comments can be addressed to jchaname@ucmerced.edu

Abstract

In 1876, William Grylls Adams discovered that the metal selenium produced energy when exposed to the sun: solar energy. Over a half of a century later, all space programs from The United States and The Soviet Union were powered by solar energy. Therefore, solar energy became the standard energy source for all satellites. There are many ways to use solar energy technology. Despite this fact, it plays a small part in the global electricity market today. One reason is that the cost to buy and install solar cells are more expensive compared to the cost to obtain energy from fossil fuels. As the price of energy from fossil fuels slowly increases, researchers are investigating new and inexpensive ways to manufacture solar cells on a large scale in the future.

Solar energy may be a green and clean renewable energy source. But, there are three major problems to address in order to truly support the green, renewable, and sustainable energy that solar energy promises. The problems are mass production, implementation in developing countries and efficient ways of recycling solar panels. Solutions for these problems will be discussed. In the future, when the solar energy industry has matured, which could be in the mid-century, it can be a sustainable and reliable energy resource. It will not harm the environment when it becomes waste nor will it be harmful for the people who produce it.

Whenever people used to look up at the sun, they would be grateful that it eliminated the cold and darkness and replaced it with warmth and light. People knew that the sun was the source of life on earth, even if they did not understand how or why. The great power of the sun had convinced people in ancient times that the sun was a god. In Michio Kakus book *Physics of the Future*, he opens up Chapter 5: Future of Energy by talking about Apollo. He stated that "Apollo… illuminated the heavens and the earth with infinite power of the sun. His power was rivaled only by that of Zeus himself." The gods ranging from the Chinese sun deity Ri Gong Tai Yang Xing Jun to the Native American sun god Tonatiuh all represented the enormous power of the sun. This power is already within our reach, we just now call it solar energy.

By knowing the history of solar energy, we can begin to understand the direction of this technology. Moreover questions will be asked as to how this technology works, what the state of this technology is currently, and how it will appear in the future. These questions are important when discussing the future of solar energy technology; however, it is important to consider the impact of this technology on society also; how will it impact our lives, will it be affordable in the future, what it will do to the job market, what are the pros and cons of this technology on society and what are the unintended consequences of this technology.

What is Solar Energy?

What is solar energy? According to Solar Energy Industries Association, "Solar power is energy from the sun that is converted into thermal or electrical energy." There are three current ways in which solar energy is harnessed. The first way is called solar electric, or photovoltaics. Photovoltaics are a type of solar panel that uses sunlight to create electricity via semi-conducting metals (See Figure 2). In these metals, electrons are released and travel down an electrical circuit

whenever sunlight shines on it. This conversion of solar energy into electricity is mainly used for electronic devices and sending electricity to the grid ("Photovoltaic (Solar Electric)").

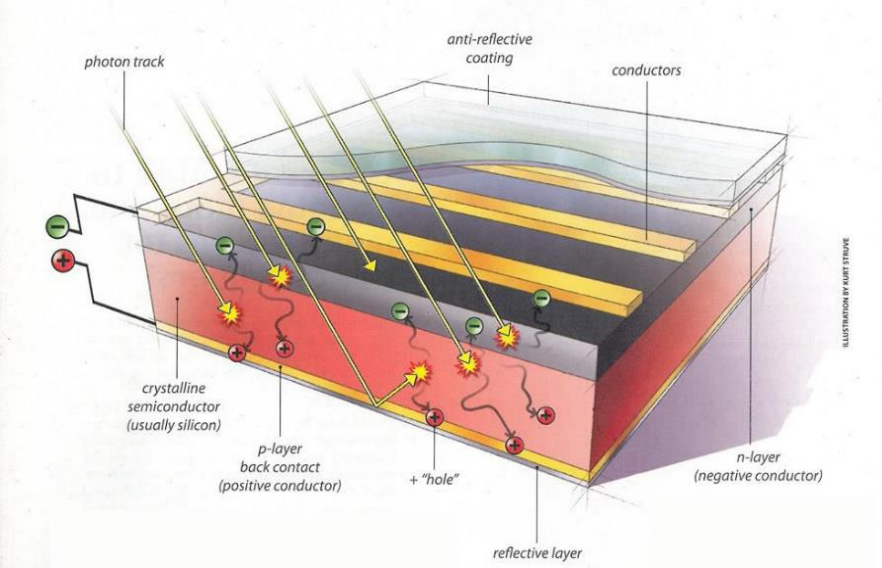


Figure 2: Diagram of a Photovoltaic Solar Cell. “Photovoltaics (Solar Electric)

The second way in which solar energy is harnessed is called solar heating and cooling. This type of technology collects the thermal energy from the sun and uses it for any applications that involve heating or cooling, hence the name. This technology is used for mainly water related activities such as heating a pool, providing hot water to the bathrooms and sinks, etc. This technology has been growing; according to the International Energy Agency (IEA), the solar heating and cooling sector of solar energy grew by about fourteen percent in 2010.

The third way in which solar energy is harnessed is called concentrated solar power. This technology uses mirrors and sunlight to drive turbines that create electricity. The mirrors help focus the sun’s thermal energy onto a synthetic oil and passes through a heat exchanger to heat up water. Once the water has turned into steam, the pressure of the vapor will drive the turbines

and generate electricity ("Concentrating Solar Power"). This technology, like photovoltaics, is mainly used to power an electric grid.

How Are Solar Cells Made?

In order for a solar panel to capture solar energy, it must be adequately manufactured. This process will be based on the production of photovoltaics, the most commonly used system for collecting and converting solar energy into electricity. It starts off with pure silicon, which does not occur naturally on earth. In order to get the silicon, miners must mine through caves filled with silicon dioxide, also known as quartz (Mulvaney, "Solar Energy Isn't Always as Green as You Think"). Once the quartz is crushed to fine particles, the silicon is removed from the compound using a special type of furnace to remove the oxygen from the silicon. However, this process only purifies 99% of the silicon, which means that it needs to be purified even further by essentially heating the silicon so much that the impurities will separate from the silicon. Another way of removing the impurities is to add hydrochloric acid to the silicon which makes a very toxic silicon tetrachloride as waste (Mulvaney, "Solar Energy Isn't Always as Green as You Think"). Once the pure silicon is removed, it is treated with phosphorus and boron to make it into a semiconductor capable of conducting electricity ("Solar Cell"). After it is placed in the solar panel, it is covered with glass and the process of making a solar panel is complete.

