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Section 1

Group 2

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First we made some changes to the central topic, from *Solar panels serve as an effective way to bring the general public into an attitude surrounding self conscious energy usage and carbon footprints, in addition to generating a sense of urgency surrounding renewable energy and the ongoing climate crisis*, to *While solar panels are an effective way to get the general public to care about renewable energy, the reason the public hasn't switch is because of the state of our current social and economic systems*. In light of such changes, we also modified the content listed below.

First, in the refactoring of the first section, we linked the solar panel to the readings of the third week, not the second week, which is more closely related to the new thesis. In accordance with the progressive relationship, we have also rearranged the order of paragraphs. The last paragraph now is the 2nd and 3rd paragraphs before, with minor adjustments.

In addition, we have added a citation from the classroom reading material (*Social Life of Small Urban Places*), focusing on the tenth paragraph to discuss the potential changes in urban construction and how the new energy economic behavior of the last decade has gradually affected public attitudes towards solar energy installations.

Lastly, some paragraphs added or modified citations, which we have also revised.

An Analysis of Solar Energy Systems

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For a few years now the world has been on the lookout for the next big source of energy. Fossil fuels and other non renewable sources of energy have been used for over a century and with the massive expansion of the population of the world, the energy demands have skyrocketed. To meet these demands, engineers continued to develop infrastructure that maximized the usage of non-renewable sources of energy. From massive oil rigs in the ocean and giant electrical power plants that burn coal, modern engineering has built a system that seemingly fulfills the daily requirements of everyday people with minimal footprint. However, further scientific research discovered that the footprint created from the usage of fossil fuels has put us on a collision course with unfortunate consequences. Thus a new need for renewable energy with little to no footprint has arisen, and solar panels are one of the technologies at the forefront. Solar panels have yet to be introduced to the larger modern population despite their benefits being numerous. This scenario could be attributed to a multitude of factors and reasons, but what must be emphasized is the importance of a socio-technical system such as solar panels being able to handle this growing problem in nature. While solar panels are an effective way to get the general public to care about renewable energy, the reason the public has not switched is because of the state of our current social and economic systems. To analyze how solar panels, as a socio-technical system, can work towards accomplishing that goal, a broad perspective will be taken including but not limited to manufacturing, alternate options, and sale of the device.

While solar panels provide an alternative to more environmentally harmful sources of energy, it would definitely be incorrect to think the Solar Energy Energy system has zero negative effects on the environment. Like most other technologies, the process of manufacturing creates waste. Some waste that can do more harm to the environment than others. As the solar energy system grows in use, more and more of this waste will accumulate. This problem has

been addressed by various organizations, such as the International Renewable Energy Agency (IRENA). In 2016, the IRENA published a report addressing the issue, as well as some methods on how to approach the issue. There are three methods reported that can prepare the various stakeholders of solar energy, such as industry and government, for the encroaching waste issue. These methods are:

1. Adopting waste regulations that are specific to solar energy technology.
2. Expanding waste management infrastructure.
3. Promote ongoing innovation in solar energy system design, both during use and at end-of-life.

Adopting solar cell specific waste regulations has already been done in certain parts of the world. For example, the European Union added solar panels to its WEEE Directive, which is their policy on the disposal of waste from electrical and electronic equipment.

The expansion of waste management infrastructure has also been undertaken in europe. The PV Cycle is a non-profit organization that offers services to companies and waste holders across the world, for waste management and legal compliance. (Barnes, 3).

The third method is a bit more complex as it refers to a change in how we design systems. The promotion of ongoing innovation in solar energy technology involves multiple different aspects. To be specific, the classic three Rs principles: reduce, reuse, and recycle. It would be most preferable to design solar panel systems that use less materials, thus leading to less waste both during manufacturing and at end-of-life. The second most preferable option is to incorporate the reuse principle, an idea for this is to repair older or damaged solar cells and resell

them at a reduced price on a second hand market. As for the solar panels that are not able to be repaired, they are to be recycled. This can vary in difficulty, depending on the size and complexity of these systems. Ironically, smaller systems are more difficult to recycle because while some installers offer disposal services, not all of them recycle the solar panels or offer them at all. The improvement of design aligns directly with week 3's content that we learned from "Engineers for Change" by Wisnioski. It is not only important for engineers to ensure their systems are benefiting society at its most optimal level, it is their professional and personal responsibility and duty as people with the means and authority to do so. While not every aspect of the solar energy system is within direct control of engineers, they operate within a special place where technical knowledge combines with social order. As a result, engineers have more potential influence than they may realize; to not use this would be a waste for them and the future of society. Overall, while the increased use of solar energy may lead to issues involving waste management, with professional responsibility, improved designs, and the application of social and economic incentives we should be able to tackle this issue head on.

