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Solar Energy and Cities: A Solution To Environmental Degradation - A Case Study of the Emergence of Solar Energy in San Jose, California; San Antonio, Texas; and Honolulu, Hawaii

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Solar Energy and Cities: A Solution To Environmental Degradation

A Case Study of the Emergence of Solar Energy in San Jose, California; San Antonio, Texas; and
Honolulu, Hawaii

Submitted to the Social Studies Department of Bard College

By

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Introduction

The two trends of urbanization and environmental degradation are going to be largely responsible for shaping the remainder of the 21st century. This project will analyze these two trends in discussion with contrasting theoretical perspectives, juxtaposing the approach of viewing urbanization as a catalyst of climate change, against the approach of viewing urbanization as a route towards sustainable development.

Many academics highlight the demographic shift from rural areas to cities as conducive to global warming, as urbanization can increase economic activity along with its subsequent negative externalities (Schnaiberg et al. 2002). Carbon emissions that emerge from human activity and man-made processes have led to the greenhouse effect, which in turn has led to concerning levels of global warming (EPA 2021). Scientists argue that unless dramatic changes in behavior occur across the global population, climate change will make planet Earth uninhabitable.

On the other hand, some argue that the simultaneous trends of environmental degradation and urbanization highlight the necessity of utilizing cities as opportunities to mitigate climate change (Mol and Sonnenfeld 2000, 2-14). As the growth of cities has solidified itself as a defining trend of the future, it should be seen in alignment with sustainable development, instead of as an inherent detriment to the state of the planet.

The primary goal of this study is to explore the potential of using renewable solar energy to power urban centers as a method of mitigating environmental degradation. Renewable solar energy is a malleable, polished technology with the potential to replace the carbon-based energy sources that largely contribute to the greenhouse effect. However while humans have been harnessing the power of the sun for thousands of years, there has been minimal progress in terms

of implementing renewable solar power as a primary source of energy for any large population. A fundamental point of this project is to investigate why renewable solar power has not been able to find more success despite presenting a powerful alternative form of energy generation.

In order for solar energy to meaningfully offset carbon emissions, it must be able to find success amongst the large urban populations that have emerged around the planet. Cities have never been more impactful or powerful than they are today, and will need to be a part of the transition to clean energy. I will be using this study to examine three American cities which have shown promising signs of success in utilizing renewable solar power. Through a comparative analysis of San Jose, California; San Antonio, Texas; and Honolulu, Hawaii, this project will highlight the ways in which cities can lead the movement away from fossil fuel dependence.

These three cities were carefully chosen because despite their differences, there are certain fascinating commonalities which tie each pairing of cities together. San Jose and San Antonio have drastically different state-wide political leanings and state-wide energy policies, yet are both large cities in large states that have massive economies and an abundance of resources. San Jose and Honolulu are different sized cities, in different sized states, yet have similar state-wide political leanings historically and share state-wide commitments to the growth of renewables. Honolulu and San Antonio are different sized cities in different sized states, with differing state-wide political tendencies, yet have both heavily relied upon fossil-fuel based energy sources historically. The vast political, economic, and geographic differences between these cities highlights that there is no one specific prototype that translates to solar success, an encouraging sign for any American city. These locations have utilized carefully catered municipal-level action to successfully grow the solar industry, and can be used as models for other cities to adopt renewable solar power.

SECTION I - Trends of the Future

Environmental Degradation

As we look at the past 100 years, there is overwhelming evidence that the planet is deteriorating, as pollutants and man-made processes have taken a toll on the natural environment. While in the past there may have been less concrete evidence to support this claim, there now exists an overwhelmingly clear connection between human activity and dramatic change in global climate. The quantity of carbon dioxide in Earth's atmosphere had not surpassed 300 parts per million over the past 800,000 years, yet now is at levels of about 420 parts per million after a sharp spike beginning in 1950 (EPA 2021). This is caused by carbon emissions, which warm the atmosphere and planet, in what is known as the greenhouse effect. These greenhouse gasses trap the heat from the sun within Earth's atmosphere, which in turn makes the planet hotter (NASA 2021). Even just a slight increase in global temperature can have an enormous impact on the state of the planet, and cause dramatic changes in the functionality of our planet's systems (NASA 2021). In all of recorded history, the two hottest years ever are 2016 and 2020. This has already begun to impact humanity through an increase in extreme weather events, shifting seasonal temperatures impacting agriculture, and levels of air and water pollution that make entire certain areas uninhabitable. With the planet's existing conditions, about 9 million people die every year as a result of pollution (Borenstein 2021). All of these factors can also translate into the abrupt mass movement of people, potentially leading to challenges which are reflected in the social, political, and economic landscape. Scarily enough, the impacts of global warming and climate change that have already taken place appear to be quite insignificant in comparison to some predictions for the future. Rising sea levels have the potential to become a