Solar Energy Presently

Despite the various uses for solar energy, it plays a small part in the global electricity market today. As of 2014, according to the U.S. Energy Information Administration, the U.S. only used 0.429 quadrillion Btu (British Thermal Unit) of solar energy (See Figure 3). This is only about .4% of the total energy used by the U.S. in 2014 according to the International Energy Agency (See Figure 4). In 2014, solar energy only accounted for 1% of the world's electricity

(MIT Energy Initiative, MITEI, 2015, ch. 1). This is probably because the cost to buy and install solar cells are more expensive compared to the cost to obtain energy from fossil fuels. But trends show that the price of energy from fossil fuels is slowly increasing. In 2015, the projected percentage of increase in residential electricity prices is about 1.3% in the United States ("U.S. Energy Information Administration - EIA - Independent Statistics and Analysis"). According to Figure 3, the use of solar energy within the U.S. will increase from .427 Btu in 2014 to .622 Btu in 2016.

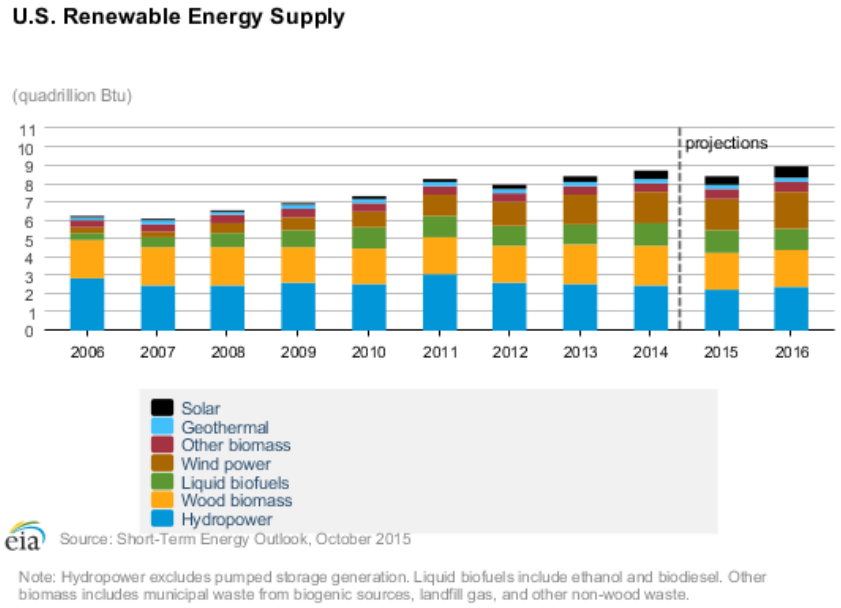


Figure 3: U.S. Renewable Energy Supply. U.S. Energy Information Administration, "Renewables and Carbon Dioxide Emissions"

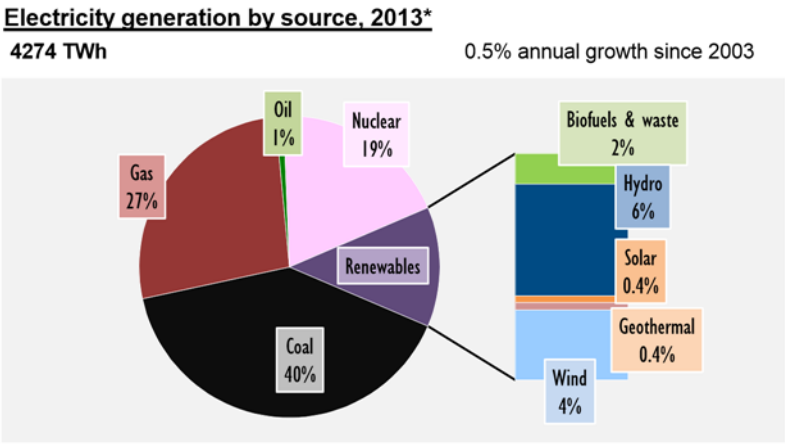


Figure 4: Electricity generation by source. International Energy Agency, "US Energy Overview 2014"

Despite the small global impact, researchers are looking for new and inexpensive ways to manufacture solar cells on a large scale in the future. One possibility is a Dye Sensitized Solar Cell (DSSC) which is a simpler and low-cost solar cell in development. The basic idea of a DSSC is to use molecules and their electrons to convert light into electricity (See Figure 5). When light strikes the glass, its photons, which are particles of light, react with Titanium Dioxide molecules, covered in a light absorbing dye. An electrolyte is present during this stage to act as a "pathway" for the electrons to reach their destination. Once they react, the titanium dioxide converts the photons into electrons and are sent down a wire to its destination. This is a more natural way of obtaining solar energy because titanium dioxide is a naturally occurring material that has existed before humans. This process of obtaining solar energy is less expensive because titanium dioxide "is one of the top fifty chemicals produced worldwide" (Stryker, "Titanium Dioxide: Toxic or Safe?").

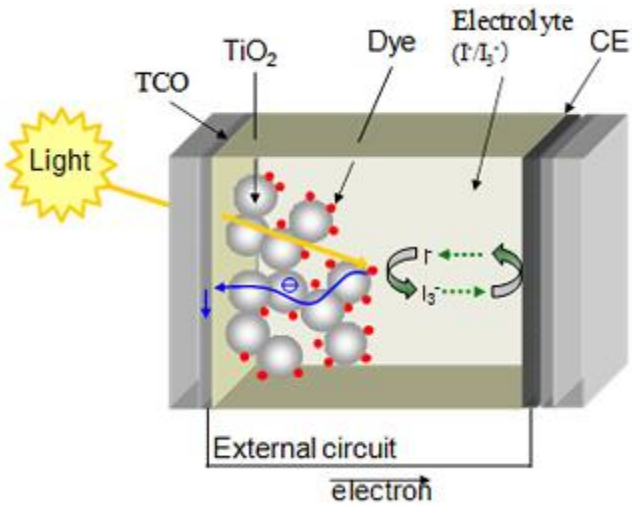


Figure 5: Dye-Sensitized Solar Cells (DSC). Han, "Dye-Sensitized and Perovskit Solar Cells Group"

