2020 Independent Study

SOLAR ENERGY

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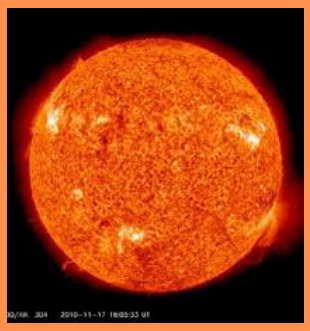

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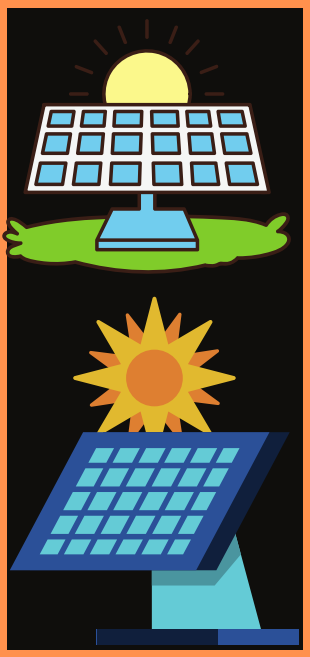

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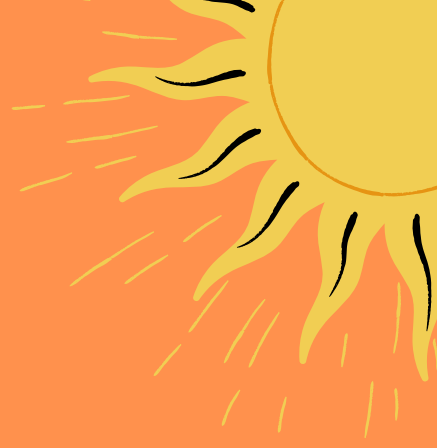
INTRODUCTION

My thematic sustainability topic is solar energy. When I was looking for a sustainability topic to study, I realized that I had a lot of questions about solar energy. I found this as an opportunity to learn more. I didn't just want to learn about the mechanism of solar panels; I wanted to learn about the science of all solar energy. With that, I could explore numerous things like photosynthesis, the history of the sun as energy, different elements, and more about the world we live in today. This is why learning about solar energy is so intriguing and fun - it can teach us what solar energy is doing to our community and how to use it knowing its advantages and disadvantages. When you use energy to charge a phone, drive a car, or turn on a light, do you ever think about the consequences and effects these things have on the earth? When you eat food from a plant, do you ever wonder how it came to be? Do you ever consider the large role that the sun plays in our life on earth? Well, all of these things can relate to solar energy, and understanding them can help in many different ways.



THE SUN

The sun is a giant, hot, glowing sphere of gases in our solar system. The sun is a star in space that all the planets in our solar system orbit around. It is just one regular star out of the billions of stars in our solar system, but earth and other planets revolve around the sun and rely on it to live. As we know, the sun is a huge part of our lives; it helps us in so many ways. The sun creates our life and land! The sun creates our land by giving energy to all plants, which provides food for animals to grow. This also gives meat for people to eat and get nutrients. Without the sun, there also would not be a water cycle, which means no clouds, no rain, and no weather. It would be impossible for any living being to survive on earth without the sun. Earth would be a frozen lifeless planet floating in space with no sun. One of our natural energies on earth comes from solar energy. Natural energy is energy that we use to generate power that does not give off any harmful emissions to the earth. We use natural energy by harnessing the natural resources of the earth and turning them into power. The sun's energy is generated by the sun sending photons and wavelengths to the earth, which we feel and see as warmth and light. Photons are the basic unit of all light. They are tiny particles shooting out from the sun or a light bulb. A photon carries energy from light and electromagnetic radiation. Electromagnetic radiation is the movement of energy in both electric and magnetic waves. It is expressed as high and low frequencies that are around us. For example, these waves come from microwaves, radios, x-rays, and as a form of the visible light we see. High and low electromagnetic radiation frequencies depend on the amount of energy in the radiation and how small the wavelengths are.

