Changing Power Production in the United States from Fossil Fuels to Solar Energy Technologies.

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Introduction

Economic and social development will continue to increase in the coming years to support manufacturing, public and private transport, building needs, and home electronic requirements. A change from past development is that the upcoming energy needs are constrained by reliance on fossil fuels, such as coal, oil, and natural gas. One reason for this change is the fact that easy to extract coal and oil reserves are largely depleted, and projected extraction areas are faced with highly increased cost to produce the same energy output. Another is that most countries are experiencing rapid urbanization that concentrates their energy needs in a smaller area and makes traditional coal and oil plants unwelcome in those areas. Furthermore, we need to find an energy source that will help contribute to battling global climate change and adapt our current energy supply systems to deal with the expected climate disruptions that are predicted to impact the various regions of the US.

When looking at US power production, we find that existing fossil fuel power plants produce most of the US's energy supply and tend to be located in areas that require long-distance high capacity transmission lines. These lines deal with a substantial amount of energy loss before they hit most residential areas, not to mention that a large portion of them are older and prone to malfunction as we saw with the PG&E power lines in the California fires. What is needed is an alternative power source that can be tied into local grids, as well as larger regional power needs. In the last few decades, an additional option has become more widely available,

the energy produced by renewable sources, primarily solar panels, and concentrated solar power (CSP) production facilities.

In the following sections, we will look at the basics of climate change and the breakdowns of different solar technologies. Also presented is the differing energy storage options available with the use of solar power generation.

A look at the factors behind climate change.

In order to properly understand climate change, we need to take a look at the basics behind the Earth's greenhouse cycle. The sun is the energy source that fuels the Earth's greenhouse cycle. The energy entering the Earth's atmosphere is considered short wave radiation. That energy is then absorbed by the ground and oceans, with some reflected into space according to their albedo rating. Albedo is the ability of a surface to reflect incoming light; darker materials such as vegetation and the oceans reflect very little energy and, as such, have a low rating. Elements like snow and ice reflect more of the incoming energy and have a high albedo rating. The effect on climate starts with the amount of energy either absorbed or reflected by the Earth. Large amounts of ice, snow, and cloud cover will reflect the energy of the sun and cool the planet by limiting the amount of incoming energy that can be absorbed.

In contrast, large areas of land with vegetation and areas of open ocean absorb that energy and cycle it into the greenhouse effect. The energy that is absorbed is then re-radiated into the atmosphere as long wave or heat radiation. This energy interacts with the atmosphere in a couple of different ways. Some is lost to space, while the rest is captured by greenhouse gasses in the atmosphere and then re-radiated again, increasing the amount of heat retained. This

energy is often captured and released multiple times, increasing the amount of heat energy contained in the atmosphere and oceans.