In June of 2014, John Aziz reported that "Germany gets 50 percent of its electricity from solar for the first time." Germany has a goal of "producing 35 percent of its electricity from renewable sources by 2020 and 100 percent by 2050" (Aziz, "Germany gets 50 percent of its electricity from solar for the first time"). However, according to Roland Berger, in the first eleven months of 2014, Germany only received 7 percent of its electricity from solar energy (Aziz, "Germany gets 50 percent of its electricity from solar for the first time"). Many ways were proposed to solve this problem but only two have been mentioned widely. They either increase storage capacity of solar energy or use different energy sources to substitute for solar energy when it is not producing as much electricity as required. With the second solution, solar energy promotes other types of renewable energy such as wind or hydro-power which can help us utilize all of our renewable energy options.

Impact of Solar Energy on the Johnsons

Bea Johnson, author of Zero Waste Home, and her family of two boys and a husband, made a commitment in 2008 to live a zero-waste lifestyle in their home. She created the 5 R's in living a zero-waste lifestyle: Refuse, Reduce, Reuse, Recycle and Rot. Following these R's in their home, they cut down as much as they could on electricity and waste, but it was not easy. They had to give away their small appliances that were needlessly using electricity, turn down the thermostat, improve the insulation and use low energy light bulbs. With all these actions, they calculated that their electric energy usage over a 12-month period was 5,431kWh. They decided to install solar panels to reduce energy usage from fossil fuels.

In one month, from February to March, they used negative 5kWh. This was because they had "a sunny, warm February, with virtually no rain" (Johnson, "My Husband's Story: Solar Energy). Between March and April, there was not as much sun as before. Consequently, the solar panels could not generate enough electricity for the meter to run backwards. This caused them to use 141kWh from fossil fuels. However, at the end of two months, their total electric bill, with solar panels, was only $26.38. While on the other hand, without solar panels, their total electric bill for the same two months the year before cost them $207.28 (Johnson, "My Husband's Story: Solar Energy). The family also stated that "As of Friday, April 27, Solar City happily informs me that we have generated 1579 kWh of electricity, eliminating 2022 lbs. of CO2 since installation (equivalent to 1.0 mature trees)." (Johnson, My Husband's Story: Solar Energy).

Solar Energy in the Future

As seen from the statistics, solar energy is not having a huge impact on our lives because not many people use this energy source. However, in the future, when fossil fuels are scarce, people will use solar energy to power their lives. According to the Solar Energy Industries Association, there is a huge market for space heating and cooling as 72% of energy in

households are used for those two purposes. This market can promote solar energy into people's lives in the future. Homes could be constructed with solar panels for heating and cooling our water and air while at the same time powering our devices such as TVs, lights, outlets, etc. Solar energy could be the energy source that powers our homes. This would change the energy industry completely. By the time everyone uses solar energy, no one needs to pay for electricity because it is given to them for free by the sun. The only thing people would have to pay for, in regards to energy, would be installation, repair and maintenance.

With no need to pay for energy, people's lives will change. For example, the electric cars that only use electricity can be charged at your house, for free. Since you do not have to pay for electricity, you can use as much electricity as you need to charge your car. Solar energy could indirectly increase the market for electric cars as electricity would basically be free. But solar energy is not only free, it is also clean. Solar energy does not produce any greenhouse gases, thus reducing our climate change dramatically. Even though there are alternatives to solar energy that can help reduce our greenhouse emission, governments set limits on the expansion of those energy sources.

For example, according to Richard Schmalensee, expansion of hydro facilities is being limited by the United States due to environmental concerns. If this is the case for hydro facilities now, it is reasonable to infer that there would be a limit set on other renewable energy sources such as wind, nuclear, geothermal, etc. in the future. This means, according to Richard Schmalensee, that solar energy would need to increase production in order to reduce emissions to desired levels. Solar energy would not be limited due to environmental concerns because not much land is needed to produce all the energy the United States consumes today. "Using current PV technology, solar plants covering only about 0.6% of the land area of the continental United

States and experiencing average U.S. insolation over the course of a year could produce all the electricity the nation currently consumes**."** (Richard Schmalensee).

Not only can we obtain solar energy through solar panels laid out in the sun in a field, we can have roadways made out of solar panels to obtain the energy. A company called Solar Roadways is currently researching this technology. In 2006, the company was founded by Scott and Julie Brusaw, wanting to replace all of the asphalt (streets, sidewalks, concrete, etc.) with structurally sound solar panels. The solar roadways would be able to withstand vehicular and pedestrian traffic, as well as capture the sun's energy. Research has been conducted since 2006 to make transparent, strong, self-cleaning solar roadways that would be able to have enough traction for vehicles and pedestrians to safely use (Brusaw, "Solar FREAKIN' Roadways!"). This technology will also have LED lights, powered by solar energy, for vehicles and pedestrians to use. Imagine, driving down a road at night in the woods where you know there will be wildlife on the road. What if the road was able to detect if there was something on the road in front of you before you could actually see it? What if that road was able to signal you through LED lights to slow down and be cautious (Brusaw, "Solar FREAKIN' Roadways!")? Solar roadways could help prevent accidents on the roadway and also direct traffic in a more efficient way by using its LED lights to communicate to drivers while at the same time collecting energy from the sun. However, it will take some time for solar energy to become a big player in the energy market because of its limitations such as cost of resources. Nevertheless, Germany has shown that solar energy can be reliable as it produced about 50 percent of the countries' electricity in June of 2014 (Aziz, "Germany gets 50 percent of its electricity from solar for the first time"). Also, in the future, people will not have to worry about electricity bills, as they do today, because the energy supplier is the sun and gives out its energy for free every day. Also, according to Richard

Schmalensee**,** only .6 percent of the land of the continental United States will be needed in order to provide all the energy its citizens use today.