much bigger threat than they currently pose, with some timelines suggesting that coastal cities around the world may become completely submerged in the near future. Officials in Miami, Florida have already established a “Miami-Dade County Sea Level Rise Strategy” in anticipation of the two-foot or more sea level rise projected for 2060 (Flavelle and Mazzei 2021). This is not a distant, long-term issue. This is one that must be dealt with now, or will permanently impact the state of the planet for us, and the very next generations. Environmental degradation cannot be seen as a fringe topic or only pertinent to those invested in the environmental movement, but instead as an issue relevant to all of humanity. It unfortunately is, and will continue to be, a fundamental part of the 21st century.

Urbanization

The second trend which will continue to shape the next century is urbanization. The 21st century world is filled with cities larger than have ever existed historically. In 1996, it was projected “half of humanity will be city-dwellers by the end of the century” (Rees and Wackernagel 2008). By that point, “75% or more of the people in so-called industrialized countries” were already living in urban areas (Rees and Wackernagel 2008). This demographic shift has continued over the course of the 20th century, with no signs of slowing down. A report from the United Nations in 2018 confirmed that about 55% of the global population was living in cities, a proportion which is only expected to increase (UN 2018). The UN projects that the percentage will reach 68% by 2050, suggesting that urbanization is not going anyway anytime soon, and urban environments will play a larger role in our future than they ever have (UN 2018). This change in demographics is drastic, and it is worthwhile to understand the magnitude

of these shifts. In 1950, 751 million people around the world lived in cities, and in 2018, that number stood at 4.2 billion (UN 2018). This means that people have left the rural areas they once inhabited, and are instead moving in the masses towards the centers of economic activity and human interaction.

SECTION II - Theoretical Frameworks to Make Sense of these Trends

The connection between urbanization and environmental degradation is an essential relationship to consider for anyone who is mildly concerned about the ecological well being of our planet. Cities are playing a larger role in our societies than ever before. Since the 20th century, academics and experts have speculated on the rapid growth rates of cities around the world, and the demographic shifts as the percentage of humans living in urban areas has continued to increase. These dynamics are imperative to analyze in any efforts to lower global carbon emissions, and mitigate environmental degradation. The debate today is between if densely populated urban environments can increase efficiency of production and reduce consumption of different materials, or if urbanization is instead harmful to any environmental progress by intensifying processes of waste and consumption. To frame this debate, two distinct theories, the treadmill of production and ecological modernization, will be used to fully understand this relationship.

Treadmill of Production

The treadmill of production (TOP) highlights the detrimental relationship between urbanization and the state of the natural environment. Economic growth and urbanization have

been connected since the advent of industrialization. The need for proximity to economic activity, access to labor, and the growth of non-agricultural sectors contributed to the relationship between urbanization and economic growth. This is a fundamental connection to consider to make sense of the TOP.

The TOP was established in the 20th century by Allan Schnaiberg, and is a phenomena which arose from two specific trends. One of these trends was the impact that resulted from production processes in the second half of the 20th century. As industrialization and technology advanced, the waste emerging from these processes became more present and more detrimental from an environmental standpoint (Schnaiberg et al. 2002). The second trend that led to the inception of the TOP was the “social and political responses to these impacts” which are described as “quite variable and volatile” (Schnaiberg et al. 2002). Some responses suggested an alarming reaction to the glaring environmental degradation problems which were becoming increasingly prevalent, but others saw a further investment in new technology as the best way to mitigate this onslaught of environmental problems. This portrays “political and economic trends as minimizing and often undermining progress on both the social and ecological goals” (Schnaiberg et al. 2002). What this points to, is that the state maintains the orientation of economic primacy, even in the face of ecological duress, reinforcing the treadmill of production instead of restructuring the system with hopes of “creating conditions for sustainability and ecological responsibility” (Schnaiberg et al. 2002).