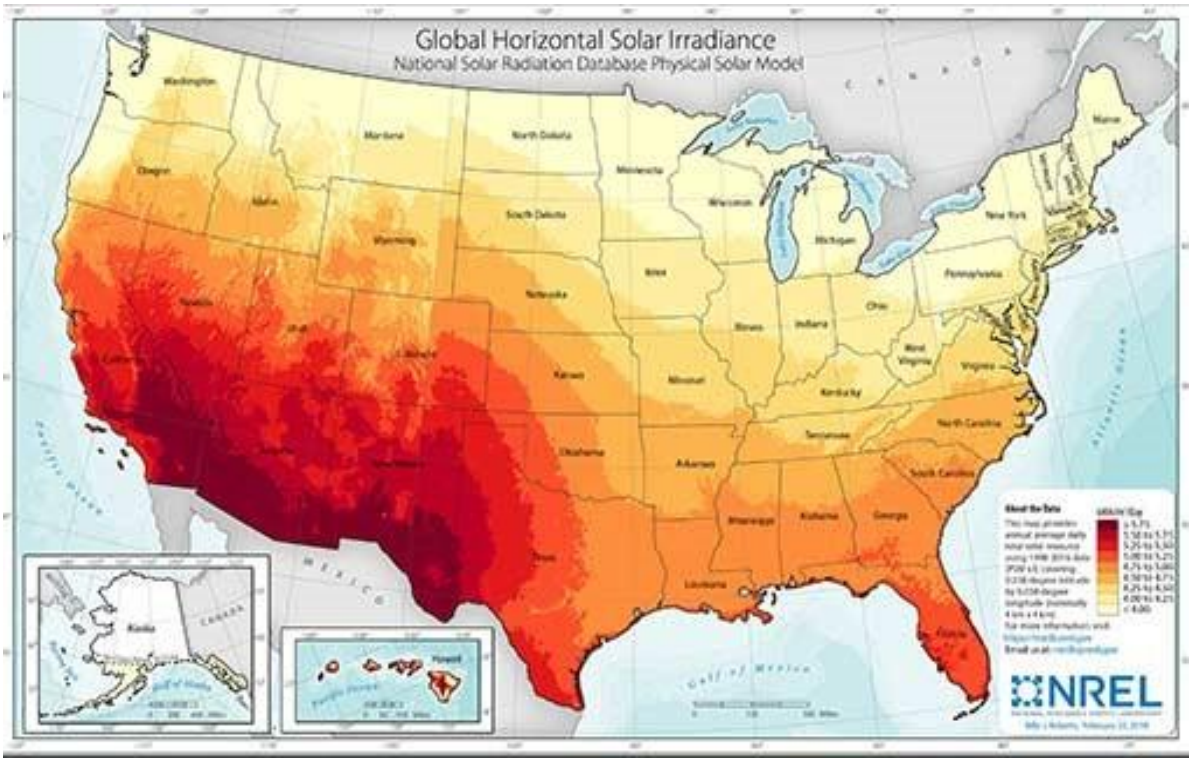
Studies have shown that water vapor and CO2 are the primary greenhouse gasses in our atmosphere. Studies have also shown that CO2 is the dominant factor that controls climate change. CO2 is a long-lived gas in the atmosphere, while water vapor and clouds are a more active part of the climate system that is continuously cycling between water and vapor states in various weather systems. When looking at the percentages for how each gas affects the planet, we see that water vapor and clouds account for around 75% of the greenhouse effect, with CO2 at 20% and other GHGs at about 5%. Because water vapor is considered a fast responder and CO2 with the remaining GHGs are classified as forcers, we then see that the 25% total of gasses in the atmosphere drives the entire greenhouse effect. We can also then infer that without the gases such as CO2, the Earth would be rapidly cooling into another glacial state. (Lacis, 2010)

The critical point to consider when looking at conditions today is that very rarely would CO2 levels in the atmosphere rise about 300 parts per million. In contrast, today, we have increasing levels over 415 ppm. We also need to keep in mind that CO2 can stay in the atmosphere for hundreds and even thousands of years.

Another point we need to consider is the exponential increase in emissions from industry and power plants. Our dependence on oil and gas has led us to a tipping point when we are looking at the future of the planet. Every year we produce billions of tons of CO2 and other GHGs that our world has to deal with. With the industrialized nations wanting to keep their lifestyles and the developing countries driving to reach the same levels, we have a nearly logarithmic increase every year of emissions that our supporting industries put out.

Solar technologies and their implementation.

Global energy and electricity consumption are increasing rapidly due to the growth in population, industrialization, and urbanization. Compared to global population growth, energy consumption is growing much faster, and within the next 20 years, studies predict that total consumption will double (Sampaio, 2016). Energy consumption of both conventional and renewable sources will play an essential role in future sustainable development. At present, at least 80% of the global energy supply comes from fossil fuels, which are considered a depleting energy source and responsible for emitting greenhouse gasses (Balijit, 2016). Acknowledging that there is an urgent need for the development and implementation of renewable energy technologies. As we can see from the following map, the majority of the US has a receptive profile for the production of solar energy, either using home-based solar cell systems or larger regional solar plants



Solar energy, as an intermittent power source, requires either energy storage or a fuel-based backup power system (Lingkun, 2017). Solar PV cells by themselves have a variable power output, which leads to grid reliability issues. Concentrated solar power (CSP) technology offers a renewable energy source that can incorporate a large amount of energy storage.

Capturing solar energy through photovoltaic panels in order to produce electricity involves the conversion of that solar radiation into usable electricity using semiconductor materials, the most common of which is silicon. Numerous examples of this are readily available and are in everyday use today. Another method of capturing solar radiation is through concentrated solar plants. CSP systems involve heating a working fluid using concentrated sunlight (Islam, 2018). This heated fluid can then be used with conventional power generation equipment (i.e., turbines) to produce electricity. Because CSPs are capable of bulk electricity generation and off-peak power storage, many nations are investing heavily in that technology.