On the other hand, solar energy is not as perfect as they say. Solar energy may be a green and clean renewable energy source that can help reduce greenhouse gas emissions, but it does not mean that it is perfect. Like any other new technology, solar energy has a couple of problems that will negatively affect our lives in the future**,** if not addressed promptly. The first problems we must face are the ethical and environmental problems that mass production of solar panels will cause. Our second problem is implementing solar technology in third world countries whose citizens may not have the funds to support this renewable energy source. Lastly, the third problem to solar energy is recycling of old and broken solar panels, which there seems to be no official and effective way of doing, as of today. These three major problems must be addressed if we are to truly support the green, renewable, and sustainable energy that solar energy promises.

First Problem: Mass Production

As with all other machines and inventions, solar panels are produced in factories (see Figure 6) that contain toxic chemicals and produce toxic waste. And as with other factories that mass produce machines, there are many ethical issues that extend from the workforce to the environmental problems that they cause. The first problem is that the materials needed for the production process of the product must be less expensive and more efficient. The least expensive metal to make a solar panel is cadmium telluride and "Cadmium is one of the six most toxic substances and has been banned by the European Union for use in electronic devices**."** ("The process and Ethics of Mass Producing Solar Energy"). This means that manufacturing workers will have to work with a toxic metal that could have negative and long term effects on their

health. This metal will also be exposed to consumers who use the product daily and this could potentially be harmful.

Figure 6: Solar City Factory. Kanellos “SolarCity Answers The Siren Song of Panel Manufacturing”

Another problem with the manufacturing side of solar energy is the chemicals used to purify the components of the solar cell. As described in the process of purifying silicon, it requires chemicals that are toxic to human health. However, for the silicon to be pure enough for it to be a semi-conducting metal, it must be more than 99% purified. In order to achieve this, chemicals such as boron, phosphorous, and hydrochloric acid must be used. By using these harmful chemicals, the product of the reactions can be harmful as well. For example, another step to purify silicon is to use hydrochloric acid and copper which produces trichlorosilane gas (Mulvaney “Hazardous Materials Used in Silicon PV Cell Production: A Primer”). According to Hemlock Semiconductor, trichlorosilane reacts with water to form hydrochloric acid which

means, if exposed to humans, can potentially react with the water in our bodies to form an acid that could be fatal.

Another toxic waste that is produced when making solar panels is silicon tetrachloride. This chemical is produced in huge amounts: “three or four tons of silicon tetrachloride for every ton of polysilicon,” (Mulvaney, "Solar Energy Isn’t Always as Green as You Think"). Polysilicon is the product of combining pure silicon with hydrochloric acid. According to CAMEO Chemicals, silicon tetrachloride “can cause serious or permanent injury … Reacts violently or explosively with water … is corrosive to metals and tissue in the presence of moisture.”

However, according to Dustin Mulvaney, manufacturers actually use silicon tetrachloride to make more polysilicon which requires less energy than the original process. The reason other manufacturers do not use this process is because “the reprocessing equipment can cost tens of millions of dollars,” (Mulvaney, "Solar Energy Isn’t Always as Green as You Think"). Because of the high cost of equipment, other manufacturers just discard their waste, and when it enters the water, the silicon tetrachloride reacts with the water to make hydrochloric acid. This poisons the water and the soil around; it also emits a toxic fume that can harm living things around the area. An example of this happening was reported by the Washington Post in March of 2008 when reporters investigated a Chinese polysilicon facility to see how they deal with their waste (Mulvaney, "Solar Energy Isn’t Always as Green as You Think"). The reporters learned that the company was dumping the silicon tetrachloride on nearby fields (see Figure 7), poisoning the soil and harming the people that lived there (Mulvaney, "Solar Energy Isn’t Always as Green as You Think").

Figure 7: Chinese Crops poisoned by Silicon Tetrachloride. Cha “Solar Energy Firm Leave Waste Behind in China”

Ironically, manufacturing of solar panels requires electricity which is made from coal. Solar companies need energy in order to produce their solar panels, but that energy can come from fossil fuels which generate carbon emissions. As in Figure 8, China has been producing the most amount of carbon emissions compared to Europe because China relies more heavily on coal than Europe (Mulvaney, "Solar Energy Isn’t Always as Green as You Think"). So as more solar panels are being built, the more greenhouse emissions are being produced in an effort to reduce them. An estimate life cycle emission of a photovoltaic system is between .07 and .18 pounds of carbon dioxide per kilowatt-hour ("Environmental Impacts of Solar Power"). Even though this is less than the lifecycle emission rate for natural gas (.6 and 2 pounds of carbon dioxide per kilowatt-hour) this will become a problem when they are being mass produced ("Environmental Impacts of Solar Power").

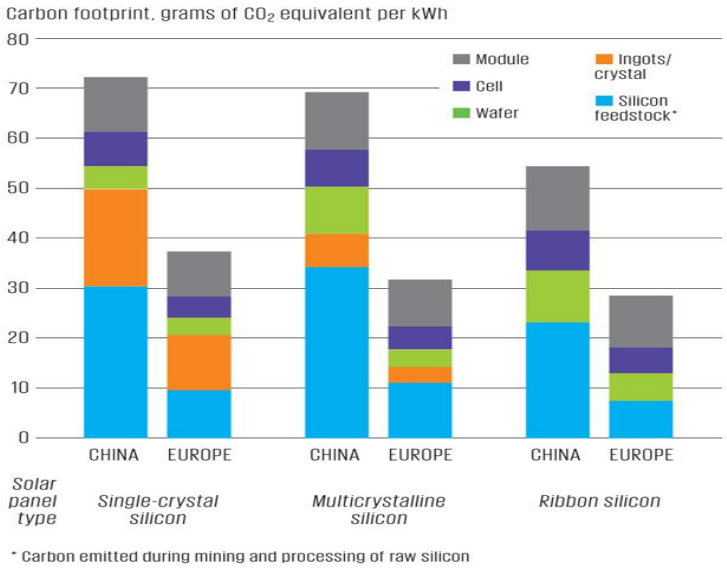


Figure 8: Carbon Footprint of making Solar Panels; China vs Europe. Mulvaney, "Solar Energy Isn't as Green as You Think"

Problem 2: Implementation in Third-World Countries

There is an increasing market for solar energy in developing countries as there have been a number of increasing projects for solar energy (Foroudastan, Dees "Solar Power and Sustainability in Developing Countries"). This statement makes sense, considering that with increasing research, less expensive and more efficient models of solar panels are being made. Therefore, developing countries would be able to afford to implement this renewable energy source throughout their countries. While this is happening, about 1.3 billion people live off the grid, meaning they do not have access to electricity provided by the electric companies or the government, and cannot afford a solar panel setup for their home.