It has been nearly 50 years since photovoltaic technology was accepted by the industry in the 1970s. According to the statistics from the U.S. Depart of Energy, Solar gen accounts for only 3% of the total power generation. Before 2010, it was even less than 1%. The government was vigorously promoting the development of solar energy through financial subsidies, but from the perspective of replacing one or more mainstream traditional energy industries, it has not yet achieved significant results. This section therefore mainly studies the 2 stages of the development of solar energy systems before and after 2010. "The growth of small-scale solar, especially in the commercial and residential sectors, drove early growth in net solar power generation in the United States. In 2011, small-scale solar accounted for 68% of total net solar

power generation in the United States. However, over the past decade, with U.S. utility-scale solar power generation has increased substantially as the average construction cost of solar power plants has fallen." That is, the capacity ratio of solar power generation has gradually shifted from individual to large-scale enterprise-based solar equipment clusters over a decade. From one perspective, solar technology itself is maturing, so the cost of construction is gradually falling. Such advancements should be effective for anyone interested in solar panels: small solar equipment owners, those individual households. and so more people will be willing to deploy home solar equipment. However, this is not the case. The electricity sector has already generated 68% of total electricity generation in 2020. Small solar panels are also on the rise, but not significantly. Who is driving this development: government, enterprises, both? Or has the business itself changed?

With reference to this research report, published in 2012, it reviews the history of solar energy business from the 19th century to the present and discusses the relative importance of entrepreneurs and public policy in shaping the industry's corporate structure. According to the survey of the article, before the publication of The Public Utility Regulatory Policies Act (PURPA) in 1978, most of the major solar power technologies and orders in the United States were for special customized industries (such as solar sails for satellites). Thereafter, the decree "opened the door to competition in the electricity supply by requiring utility companies to buy electricity from "qualifying facilities" also known as "nonutility facilities that produce electric power" including renewable power plants." (Jones & Bouamane, 2012)

At this time, oil companies became major investors in these commercial solar power companies. From then until the 2010s, the American solar industry grew up with government support. However, blind subsidies and investment cannot reverse the commercial setback of solar

panels. With the addition of overseas factories, a dilemma gradually emerged. While innovation is driven by companies, solar, like other renewables, requires supportive and consistent (but often wobbly) government policies to compete with traditional fuels, and to keep investing: but not profitable in the short term. Thus, oil companies have also gradually cut back on investment or even excitement.

After 2010, instead, we see a completely different picture from the solar industry that has survived to this day. These companies do not hold such businesses of producing or selling original products, but package the entire production activity into an economic product for investors. In the article "Good to Great", we have seen a similar line of strategy. Leaders are well aware of the crisis they face, and decisively dump these tasteless businesses. At the same time, they shrewdly set their sights on today's crowdfunding-like business model: pooling investment from individuals to build a large-scale photovoltaic plant and cooperating with the energy sectors to settle the return on investments. There's not enough data available to show what kind of effort leaders have put into the "transformation" process, but we do see a good shot that a savvy navigator made. End with an example "DHA developed a new model for expanding solar access to residents of its multifamily affordable housing buildings. Its model is the first community solar project to be owned and operated by a housing authority. DHA worked with its local utility, Xcel Energy, to allocate benefits to housing subscribers by using a power purchase agreement model developed with project partners. This structure allowed DHA’s tenants to access solar energy without having to fund any of the up-front construction costs, which meant lower energy costs for both the customer and DHA. Essentially, DHA acted as the conduit for them to gain access to the 30% savings provided by the ITC." (ENERGY.GOV, 2020)

On the other hand, such a transition will somewhat reduce the attractiveness of solar equipment to the public. It is true that securitization has paved the way for companies to have more financial means and access to multi-party investment. But solar energy is therefore no longer a device that ordinary people really touch. When a complete power generation system is placed in a garden, it is different from comparing it with a financial product and tens of thousands of investment methods on the Internet. Also because of the absolute benefits and payback period, limited by technology and weather, solar power plants do not have any absolute advantages as an investment project, so they gradually fade away in the eyes of the public. Referring to the video Social Life of Small Urban Places, the facility itself has an impact, even assuming the same economic benefits. For example, in a community that is generally equipped with solar energy equipment, new residents will also be more willing to choose to try it. These (compared with solar plants) small panels of equipment also create an atmosphere, like a plaza, attracting people gathering.