PHOTOSYNTHESIS

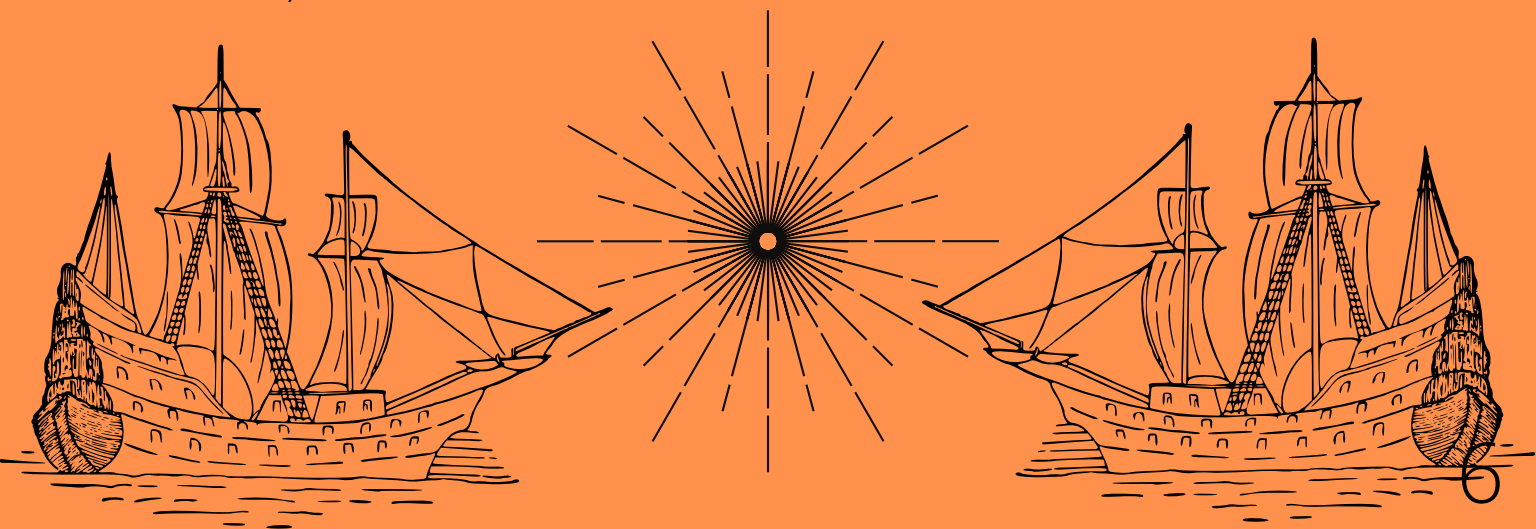
When photons shoot out from the sun, plants capture this sunlight using something called chlorophyll. Chlorophyll inside a plant is what makes it green. It is a green pigment that allows plants to absorb energy from light and convert it with carbon dioxide into oxygen and glucose sugar (food). This process that plants go through is called photosynthesis because it is made from combining two words: photo, which means light, and synthesize, which means put together. In this process, plants are doing just this. They are using light to put together water and carbon dioxide. Water gives nutrients to the plant and helps break down the carbon dioxide molecules in order to make food. Everything in the photosynthesis process allows us to breathe clean air and eat a variety of foods.

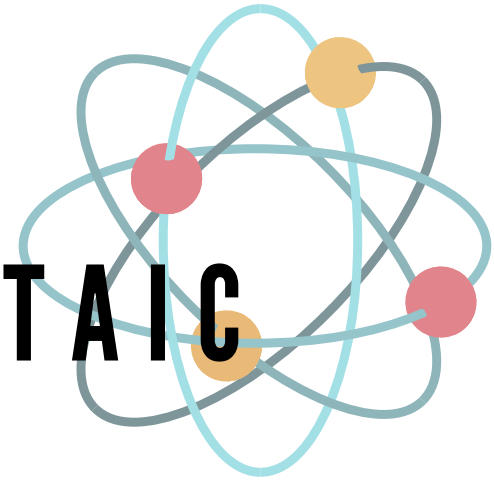
CHLOROPHYLL

Chlorophyll in a plant reflects green wavelengths from the sun, which makes a plant appear green. Chlorophyll is very essential in the process of photosynthesis and allows the plant to get water and energy to create food or sugars.

HISTORY OF THE SUN AS ENERGY

Some people might think solar energy is something new, but that is not the case. Humans have been using solar energy from as early as the 7th century BC, and it has evolved a lot over the years. Solar energy is not just the panels on your roof. It all begins with the sun giving energy to all of the natural life around you. One of the earliest uses of solar power included focusing sunlight on a magnifying glass to start a fire. This happens by positioning the glass so that the sun's rays pass through the lens, forming a small circle of light where you want to start your fire. Later, in the 3rd century BC, the Greek inventor Archimedes is said to have used huge mirrors so that the sun would reflect off the mirrors and burn the wooden Roman ships that were trying to attack the Greeks. Another way people used the sun to their advantage was by inventing sunrooms. Sunrooms were invented a long time ago to capture the natural warmth and light of the sun, even in harsh weather.