There are many contributors in preventing solar energy in third-world countries, such as the government, "bottom-feeding" companies, culture, funding, and affordability. Governments have prevented new technologies from companies overseas from delivering reliable and

affordable solar panels by having import tariffs and fossil fuel subsidies (Marshall, "Solar Energy Solutions for the Developing World"). Another factor preventing solar technology from reaching third-world countries is the culture of each country. According to Jessica Marshall, solar “technologies sometimes don’t mesh with the way people actually live.” People may not want solar technology because they might want to stay with traditional methods of living, which is something that is very hard to change within a culture.

However, a big problem for small start-up firms is the “uphill battle of ... making good products against massive ‘bottom-feeding’ manufacturers dumping shoddy products into the market by the container-load,” (Marshall, "Solar Energy Solutions for the Developing World"). This means that there are companies that make inferior quality products which cost less than the good quality products. In turn, as more people buy the less expensive products, the company that was making the good quality products will go out of business because no one would be buying from them. Consequently, the customer will have an unsatisfactory experience with solar energy which would lead them to assume that it is no good and not worth buying. Therefore, they go back to using kerosene and other fossil fuels to power their homes. As Ned Tozun, the president of a global social enterprise that delivers solar powered solutions called d.light, says, “We go into markets all the time where people … have had a bad experience [with solar]. We are being fanatical about making our products extremely rugged and affordable.”

According to Jessica Marshall, “many potential buyers have irregular income streams that make a loan with regular repayment, however small, an intractable option.” Since consumers in third-world countries, according to Jessica Marshall, do not have a regular scheduled income, it would be hard for them to be able to pay off a loan because they might have the money to pay off the payment for one day and not enough for the next payment. This also means that citizens

of third-world countries are not likely to take out loans in order to purchase a technology that could be very beneficial to them in the future. Because of their conditions, the solar energy market cannot do much to reach out to them. Consequently, those people are stuck with using kerosene to light their houses and fossil fuels to provide electricity, assuming that they are not part of the enormous population who live off the grid.

Problem 3: Recycling

Recycling of solar panels has not become a major issue as of today and hardly anyone is talking about it. This is because, according to Christina Nunez from National Geographic "There aren't enough defunct solar panels to make recycling them economically attractive." This quote means that there are not any effective ways of recycling solar panels because there is no economic incentive to do so. The reason there is no economic incentive is because, unlike plastic and glass bottles, there are not enough of these solar panels for people to make money by recycling them. Ben Santarris, from SolarWorld also said that they have solar panels from 1978 still working which goes to show how long these solar panels can last.

As of now, there is no real or efficient way of recycling solar panels because there is no demand for it, basically. This issue will be solved later when solar panels from long ago start to break or people start discarding their old solar panels for new and better ones. However, today "The SVTC said it's leading an effort to develop a first ever sustainability standard for solar panels, similar to the U.S. Green Building Council's Leadership in Energy and Environmental Design or LEED, within the next two years" (Nunez "How Green Are Those Solar Panels, Really?").

Another reason why solar panels are not being recycled is because there are not many places where people can recycle them. "Currently the recycling of solar panels faces a big issue,

specifically, there aren't enough locations to recycle old solar panels," ("Impact Of Solar Energy On The Environment"). Recycling our solar panels will become very important in the future when there are many solar panels that do not operate properly. Solar panels have precious metals such as silver, tellurium, indium, and so on. This situation means that in the future, if we do not recycle the solar panels, we could have resource scarcity concerning those metals.

All three problems have a major impact on society; from the workers in factories making the solar panels, to the citizens of third-world countries who cannot financially support solar technology, to the innocent people who have to deal with the toxic waste from producing solar panels. If these issues are not addressed quickly, workers and innocent people affected by factories will be exposed to the toxic waste from producing solar panels. People in third-world countries would not be able to have solar technology to make their lives a little more comfortable and less reliable on fossil fuels. A scarcity of precious metals would happen due to the inadequate method of dealing with broken or old solar panels. If we do not want these events and negative effects to happen, we must address these issues as soon as possible and develop solutions to make solar energy as green and sustainable as we hoped it to be. Fortunately, there are solutions to each of the three problems stated above that are either in research and development or are being implemented as of today or very soon.

Solution to Problem 1

Mass production of solar panels is inevitable, primarily because it is needed to help grow the solar energy market on a global scale. Mass production of solar panels needs to be cost-effective and efficient in order for the market to grow and compete with fossil fuels. However, ethical and environmental problems will come about when companies strive for efficiency and low cost manufacturing. Problems such as the use of toxic chemicals to make the solar panels,

toxic waste and the use of fossil fuels to produce solar panels will be made evident as this technology grows. Fortunately, the problems that come with the mass production of solar panels are preventable with simple and creative solutions.

One simple yet creative solution for the use of toxic chemicals to "activate" solar cells is to use magnesium chloride. Currently, according to Steve Connor, cadmium telluride is seen as the future of solar cells. As he further claims, "About 90 percent of the solar panels currently in use are made of photovoltaic cells composed of silicon semiconductors … silicon is not good at absorbing sunlight … next generation of PV cells will be based on … cadmium telluride, which absorbs sunlight so well that it only needs to be about one hundredth of the thickness of silicon" (Connor "Breakthrough in solar panel manufacture promises cheap energy within a decade"). This means that the next generation of photovoltaic cells will be based on cadmium telluride, which is less expensive and more efficient than silicon. However, this new metal needs to be "activated" by cadmium chloride which, according to Connor, is an expensive and toxic chemical.