The question of "how do we bring the general consumer to the market space of renewable energy with solar panels" remains and the answer is a key part to showcasing the ability of solar panels to change social dynamics iteratively. The effects of solar panels, both technical and social, have been discussed in previous paragraphs. However, these benefits cannot reach their full potential until the market is ready to accept them. General marketing strategies can be applied to this dilemma, but due to the nuanced nature of solar panels, that being its ability to drastically save money for consumers and contributing positively to the overall community, a different strategy should be employed. Lowitzsch writes in their paper "Investing in a Renewable Future – Renewable Energy Communities, Consumer (Co-)Ownership and Energy Sharing in the Clean Energy Package" about turning general consumers into "prosumers" for the upcoming

transition in the energy market. A prosumer, as defined by Lowitzsch, is an individual who generates their own renewable electricity and is able to share it with a larger community than the individual, and store and sell excess production (Lowitzsch, 2019). Prosumers, that Lowitzsch emphasizes the importance of, can easily be created by solar panels. As mentioned before, solar panels clearly generate the user electricity, in addition to being able to pump energy back into the power grid and generate the user income. Turning everyday people into this kind of prosumer will help aid in the energy transition as the need to do so continues to rise in severity.

The method in which society attempts to bring forth this change must address a few concerns that are currently inhibiting a smooth transition. A very important challenge is as follows, “create a coherent incentive system for RES and RE ‘prosumage’ based on market related price signals” (Lowitzsch, 2019). The general public needs to actually witness and understand the tangible or intangible benefits, related to the market, of solar systems and other renewable energy systems. In other words, this aspect of solar panels must be made an “affordance”. Norman writes that the “term affordance refers to the relationship between object and a person” (2013). Norman describes the affordance as the relationship of the characteristics of a product, and how a user might use them. Therefore it is imperative that the relationship between solar panels' ability to save, and generate energy and money is able to be afforded by the users who purchase them for their houses. The everyday individual utilizes products because they have an inherent understanding of what a product is used for. Solar panels are typically out of sight and out of mind meaning that their positive feedback is not immediate, another idea that Norman stresses. Without witnessing how a solar system can aid a user until the next utility bill, it’s difficult to argue in favor of solar panels. Fortunately strides have been in an attempt to overcome this challenge and align with the ideal design goals of everyday products. Primarily

the market entry point has been lowered in order to allow for small scale users to gain a foothold. Lowitzsch describes how the European Commision in 2018 had a “consensus among policy makers to postulate a sufficiently large number of market participants to guarantee competition and prevent market domination by a few large players” (2019). If the barrier of entry to the renewable energy system is lowered, more of the public will be willing to enter the ring and learn about the benefits of prosumage. Furthermore this will likely lead to a snowball effect as the push for policy makers to incorporate higher incentives for renewable energy systems increases as the market is flooded with participants from society at large (Lowitzsch, 2019).

For alternative energy solutions, although fossil fuels now meet the majority of the world's energy demands. Scientists and policymakers should take advantage of this period of opportunity to evaluate alternative energy sources and determine what is scientifically feasible, ecologically acceptable, and technologically feasible. Each energy source, according to the author of "Alternative Energy Technologies," has its distinctive properties. For instance, fossil fuels emit carbon dioxide, as well as other pollutants including nitrogen oxides, sulfur oxides, and ash while nuclear reactors create fission products that are radioactive. Hydroelectric energy as hydroelectric plants need building dams and having huge lakes. Solar and wind energy both require big regions and are geographically constrained. Moreover, as alternative clean energy, nuclear energy from fission provides an ideal source because the fission process does not create any carbon dioxide and will not cause global warming. However, because of public sentiment, few nuclear power plants have been developed in recent years and nuclear reactors must be made intrinsically safe and the issue of nuclear waste disposal must be resolved. Additionally, hydroelectric energy is a form of promising energy source which is a renewable energy resource and it is safe and highly efficient. However, since hydroelectric dams need many spaces,

hydroelectric power has a significant influence on communities. People who have lived in an area their entire lives may be forced to relocate. In the article, Dresselhaus and Thomas state that as fossil fuel supplies become less plentiful, more expensive, and a growing environmental problem in the twenty-first century, the utilization of alternative energy sources will become increasingly important. Therefore, solar energy is a good alternative energy source. For instance, radiation on a horizontal surface is roughly 1,000 Wm–2 when the Sun is directly overhead and the sky is clear and the entire quantity of solar energy falling on the continental 48 states in the United States is roughly 4.672104 quads every year which well exceeds the energy United States consumes annually. Thus, solar energy is a feasible and clean energy solution among clean energy solutions. It falls now to engineers to continue to reiterate this idea as time goes on.

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