Tesla Design in Solar Roof Top

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Abstract--- *Rooftop solar power systems are picking up a second job on the distribution grids that deliver electricity to homes and businesses. Right now, their photovoltaic panels just generate electricity but within a few months some systems will also start moonlighting as junior grid regulators-a role that could keep them busy even after the sun goes down.*

Keywords--- *Solar Energy, Solar Roof Panels, Energy Conservation.*

I. INTRODUCTION

Rooftop solar power systems are picking up a second job on the distribution grids that deliver electricity to California homes and businesses. Right now, their photovoltaic panels just generate electricity (meeting about 1 percent of the state's consumption), but within a few months some systems will also start moonlighting as junior grid regulators-a role that could keep them busy even after the sun goes down.

While the development in California is the result of a state-specific standard, approved by the California Public Utilities Commission (CPUC) in December, it is also part of a global movement: Germany, Japan, and other countries where solar is booming are implementing a similar change to empower rooftop solar installations to regulate voltage levels and perform other grid-support tasks.

Solar's expanding role is the result of upgraded inverters-the power electronics that link distributed generators such as rooftop photovoltaics to the grid. The inverters convert direct current from PV panels into a wave of alternating current that is synchronized with the AC grid. Inverters can also synthesize reactive power-AC whose current wave leads or lags the voltage wave-which grid operators worldwide use to control line voltage. Adding reactive power with leading current boosts AC line voltage. Subtracting reactive power (by adding power with lagging current) pulls AC voltage down.

The new inverter standards mark a big change for equipment that utilities have viewed largely as a nuisance. Standards have hitherto required solar inverters to shut down at the first hint of line trouble, in order to protect workers from unanticipated currents. “Traditionally, we've been looking for these devices to trip off with any hiccup on the distribution system. Now they are becoming a resource,” says Robert Sherick, principal manager for advanced technology at utility Southern California Edison.

Utilities must adapt because maintaining power quality gets harder with rising levels of distributed generation. German grid operators were among the first to experience this when solar started booming there a decade ago. At times of low power demand, high solar output drove up voltage levels, explains Bernhard Ernst, grid integration

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director for inverter manufacturer SMA Solar Technology, based in Niestetal, Germany. Such situations prompted utilities to freeze PV installations on certain lines.

Germany's smart-inverter requirements, established three years ago, solved the problem by requiring inverters to start subtracting reactive power when output from their PV arrays exceeds 50 percent of capacity. This counterbalances the voltage-boosting impact of the solar power generation.

II. LITERATURE REVIEW

Although solar panels are a relatively new source of energy that have recently been extensively developed, they are the most widespread form of personal renewable energy that does not require a connection to a power grid worldwide (“Solar Energy Basics”, n.d.). This freedom from the grid makes solar energy an attractive solution for powering the one billion people worldwide that do not have access to electricity. As the world moves into the digital age, electricity is becoming an essential part of improving the quality of life for many people in the developing world. With global warming on the rise and with governments in some developing

Solar energy is one of the few portable sources of energy that can provide enough power for home use (“Solar Energy Basics”). However, the expense of solar panels makes them unaffordable to many people that urgently need them. One solution is to fully redesign a solar panel from the inside out, but this approach could entail the use of overly expensive materials and lead to the development even more expensive panels while only marginally effecting solar efficiency. Cheaply build and effective external structures to solar panels have not been developed yet. An external structure would increase the amount of light that makes contact with the solar panel, thereby increasing the energy output of the solar panel significantly. As a result, fewer solar panels would be required to create the same energy necessary to power a household. Fewer solar panels result in a lower cost of production and a lower purchase cost, while helping the environment at the same time by acting as an alternative to fossil fuels.

III. A HISTORY OF SOLAR PANELS

Solar panels have been widely used since the 1980’s, but modern technology for solar panels has been around for much longer (“The History of Solar”, n.d.). The photovoltaic effect, an integral part of how most commercial solar panels operate today, was first discovered in 1839 by French scientist Edmond Becquerel. He discovered the effect by placing two metal electrodes in an electricity-conducting solution, and he found that when the electrodes were exposed to light, they produced more electricity. The first instance of modern photovoltaic technology was in 1954, when Daryl Chapin, Calvin Fuller, and Gerald Pearson developed the silicon photovoltaic cell at Bell Labs(“The History of Solar”). Unlike previous attempts at building a solar cell, Chapin, Fuller, and Pearson developed a cell powerful enough to power everyday electrical devices. Their initial design had an efficiency of four percent, meaning that four percent of all of the energy from the sunlight was converted into electricity. Even with the advent of a new solar cell, the first use of solar panels to power an electrical process in a building would come a few years later, as the Bridgers-Paxton Building would become the first building to be heated with solar energy ("The History of Solar"). As solar panels became a more viable source of energy, the efficiency of solar panels steadily rose from the initial four percent to 14% in