Jon Major, from the University of Liverpool, says that he found an alternative to the toxic and expensive cadmium chloride; magnesium chloride. This chemical is salt from sea water and can be found in tofu and bath salts. In other words, "Magnesium chloride is incredibly low-cost … and it's completely harmless and non-toxic," meaning that he does not have to wear a mask when working with the chemical, see Figure 9 (Connor "Breakthrough in solar panel manufacture promises cheap energy within a decade"). In a study, published by the journal Nature, researchers showed that the efficiency of cadmium telluride with magnesium chloride were as good as the widely used and toxic cadmium telluride with cadmium chloride (Connor "Breakthrough in solar panel manufacture promises cheap energy within a decade"). This proves

that using a salt found in sea water is as good as a toxic chemical when it comes to solar panel efficiency. This simple yet creative solution is one of many that can be used to improve the mass production side of solar energy.

Figure 9: Jon Major spraying magnesium chloride on a solar cell. Ghosh "Researcher develop cheaper way of making solar cells"

Toxic waste is also a big issue when it comes to manufacturing solar panels. Cadmium chloride is only one of many toxic chemicals used in the manufacturing process of solar panels. Furthermore, some of these toxic chemicals end up as waste, destroying people's lives if not treated properly. Like the Washington Post reported in March of 2008 "workers dumped buckets of bubbling white liquid onto the ground. Then they turned around and drove right back through the gates of their compound without a word." In order for these incidents not to occur, there needs to be strict regulation on how toxic waste is handled in factories.

In light of these findings by the Washington Post, the stocks of solar companies fell because the story showed that these companies were not all green (Mulvaney, "Solar Energy Isn't Always as Green as You Think"). Consequently, according Mulvaney, "In 2011 China set

standards requiring that companies recycle at least 98.5 percent of their silicon tetrachloride waste." This is a great improvement for China, considering that it does not do a good job at protecting the environment, and it goes to show that this problem of toxic waste can be completely eliminated in the future.

Another big, yet ironic, problem with manufacturing solar panels is that it requires energy generated from fossil fuels, which unfortunately emit greenhouse gases. Therefore, as more solar panels are being manufactured, more greenhouse emissions will contribute to climate change. In order for the solar panel manufacturers to emit less greenhouse gases, they must switch to an alternative energy source such as a renewable energy. They may even be able to use their own solar panels to provide them with enough energy to mass produce their solar panels. Factories may be able to use other energy sources such as hydro-electric if the factory is near a dam or wind farms if they have enough land and a windy area to provide them with enough electricity. We must also consider the emissions from the transportation of materials and solar panels, the maintenance and dismantlement of solar panels ("Environmental Impacts of Solar Power"). This means that we must utilize more renewable energy sources such as biofuel that can help reduce the emissions of a lifecycle of a solar panel. Whatever the energy source, it must be a renewable and reliable energy source for the meantime until we can decide how to make solar energy more reliable for our living conditions.

Solution to Problem 2

As stated earlier, there are currently about 1.3 billion people in underdeveloped countries who do not have access to electricity from electric companies or the government. They are living "off the grid." These people may not have the funds to move closer to electricity sources or afford solar panels on their homes. Fortunately, solar energy is not just big solar panels on the

roofs of houses, it can be as small and portable as a book. Simple technologies such as the portable solar lantern can provide the people of third-world countries more comfort in their homes and at the same time, promote a green and renewable energy source. Ned Tozun says that he "sees his products not as an extra expense but a safer replacement for a dirty alternative on which people spend plenty of money," (Marshall, "Solar Energy Solutions for the Developing World"). Solar energy technologies such as the solar lantern are affordable and portable because LED lights have become lower priced and more efficient.

Another problem in third-world countries regarding solar energy concerns the "bottom feeding companies" which sell defective products. These companies make very cheap, poor quality products and sell them to consumers who may not afford the good quality version of the products. Unfortunately, what this does is drive the good quality companies out of business because no one is buying from them. In turn, the consumers who bought the bad quality products will have a bad experience with solar energy, which discourages them from supporting solar technologies. In light of this problem, two organizations, Lighting Africa and Lighting Asia, now "offer product testing and a set of criteria to ensure quality in small devices such as portable lamp," (Marshall, "Solar Energy Solutions for the Developing World"). This is similar to the FDA in the United States, the only difference is that they inspect solar technologies and not food and drugs. This is a great solution to help prevent bottom-feeding companies from discouraging consumers to support solar technologies as they will inform the consumer of the quality of the product. While this is great for making the buyer trust the product, another big problem is making this technology affordable to the majority.

According to Jessica Marshall, most citizens of third-world countries do not have a regular scheduled income, making it hard for them to make a big purchase with scheduled

payments. However, a new system of payment was introduced by Paul Needham, founder and president of Simpa Networks, called progressive purchase. “In Simpa’s system, customers make payments—via mobile phone if they have access to mobile banking—for a particular amount of energy, and the company unlocks the customers’ equipment until they use what they’ve paid for. When a customer has paid in full for the equipment, it unlocks permanently.” This is also known as “pay-as-you-go pricing” which seems like a viable option for third-world consumers because of the flexibility of payments. While this method of payment has not been tested large-scale, it is one attempt at making solar energy available to third world countries. One day in the future, everyone will be able to purchase their own solar system, because of solutions such as this, in turn, making their lives more comfortable while at the same time, promoting the environment.

Solution to Problem 3

Not many people have talked about recycling solar panels. Frankly, it’s because there are not enough solar panels that are broken or old enough for the industry to boom. Ben Santarris says that he has solar panels from 1978 that are still working. This means that the recycling industry of solar panels does not have a chance at becoming big because there is no economic incentive and there are not enough defunct solar panels to drive the industry. However, according to Hamza Tahiri, co-founder of Photocycle Industries, in order to kickstart the recycling market for solar panels, regulations must be put in place to create the conditions to make it necessary for companies to research ways to recycle their solar panels.

Through these conditions and regulations “efficiencies [will be] made and a profitable industry created,” (Tahiri, “How Do You Recycle a Solar Panel?”). When these regulations are in place, designers for solar panels can design a solar panel that can be prepared to be recycled by the end of its life cycle. As with new and promising industries, the recycling industry of solar

panels needs a cushion, i.e. subsidy, to kick start the market. That way, it will have a chance at being a viable and strong industry to pay attention to and invest in. This industry can help promote recycling for all renewable energies and can also prevent scarcity of precious metals as they will always be recycled. This new and booming industry could also provide millions of new jobs in the future that would support sustainable solar panels and drive a green industry. In other words, workers may not have to work in coal based factories to make a living.