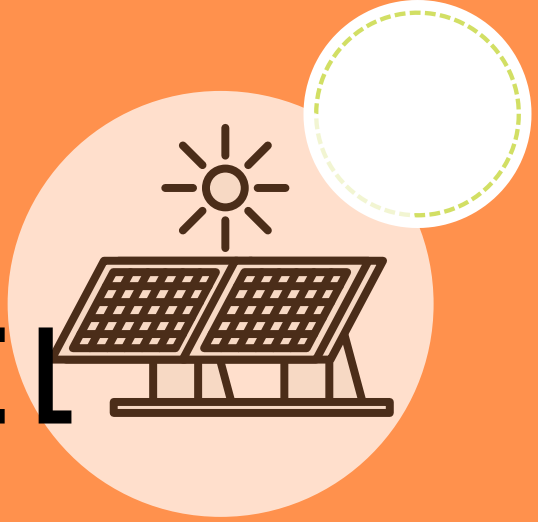




THE PHOTOVOLTAIC EFFECT

Later on in 1839, a French physicist named Edmond Becquerel discovered the photovoltaic effect. The photovoltaic effect is when a material generates an electrical current when exposed to light. In order to understand this, you should know that electrons are very tiny particles that make up an atom. These electrons inside certain materials get very excited, which generates a flow of electricity. An electrode is a solid electric conductor that carries electric currents to non-metallic solids, liquids, or gasses. Electrodes are in some of the electrical gadgets that we use day-to-day, like batteries. Batteries contain different kinds of electrodes depending on the type of battery. While experimenting with a cell made of metal electrodes in conducting solutions, Edmond realized that the cell produced more electricity when exposed to light. This discovery inspired many new ideas - it even led to a big source of energy that we use today, solar panels! Solar panels are a renewable source of energy that use the photovoltaic effect to function. Solar panels are renewable because there is no short supply of sunlight, and we are using them only to harness power and turn it into electrical energy. Solar panels were actually designed to be very similar to photosynthesis, but instead of plants converting solar energy into chemical energy (sugar), solar cells convert solar energy into electrical energy. They are both doing the same job, just in different ways.

A SOLAR PANEL

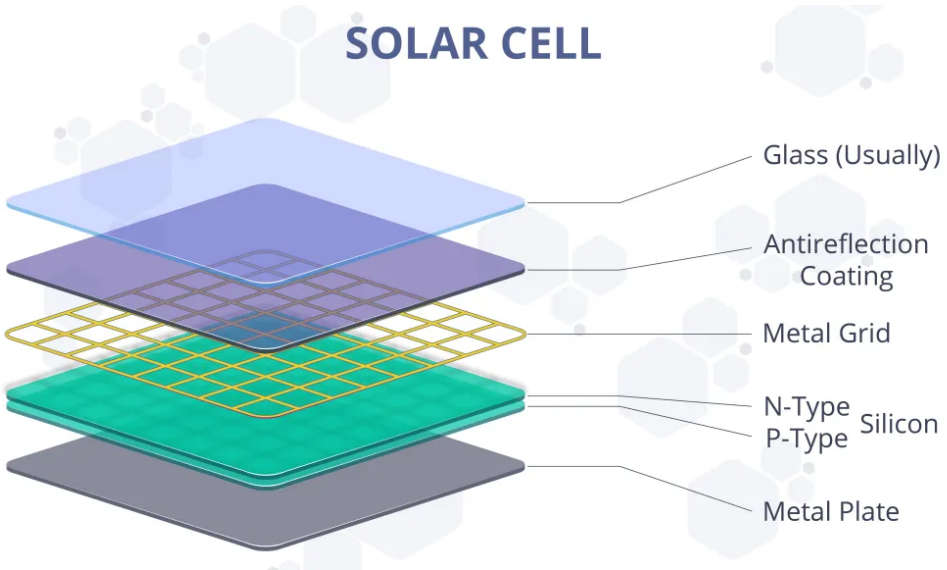


Solar panels are made up of smaller units called solar cells, which are usually made from silicon. Silicon is a semiconductor, which means it is a type of material that normally does not conduct electricity very well, but can conduct more energy with the help of the sun. Silicon is a chemical element that is all around us. You might not see the silicon but it is there - it's in our phones, in the sand at the beach, in glass, in solar panels, and 28% of the earth's crust is made out of silicon. Silicon is one of the most abundant elements on earth! Silicon is a lot like metal and is referred to as “neither a metal nor a nonmetal,” or a metalloid, an element that falls somewhere between the two. In a solar cell, silicon holds atoms which are connected by strong bonds that keep electrons in place. Atoms can not be seen with the human eye because they are so small, but atoms make up everything around us, including ourselves. Atoms are made up of three different particles: protons, neurons, and electrons. Protons are positively charged, electrons are negatively charged, and neutrons are neutral. A silicon solar cell is made up of two different layers: a n/type silicon and a p/type silicon (this stands for negative and positive). Where these two types of silicon meet, electrons can move freely throughout the p/n junction, creating a positive charge on one side and a negative charge on the other.