To further elaborate on the “treadmill” that so justly summarizes this theory, there is a specific set of principles which allow for this imagery to fit so appropriately. Even as far as societies have been removed from nature as the world becomes further urbanized, there is still an existing relationship with the natural environment. Societies in fact still depend on the

fundamental laws of thermodynamics, no matter how much culture and other factors may create the illusion of society being above those principles (Barbosa 2009). The first two laws of thermodynamics are both fundamental parts of the TOP. The first law of thermodynamics is the conservation of matter and energy, meaning that “matter and energy cannot be created or destroyed; they can only be transformed” (Barbosa 2009). As described in the technical definition, this means that there is no way to completely get rid of any form of matter. A natural resource may be transformed into a commodifiable product, and then transformed into a part of a landfill, but it will never fully be destroyed. This paints the picture of a loop, as resources may be transformed, but in a truly cyclical way they are never actually gone.

The second law of thermodynamics, which is also crucial to paint the full picture of the treadmill of production, is the law of entropy. This refers to the fact that “all energy transformations are degradations that change energy from more to fewer forms” (Barbosa 2009). Entropy is defined by the Oxford dictionary as “a lack of order or predictability”. According to the law of entropy, as humans choose to turn a natural resource into a commodifiable product, they have enacted an “energy transformation.” As is said in the definition, “all energy transformations are degradations” meaning that a process such as industrialization would result in a system of constant environmental degradation (Barbosa 2009). As societies and economies became more complex and further modernized, the pressure placed on the natural environment increased as well.

When industrialization occurred, the “speed” of the treadmill became faster than ever. The sources of labor changed dramatically, as mechanized labor replaced human capital for the sake of production efficiency and maximizing profits. This trend coincides with the fact that “new technologies were more energy and chemical intensive”, a tremendously harmful

combination from an environmental and ecological perspective (Barbosa 2009). This once again highlights how some features of modernization such as economic growth and innovation serve as detriments to the natural environment.

In order to sustain these complex economic systems in the name of expansion and growth, industries were forced even further to withdraw more resources from the environment, and then in turn dispose of additional “toxic elements” back into it (Barbosa 2009). This combination of withdrawals and additions is a constant exchange, and hence is what defines the “treadmill” of production. The system is self-fulfilling and continuous, and must keep growing, regardless of externalities, in order to generate profit for all of the actors involved in the economy.

Proponents of the treadmill of production also highlight the pieces of society which continue to reinforce this environmentally unsustainable system. Examples include benefits provided to workers, and general values of economic growth which continue to be presented in a positive light to the general public (Barbosa 2009). These benefits provided to employees, such as workers compensation and unemployment insurance, are financial mechanisms that provide enough financial relief to keep workers involved, but not enough to enable social mobility (Barbosa 2009). This is a method of reinforcing inequitable societal structures through economic means. In terms of notions of economic growth promoted to the public, this constant state of growth associated with progress is exactly what fuels the treadmill. The main takeaway is the emphasis on economic growth, and acknowledgement of the mechanisms reinforce unsustainable and inequitable economic patterns - as portrayed in the TOP.

Another component to consider alongside the TOP is known as Jevons Paradox. Jevons Paradox refers to “when technological progress of government policy increases the efficiency with which a resource is used (reducing the amount necessary for any one use), but the rate of consumption of that resource rises due to increasing demand” (Clement and Schultz 2011, 581-600). Jevons Paradox suggests that consumers will change their habits in adjustment with technological innovations, as opposed to utilizing efficiency as a way to cut down on consumption (Clement and Schultz 2011, 581-600). Instead of appreciating its efficiency, the product will be consumed at higher levels, and the increase in usage will offset the newly made technological progress. In turn, the increase in efficiency will in fact convince the consumer that their consumption habits are justifiable.

Ecological Modernization

The contrasting theory to the treadmill of production is known as ecological modernization, which was originated by German sociologist Joseph Huber in the 1980s (Mol and Sonnenfeld 2000, 2-14). Huber’s ideas can be “characterized by a heavy emphasis on the role of technological innovations in environmental reform, especially in the sphere of industrial production” (Mol and Sonnenfeld 2000, 2-14). The crux of this theory is that modernization can be used as a tool to mitigate the historically environmentally damaging processes of economic growth and urbanization. This school of thought suggests that characteristics of a modern society, such as urbanization, are tools which can fight against climate change. A key point of this theory is the emphasis on economic growth, which includes various mechanisms of a capitalist economy, one of which is competition. Manufacturers and innovators within the

confines of a capitalist economy compete against each other to create a product which will generate the most revenue, which means it must also appeal to consumers.

Urbanization is a key component of ecological modernization, as the theory itself acknowledges the “energetic impacts” of the increasing percentage of the world’s population moving into densely populated urban areas (Clement and Schultz 2011, 581-600). This portrays cities as areas which can “allow for better energy efficiency” and create “opportunities for more environmentally sustainable behavior” (Clement and Schultz 2011, 581-600). The combination of economic growth and urbanization is suggested to be the approach to combating the relevant contemporary challenges of climate change.