While there are problems with this technology, it is still a relatively new and emerging industry that needs it's time to grow and mature. Efforts are being made to make this clean energy source more sustainable and leave less of a carbon footprint when being made. In the future, when the solar energy industry has matured, which could be in the mid-century, it can be a sustainable and reliable energy resource. It will not harm the environment when it becomes waste nor will it be harmful for the people who produce it. Also, people will experience a new type of energy that promotes and protects the environment. Maybe even new ways of capturing solar energy, such as solar roadways, may be realized with more research and innovative strategies. We just have to be daring enough to imagine the endless possibilities of what the power of the sun gods can do to shape our world for the better.

Notes

References

Aziz, John. "Germany Gets 50 Percent of Its Electricity from Solar for the First Time." Germany Gets 50 Percent of Its Electricity from Solar for the First Time. The Week, 20 June 2014. Web. 7 Oct. 2015.

Brusaw, Scott. “Solar FREAKIN’ Roadways!” 2014. YouTube Video

Cha, Ariana Eunjung. "Solar Energy Firms Leave Waste Behind in China." Washington Post. The Washington Post, 9 Mar. 2008. Web. 6 Dec. 2015.

"Concentrating Solar Power." SEIA. Web. 7 Oct. 2015.

Connor, Steve. "Breakthrough in Solar Panel Manufacture Promises Cheap Energy within a Decade." The Independent. Independent Digital News and Media, 25 June 2014. Web. 17 Dec. 2015.

"Environmental Impacts of Solar Power." Union of Concerned Scientists. Union of Concerned Scientists, 5 Mar. 2013. Web. 5 Dec. 2015.

"Fact Sheet: “Trichlorosilane”." Hemlock Semiconductor Corporation, 30 Nov. 2009. Web. 22 Nov. 2015.

Ghosh, Pallab. "Researchers Develop Cheaper Way of Making Solar Cells - BBC News." BBC News. BBC, 25 June 2014. Web. 17 Dec. 2015.

Han, Liyuan. "Dye-Sensitized and Perovskit Solar Cells Group." - Photovoltaic Materials Unit. National Institute of Materials Science. Web. 5 Nov. 2015.

"Impact Of Solar Energy On The Environment." GreenMatch, 29 Jan. 2015. Web. 6 Dec. 2015.

Johnson, Scott. "Zero Waste Home: My Husband's Story: Solar Energy." Zero Waste Home: My Husband's Story: Solar Energy. Web. 5 Nov. 2015.

Kaku, Michio. "Future of Energy: Energy from the Stars." Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100. New York: Doubleday, 2011. Print.

Kanellos, Michael. "SolarCity Answers The Siren Song Of Panel Manufacturing." Forbes. Forbes Magazine, 17 June 2014. Web. 6 Dec. 2015.

Marshall, Jessica. "Solar Energy Solutions for the Developing World." Ensia. 13 Feb. 2013. Web. 6 Dec. 2015.

Miller, Amanda H. "Solar Market Expected to Hit $118 Billion by 2017." Solar Energy News. Clean Energy Authority.com, 17 July 2013. Web. 17 Dec. 2015.

Mulvaney, Dustin. "Sidebar_headline." Hazardous Materials Used In Silicon PV Cell Production: A Primer. Web. 22 Nov. 2015

Mulvaney, Dustin. "Solar Energy Isn't Always as Green as You Think." IEE Spectrum. 12 Nov. 2014. Web. 5 Dec. 2015.

Nunez, Christina. "How Green Are Those Solar Panels, Really?" National Geographic. National Geographic Society, 11 Nov. 2014. Web. 22 Nov. 2015.

"Photovoltaic (Solar Electric)." SEIA. Web. 7 Oct. 2015.

Schmalensee, Richard. "The Future of Solar Energy: An Interdisciplinary MIT Study" MIT Energy Initiative (MITEI), 2015

Schmalensee, Richard. "The Future of Solar Energy: A Personal Assessment." The Future of Solar Energy: A Personal Assessment. Science Direct, 28 Aug. 2015. Web. 7 Oct. 2015.

"Silicon Tetrachloride." CAMEO Chemicals, 2010. Web. 6 Dec. 2015.

"Solar Cell." How Solar Cell Is Made. Advameg. Web. 22 Nov. 2015.

Stryker, Lori. "Natural Organic Make-up - Titanium Dioxide: Toxic or Safe?" Natural Organic Make-up - Titanium Dioxide: Toxic or Safe? The Organic Make-up Company, 30 Apr. 2013. Web. 5 Nov. 2015.

Tahiri, Hamza. "How Do You Recycle a Solar Panel?" The Huffington Post. TheHuffingtonPost.com, 23 Jan. 2014. Web. 6 Dec. 2015.

"The Process and Ethics of Mass Producing Solar Energy." Untitled Page. Web. 7 Oct. 2015. <http://www.pitt.edu/~rsg31/solar_power.html>.

Tsoutsos, Theocharis, Niki Frantzeskaki, and Vassilis Gekas. "Environmental Impacts from the Solar Energy Technologies." Science Direct. Elsevier Ltd, 1 Feb. 2005. Web. 7 Oct. 2015.

"U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Short-Term Energy Outlook. U.S. Energy Information Administration, 6 Oct. 2015. Web. 5 Nov. 2015.

"US Energy Overview 2014." Energy Overview. International Energy Agency, 1 Aug. 2014. Web. 7 Oct. 2015. <http://www.iea.org/countries/membercountries/unitedstates/energyoverview/>.

"What Is Solar Energy?" What Is Solar Energy? Greenough Solar Farm, 2015. Web. 22 Nov. 2015.

Tabling Director - Alma Bogarin

Alma Bogarin is currently enrolled at the University of California Merced. She is a first-year Sociology major with a minor in Management and Business Economics. Alma was born and raised in Escondido, California. She is the first in her family of six children to attend a university and is serving as a role model to her younger sister. In her spare time, she enjoys going on hikes, attending yoga classes, and adventuring out into new places. She is highly passionate about helping people in need and preserving our environment. Alma is currently striving to graduate in 2019 with a Bachelor's degree and then begin her own non-profit organization helping the homeless youth population. In her non-profit organization, she plans on assisting the homeless youth population by giving them a place to temporarily live, health services, and workshop classes on how to get a job.