Light is a flow of tiny particles shooting out from the sun. When photons from the sunlight hit a solar cell with enough power, they can knock an electron from its bond and generate a flow of electricity.

LAYERS OF A SOLAR PANEL

A solar cell is made up of 6 different layers. Each one does its part to turn the sun's energy into electrical energy. The first layer is a sheet of glass. This glass helps the sun go into the panels without reflecting the light, while not allowing the panels to get too hot. The next layer is an anti-reflection coating. The anti-reflection coating helps to increase the amount of sunlight absorbed. The third layer is a metal grid. The fourth and fifth layers are the N and P types of silicon. These layers serve the most important function in a solar panel. While the other layers help to collect the sun, this silicon layer makes the photovoltaic effect work and generate electricity. The last layer is a metal plate. This metal plate is a simple covering so that the sunlight stays inside the panel. All of these layers are extremely important to create a solar cell.



SOLAR ENERGY COMPETITION

Solar energy is good for the environment and doesn't use fossil fuels or create greenhouse gasses. Still, only a quarter of our energy today is run by renewable sources, which is split up between solar power, hydro power, wind power, bio power, and ocean power! 2.4% of our energy is run by solar power. You might be thinking, why do so few people have solar panels if it's so good for the environment? Well, having solar panels on your house does have some down sides. Solar panels are weather dependent, which means they only generate electricity when it is sunny outside, so you couldn't be totally reliant on solar energy. You could fix this problem by using a peaking power plant which stores up energy for when it is dark or cloudy to get more energy. Solar panels have a lower price than using non-renewable energy sources, but only if that person is going to have that house for ten years or more. But, the long term benefits of using solar power can make up for the price. Using non-renewables like fossil fuels contributes to global warming and pollution. This is why fossil fuels are getting more expensive - because of the “expense of causing harm to the earth.” Taxes would be more expensive using fossil fuels. Solar panels don't give off any harmful emissions into the air. Solar panels are just using the sun as a natural resource. Solar energy is getting cheaper and cheaper as we find new, advanced technology!

SOLAR POWERED GADGETS

There are many things that use solar power and the photovoltaic effect to work. People have been working hard to make more things that would usually be powered by fossil fuels into things powered by the sun. Some everyday things that people are making powered by solar are solar powered street lights, generators, lanterns, chargers, backpacks, laptops, and even solar powered cars! People have found ways to equip backpacks with solar cells and batteries so the sunlight can shine on the backpack and generate electrical energy to charge phones or laptops. This gives you a portable, eco-friendly charger that will work as long as you have sun. These things aren't necessarily easy to find and buy, though. Solar powered gadgets are much more expensive than regular non-solar powered gadgets because they are not common and use more advanced technology.

EMAIL EXCHANGES WITH JESSICA FEINLEIB

1) How did you get your interest in solar power, what inspired you?