1960. The number of applications for solar panels increased as well. Panels were sent into space to power satellites and were hoisted onto lighthouses. As time passed, solar cells became lighter and thinner, as extensive research on paper-thin photovoltaic cells was conducted. Most importantly, solar cells also saw a decrease in cost("The History of Solar"). In 1977, one watt from a traditional silicon photovoltaic cell cost $76.00 (inflation adjusted), while in 2015, the same watt cost 30 cents. The decrease in cost has resulted in the increase of personal solar usage, with a survey in 2013 estimating the number of solar-powered homes in the United States to be 400,000. Projections for solar usage in 2020 range anywhere from 900,000 homes to 3.2 million homes ("The History of Solar").

IV. Anatomy Of A Solar Cell

The most common solar cell in use is the silicon photovoltaic cell. This type of cell is divided into layers that carry out the stages of conversion from light energy to electricity. The process that solar panels use is referred to as the photovoltaic effect. The first stage of energy conversion is the reception of light. Initially, wavelengths of visible light emitted by the sun make contact with the silicon covering of the solar cell. Because silicon has a high surface reflection of 30%, most manufacturers add a coating of antireflective material on top of the silicon covering. The antireflective layer is made out of dielectric material with uneven texturing and thickness. A wavelength of sunlight that hits one portion of the dielectric layer will interfere with another wavelength of sunlight that bounces out-of-sync with the first wavelength. When these wavelengths make contact with each other, the low point of one wavelength will bounce off of the peak of another wavelength, resulting in destructive interference. Instead of those wavelengths of light bouncing away from the solar panel, they will both fall back to the solar panel and will be absorbed ("The photovoltaic effect", n.d.).

Absorbed light is then transferred to the next part of the solar cell, which is the electric field. The electric field, unlike most of the solar cell, does not consist of silicon because silicon is not a good conductor of electricity. The electric field is made with trace amounts of phosphorous and boron, which have opposite charges. While each phosphorous atom wants to get rid of three extra electrons, each boron atom wants to gain three extra electrons; as a result of this tendency, electrons are transferred from phosphorous to boron. The resultant compound has two sides of opposite charge and is therefore capable of creating an electric field ready for the conversion of light ("The photovoltaic effect").

In the next step, photons from the sun play a crucial role in the movement of electrons. These photons knock the electrons in the phosphorous and boron layers loose, and those electrons fly in many different directions. Most electrons fly away from the junction of the two layers, meaning that nothing happens. The electrons that do reach the meeting point between the positive and negative sides of the electric field are then forced to metal conduction strips at the bottom of the solar cell, generating electricity. Electricity generation concludes the three-stage process of the solar cell ("The photovoltaic effect").

V. THE USE OF SOLAR PANELS TODAY

In the present day, solar panels have a wide variety of applications. In many of these situations, solar panels replace fossil fuels as a source of energy. Solar energy powers buildings, a variety of modes of transportation, and satellites in space. Solar panels are most commonly used as power sources for buildings. (Dragza, 2008). From homes to shopping malls to office buildings, solar energy powers everything from lighting to automatic doors to wall sockets. Solar panels have allowed property owners to break free from electricity bills and these owners are therefore less vulnerable if costs for electricity rise. Solar panels, more importantly, have also replaced fossil fuels, such as coal and oil, in the buildings they power. In 2013, solar energy creation in the United States reached 8.3 million megawatt-hours (Mwh). That is 8.3 million megawatts that were not created by coal or oil (Dragza). While this is still far away from the amount of energy produced by fossil fuels, solar energy is rapidly replacing energy sources that contribute to climate change.

Solar energy has also been used in modes of transportation. While this application of solar panels has only been experimental, results have been promising. A car that was completely powered by solar panels traveled a record range of 1,000 kilometers. While electric cars are already in wide use and have been lauded as a clean alternative for power for cars, the electricity for the batteries of such cars still comes from plug-in sources that may ultimately derive electricity from a coal or oil plant (Dragza). Solar cars are 100% clean and the sun would be one of the best alternate energy sources for cars. Solar airplanes have also been built. One such airplane, named the Solar Impulse 2, completed a multi-leg flight around the world in 2015. This flight and other work from the Solar Impulse team have given airplane enthusiasts hope that solar panels may power more airplanes in the future. Current jet fuel sources are extremely harmful to the environment, and most commercial airplanes produce copious amounts of carbon dioxide, which adds to the amount of greenhouse gases in the atmosphere, allowing less light to escape and therefore heating up the earth (Dragza). The future development of jet airplanes powered by solar panels will result in the elimination of one of the largest sources of carbon dioxide in the world (Dragza).