Website Editor/ Senior Editor - Alexander Chen

Alexander Chen is a San Gabriel Valley native. He is a second year Chemistry major with a writing minor. When he grows up, he aspires to become a pediatrician and participate in Doctors without Borders. He also wants to become a teacher and is working towards his teaching credentials. During the summer, he works at a summer school to learn more about the educational field as well as obtain hands-on experience. In the gap year before he applies to medical school, he hopes to obtain a job as a science teacher at his previous high school. His hobbies include cooking, reading, and archery. Alexander hopes that his time with the URJ will help him develop his writing skills, learn about the research done on campus, and gain the skills necessary when he decides to submit his own research for publication.

Graphic Designer - Anjeliko Garcia

Anjeliko Garcia is a Second year student here at UCM. Originally from the Los Angeles area, he group with many talents and hobbies as well as a love for gaming. From a young age he wanted to become a musician, but after seeing that there was a way to get a job playing games, he decided to try for that. Sadly that dream died when the channel G4 did. Aside from gaming being one of his hobbies, Anjeliko delves into the arts, which range from painting miniature figures, to songwriting, to poetry, to video editing, and to his current project Youtube. Anjeliko became a UCM URJ editor because of he wanted to continue practicing and refining his writing skills, as well as gain some knowledge in graphic design. Currently he is bringing all of his best interests into his future plans of becoming a business man, but hopes to write a few books, become a journalist, and become a rock star along the way. Whichever comes first.

Photographer - Jazmin Jimenez

Jazmin Jimenez is a third year student at UC Merced majoring in English. Was born in Stockton and raised in Modesto. Her hobbies involve photography, writing and traveling. She has visited over 13 countries. She has studied abroad and had an three internships, one of the she was a teacher at an elementary school, the second one she was involved in was at a Jewish cultural center in Italy where she learned to work with different age groups and the third one she was a photojournalist, all of these internships she did while she was abroad. Over the summer she is involved in tutoring Japanese students. After graduating from UC Merced she plans to teach in Japan for four years and after go to graduate school to become an architect. Jazmin became a UCM URJ to expand her knowledge on writing and to be involved with UCM activities.

Treasurer - Katherine Cervantes

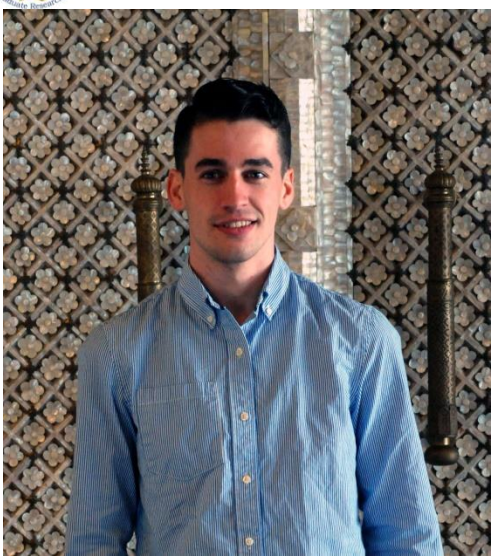
Katherine Cervantes is a second year undergrad working towards a degree in Management and Business economics in order to pursue a career in marketing management and market analysis. Katherine Cervantes is currently the 2016 spring semester's treasurer for the UC Merced

Research Journal. She was raised in San Diego, CA and descends from Hispanic origins whom is fluent in both English and Spanish with some strands of Portuguese. When Katherine isn't working on academic affairs she enjoys playing the guitar, being one with nature, and socializing with friends. She is eager to be working with the UC Merced Research Journal to expand its elite qualities by providing financial security. If you would like to contact the Journal's treasurer she may be reached at: Kcervantes3@ucmerced.edu.

Public Relations - Kevin Quintanilla

Kevin Quintanilla is attending the University of California Merced, majoring in Political Science (B.A) and double minoring in Spanish and Professional Writing. While attending UC Merced, Kevin Quintanilla has held an executive position for Merced Pre-Law Society as president of the organization. He achieved third place for both the UC Merced sustainability competition in 2015 and annual pitchfest sustainability competition. Demonstrating a great interest in law, Kevin has interned for an immigration law firm in San Jose, California where he attained valuable experience in the legal field. He currently interns at a criminal law firm in Merced, California. Subsequent to graduation, Kevin is planning to attend a prestigious Law School and focus his law practice in the state of California. He envisions of becoming an attorney and working in a law firm his first couple of years before establishing his own firm.

Social Media Director - Miles Harget



Miles Harget is a San Francisco Bay Area native and a third year spring transfer to the University of California, Merced, where he is obtaining a Bachelors of Arts in English. When he is not writing papers or reading books, plays, poems, flash fiction, short stories, biographies he enjoys swimming, the X – Files, and backpacking throughout California's expansive wilderness areas.

Miles can often be found on the second floor of the Kolligian library in a far corner, sprawled across a couch book in hand, coffee in the other. Some favorite (and recommended) authors include but are not limited to: Roger Zelazny, Larry Niven, Alistair Reynolds and Voltaire. Inquiries can be made at mharget@ucmerced.edu. Responses are generally quick, however, please allow a full 24 hours for thorough replies.

Class Presentation Manager/ Wordpress Editor - Van Vang

Van Vang is a second year student pursuing in English with hopes of becoming a novelist. He was born and raised in Fresno where the weather is unpredictable and where the wild people are. He enjoys losing himself in a good book, which drew his passion toward reading and writing. He began to strengthen his writing voice by writing poetry and had some pretty good responses from his professors and friends. His high school friends were aware of his passion for writing and took that as an opportunity to ask for his help with their papers. It was definitely a win-win situation. To this day, some of them continue to send him their papers to revise. Van is now focusing on ideas for his future short stories and novels.

Dr. Iris Ruiz is Continuing Appointment Lecturer for the Merritt Writing Program at UC Merced. She also serves as the faculty coordinator for the UCMURJ. She teaches courses in advanced composition, journal editing, first and second year composition and Chicanx Studies. Iris is the current co-chair of the NCTE/CCCC Latin@ Caucus.