As we talk about the types of solar power generation systems, we also have to examine the various methods of power storage they need in order to provide energy during off-peak energy hours. Using battery, thermal, and pumped hydroelectric storage are time tested methods of providing off-peak energy needs. There are also current trials of hydrogen production from solar power sources that are in the testing stages.

There are numerous types of batteries used for solar storage, the most popular right now are Lithium-ion and Lead-acid. Both are mature technologies that are long tested in consumer markets. An advantage of battery storage over other methods is that they are widely available if a homeowner wants to install some on their house. Another option that power companies could take advantage of is the prevalence of power substations in urban areas to house battery storage

structures. This would allow for them to be tied into local grids and avoid the power drop-offs and inefficiency of transporting that power long-distances.

Thermal energy storage is mainly used with CSP. The primary storage system that CSP use are liquid storage mediums (Lingkun, 2017). The advantage of a liquid storage medium is that it can be circulated quickly, transporting heat when required. Some of the storage liquids in use are water and molten salts (Lingkun, 2017). Water is one of the best storage mediums for low-temperature applications (Lingkun, 2017). Its advantages are high specific heat, non-toxicity, cheap cost, and easy availability. Water is best used for house space heating and hot water supply type applications. Molten salts are currently the most used thermal energy storage materials in CSP plants (Lingkun, 2017). They are cheap, and their energy density is high compared to other liquid storage mediums. Today the practice is to use salt composites that can act as a heat transfer fluid, but it is still considered safer to have antifreeze systems in place to deal with any freezing risk. One of the drawbacks of molten salts is that they are oxidizing agents and very corrosive, thus requiring more costly measures to prevent any damage (Lingkun, 2017).

Pumped hydroelectric storage offers a way to store energy at the gereration point of the power plants, by storing excess generation for later use. These plants usually have reservoirs at different levels. These plants store energy by pumping water into the upper level reservoir when storing power. When extra power is needed, the water is released into the lower level reservoir by running it through turbines to generate electricity. This method, of course, requires a placement farther away from main urban areas but is a time-tested method of power storage. A way around the remote placement is to use underground storage tanks located closer to the desired recipients but then necessitates a higher construction cost.

Hydrogen can be stored and used in fuel cells, engines, or gas turbines to generate electricity without producing harmful emissions. The use of solar energy to produce hydrogen is most often produced by using water electrolysis using solar-generated electricity. This is a good technology for larger power plants that are producing excess energy. The hydrogen thus produced can then be used in any off-peak needs, such as in remote areas, as well as in regions that do not match the ideal profile for peak solar generation. This would be ideal for automotive needs as well as any vehicle or structure that could rely on fuel cell systems.

Conclusion

In the United States, there is widespread support for solar energy from all political groups, and the enormous potential of solar energy production has only been held back from extensive use by the economic policies produced by the fossil fuel industries. One large issue that they constantly use is that technological fixes will save us without the need to change our lifestyles in any way. From deliberately releasing sulfur into the upper atmosphere to covering the Sahara Desert in white sheets, and even the relatively new ideas of taking the CO2 out of the air to make more fuel with it, we are constantly bombarded with the idea that we can keep using the high pollutant energy sources in use now without any need to change. An excellent example of this short-sighted thinking is this quote "You cannot build a scale model of the atmosphere or tent off part of the atmosphere. As such, you are stuck going directly from a model to full-scale planetary-wide implantation." (Klein, p270). Given that we still do not have a full understanding of the systems that regulate the environment, any large-scale geoengineering is a scary thought.

In order to bring about needed change, there are many paths we take to bring about a society where we care more about each other and the environment than what we can profit off of.

By finally holding companies accountable for their waste and pollution, we can change how they do business and drastically reduce the impact they have. Oil and gas companies today are making record profits and then turning around and investing in even more destructive activities. By requiring that we start to replace fossil fuels with clean alternatives instead of just adding to the overall amount, we can make a switch to an energy source with a great deal less pollution, such as solar energy production. To those who inquire about jobs lost in the oil industry, I would say that as we transition to more green energy, those jobs created by the new solar industries will be more than adequate to cover any loss in the fossil fuel sectors.

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