Solar panels are used outside of Earth as well, as they power satellites in orbit. The most famous solar panels are the ones that run the International Space Station (ISS). There are 16 wings of solar panels that stick out from the body of the space station, and they produce all of the power needed to run the ISS (Dragza). In addition, solar energy has been used to power lunar modules and rovers that explore other planets. When scientists at NASA designed their space equipment, solar power was chosen as the source of energy because it is a constant source of energy that is simple to harness (Dragza). There is no risk of running out of battery power because solar panels will always be able to create electricity from sunlight.

VI. PROBLEMS WITH CURRENT SOLAR PANELS

As solar panels use has only recently proliferated, there are still problems with the solar panels that prevent them from being a major power source. Those problems include cost, efficiency, and energy storage. The amount of monetary investment needed for a solar panel is too high for many people, which prevents a wider use of solar panels.

Solar panels cost $25,000-30,000 for an initial installation for an average of five-and-a-half hours of sunlight per day and an average use of 500 kilowatt-hours (kWh) per month. While this cost can be paid off over time, it still amounts to $210 per month ("Residential Solar Calculator", n.d.). The median income in the United States is $4,313.25 per month, which means many Americans do not have enough savings to pay $210 per month for solar energy. Though solar panels lead to more savings over time, they are still prohibitively expensive in the short term ("Residential Solar Calculator"). If conventional energy continues to cost around half of what solar energy costs, most people will not choose to invest in solar energy.

If solar panels were more efficient, homeowners would not need to purchase so many panels; increasing solar panel efficiency will therefore decrease the initial investment required to install solar energy. Most solar panels can only convert a small fraction of sunlight to electricity. The world record for efficiency among rooftop solar panels (without laboratory modifications) is just 24.1% (Wesoff, 2016). The technology used to make the world record solar panel is rare and expensive. Most solar panels today only reach 14% efficiency ("Why Are Solar Panels Inefficient?", 2016). Many sources will say that 14% is enough for the needs of the average homeowner, but in many cases, entire roofs must be covered with solar panels in order to generate enough power for the house. If solar panel efficiency were higher with the same cost per panel as modern technology, fewer solar panels would be needed to power one house and therefore less money would need to be spent ("Why Are Solar Panels Inefficient?").

One of the biggest issues with solar panels is the ability for them to store energy when night falls. By definition, solar panels use sunlight to produce electricity. As the sun is only in the sky during the daytime, there is no sunlight for solar panels to absorb at night ("Why Are Solar Panels Inefficient?"). All solar systems produce the same amount of electricity during certain times of day, even when electricity use is not as high. For example, the maximum amount of sunlight is available at noon, but noon is a time of day when no one is at home. All of the electricity produced is going to waste because the energy produced in the afternoon cannot be used at night. For solar energy to reach maximum potential, the maximum amount of energy available from sunlight must be harnessed and used ("Why Are Solar Panels Inefficient?"). This way, households do not need to switch to the grid at night, because stored energy produced from solar panels will power the house throughout the day.

VII. Previous Attempted Solutions To Problems

Scientists have been attempting to make solar panels more efficient and cost-effective with the hope that a technology will be invented to revolutionize the solar industry. Examples of such inventions include perovskite and cadmium telluride.

Perovskite is considered a surprise invention in the solar world. Although perovskite has a high price, it has resulted in the significant increase of solar efficiency (Nave, 2016). Specifically, the efficiency of a solar panel can increase up to 33% if perovskite is used. Perovskite is made of relatively common elements, such as tin, lead, cesium, and iodine (Stanford, 2016). These elements are fused together to create a thin sheet of perovskite. The thin sheet has a variety of energy gaps, which are portions of the sheet that are made to absorb a different wavelength of energy from the sun.

While a solar cell can only absorb a certain type of electromagnetic radiation (EMR), perovskite can absorb many different types of EMR, then convert all of the energy into a form that the solar panel can absorb. This results in a great increase in the efficiency of the solar panel. However, perovskite is not yet a commercially viable product. Creation of perovskite requires a lab environment that cannot be replicated in factories (Stanford). The lack of mass production results in high costs that make perovskite commercially unviable. Efforts to decrease the cost of perovskite have been unsuccessful.(was the source for your whole para Stanford? If so put it outside the last period and you will be covered)

One other attempt to improve solar technology is the creation of cadmium telluride cells. These cells are inexpensive and can be made on an assembly line (Giges, 2014). Like silicon cells, energy generation in cadmium telluride cells occurs through two layers of electron transfer. However, these layers are made of cadmium, not silicon, and contain sulfur and telluride as the trace elements that facilitate electron transfer, in place of phosphate and boron. Sulfur and telluride have more electrons than phosphate and boron do, and more electrons means that more electricity can be produced. On average, cadmium telluride cells have been shown to improve efficiency by six percentage points. This observation is significant because fewer solar panels

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