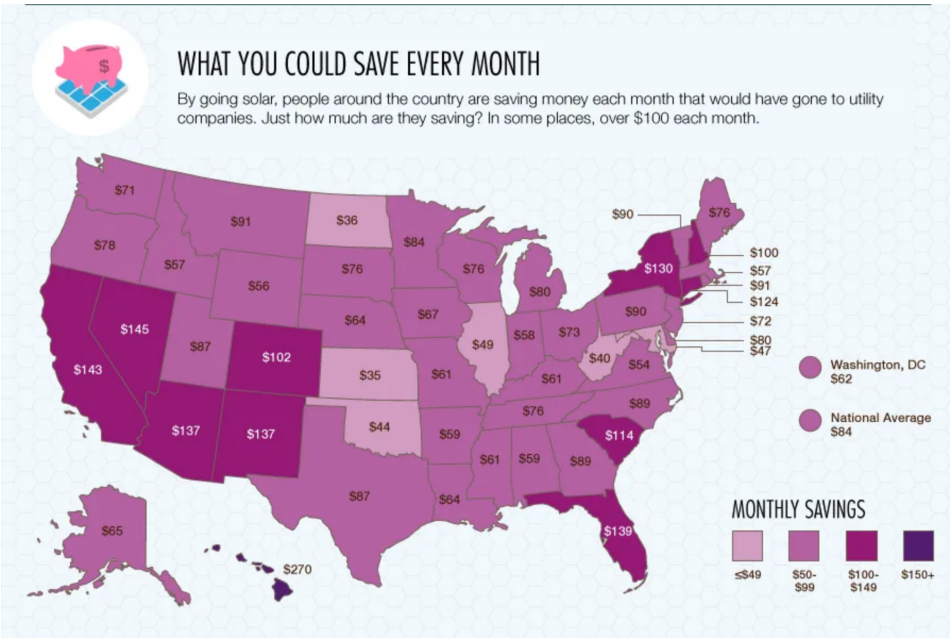
About 10 years ago, I was getting depressed about climate change. It seemed as though we were doomed, but then I realized that there was hope if we all worked together in big ways and small ways. So I decided to educate myself about the solutions to reduce carbon emissions and reduce climate change. Then I could make all the changes possible to reduce our family's carbon footprint. I would then purchase the technology that were the solutions to this issue and support companies and inventors of those solutions. This would drive those inventors and companies to make more solutions. Also if I could learn as much as possible about carbon reduction, I could demand that my government make the best decisions to reduce climate change. If I knew as much as possible I could get my neighbors and friends to make the changes that we all need to make. So it really comes to the point that I needed to learn as much as possible to make personal changes, support my local area in making those changes, and advocate for global changes.

Now we have an insulated house, use LED light bulbs, drive electric cars, have solar panels, and this winter I stopped eating meat, eggs and dairy. I still have to fly for work, but I telework when possible and take the train when possible. Many of my friends and family have made the same changes. All of these changes support others to make the same changes, and many raindrops make a river. Harnessing power from natural and renewable sources to create power is something that humans have done for thousands of years before we started to burn fossil fuels. We have used wind and water power, and so the ability to harness the sun's power just makes sense. The silly answer is that when I fly, I am always impressed by the number of roofs that I see that are really rather useless. If we can use this space that we have already cluttered up with buildings to make energy that just makes sense.

2) How has solar power evolved over time?

The biggest change in solar power over the past 40 years is the increasing efficiency and the decreasing cost. Please see this article, it is a bit old (2014), but it convinced me that the future of solar was here now!!

https://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/



3) Are solar panels good for the environment after they stop working, where do they go and can they be recycled easily? Do they give off bad kinds of waste?

Photovoltaic solar panels are made of silica (sand) and metal. They do not include toxic materials or any rare earth metals that use slave labor to obtain. They can be deconstructed to be recycled, but it is an involved process.

4) Is there a way for solar energy to be transferred from sunny places to cloudy places to get more energy?

We can transport energy via cables for some distances but the longer the distance the more the loss of energy. There is a cable from Morocco to Spain that connects North Africa to Europe. There are many solar panels in Morocco and more to come so that Morocco will be an exporter of solar energy!! For longer periods of time from a sunny day to supply power on a rainy day there are batteries. For longer distances we can convert the energy to hydrogen and use that to make electricity later.

Also, different renewable power sources can be balanced against each other. In the winter there is not much sun but a lot of wind and in the hot summer there is not much wind but a lot of sun. In the day there is a lot of sun but not much wind and the opposite is true for the night time. Hydro power can be turned on and off to smooth out the peak needs. Also, we can harness wave, tidal and geothermal energy for more reliable "base load" as it was called.

See this site to see all of the power sources in europe on a daily basis.

https://windeurope.org/about-wind/daily-wind/electricity-mix?utf8=%E2%9C%93&areas=DE&commit=Apply+filters

QUOTES FROM AN INTERVIEW WITH TODD CORT

“Solar energy is getting cheaper and more efficient as we find new, more advanced technology”

“Renewable energy is getting better and cheaper and more effective as fossil fuels are getting more expensive and less feasible”

“Fossil fuels have the expense of causing harm to the earth”

Does solar energy have any impact on animals?
“The harm on animals from solar is not very significant, but the harm on animals from solar is usually mining for minerals to use for the solar panel, and then if we had a thousand solar panels sitting in the desert it might disrupt habitat from desert species”

"Solar panels give the most cost savings in terms of renewable energy. They are the things you want to put on your roof if you live in a sunny place...”

WHO IS TODD CORT?

Todd Cort is a Faculty Co-Director at Yale Center for Business and the Environment and a Lecture in Sustainability.