One graphic which mostly concisely reflects these trends is known as the EKC, environmental Kuznets curve (Clement and Schultz 2011, 581-600). The EKC looks like an upside down version of the letter “U” and reflects how factors such as modern economic growth and urbanization impact the environment over time. While there is no dispute that components of modernization “initially consume much energy and many natural resources” there is a discussion about whether or not those levels of consumption remain constant, or begin to decrease (Clement and Schultz 2011, 581-600). The EKC aligns with ecological modernization in suggesting that as processes of modernization advance, “modern institutions are said to develop in an ecological direction, thereby reducing the demand for energy and natural resources and, ultimately, modernization’s environmental impact” (Clement and Schultz 2011, 581-600). This comes from the notion that urbanization makes “economies more efficient, thus reducing the rate of natural resource use relative to economic product” (Clement and Schultz 2011, 581-600). Cities do not diminish economic activity, but they do have the potential to increase the efficiency of it.

To once again return to the visual of the EKC, consumption of natural resources and energy will increase with urbanization and economic growth, but will then plateau and eventually drop off as the processes of “growth and development proceed” (Clement and Schultz 2011, 581-600). The point of the EKC graph is to illustrate the true extent of what can result from processes of modernization. Even with initial stages of higher levels of resource consumption, over time factors such as technological innovation, economic competition, and urbanization will lead to unprecedented levels of efficiency, making modernized cities more sustainable than urban centers have been historically. This is a direct counter-argument of Jevons Paradox, which suggests that increases in efficiency of a product will lead to higher rates of usage and therefore mitigate the increase in efficiency, in a paradoxical outcome of a technological advancement. The EKC figure however highlights that even if a particular product is not properly utilized as a result of its increased efficiency, the larger overall structure of a city will still shift closer towards a more efficient system. This macro-level shift towards efficiency in the totality of a city proves more important than the micro-level individual innovation, only further establishing the positive role urbanization can play in mitigating environmental degradation.

SECTION III - The Role of Solar Energy

Solar Energy

The potential of solar photo-voltaic (PV) technology is an example of the way in which economic growth and competition can lead to environmentally beneficial innovations. Solar PV technology provides a way to efficiently utilize a clean, accessible and limitless alternative energy source - the sun. A major shift away from fossil fuels and carbon-based energy sources is imperative in any efforts to mitigate the effects of climate change, and solar energy provides that opportunity. Statistics show that of the total greenhouse gas emissions in 2010, 65% of it was carbon dioxide due to fossil fuel use and industrial processes (EPA 2021). This issue is becoming increasingly pressing, as carbon dioxide emissions have increased approximately 90% since 1970 (EPA 2021). 78% of that increase was caused by fossil fuel use and industrial processes - almost all of the drastic increase observed over the past 50 years (EPA 2021). While climate change requires much more complex solutions than simply replacing fossil fuels with renewable sources, it would certainly be a meaningful place to start. Where the treadmill of production theory claims that economic growth is inherently detrimental to the natural environment, solar PV technology is a concrete piece of evidence for the ecological modernization theorists. This is evidence that capitalistic structures can in fact create groundbreaking solutions to environmental issues, within the confines of the economic system.

The technology continues to improve, in terms of its effectiveness and accessibility. Solar panels are becoming increasingly affordable as the industry continues to grow (Rogers and Wisland 2014). The sun can always be sourced locally, and does not require the shipping and transportation costs of non-renewable sources such as petroleum. It does not require large

amounts of land, and can work in terms of generating electricity through large utility scale projects for entire communities, or small scale rooftop projects for individual households (Rogers and Wisland 2014). This demonstrates that even with the shifting global demographic trends into urban areas, solar energy can be a success story. High population density and limited amounts of space in urban centers does not mean that solar energy infrastructure development will be hindered or impeded upon, but actually suggests that solar may be the renewable source most equipped to deal with the conditions of the future. The growth of the solar industry is potentially limitless, with the biggest optimists claiming that it has the ability to eventually completely dominate the energy market.

One main objective of this thesis is to address these questions: if factors of modernization such as economic growth and urbanization have facilitated the innovation of a potentially world-saving technology, why is it not more commonly utilized? Why is it that the majority of the world continues to lean on non-renewable resources, even after the advent of solar PV technology? To answer this, it is essential to dive into the history of the solar energy industry. This makes it possible to understand the factors which have either facilitated or impeded the growth of the solar industry in the past, and what steps must be taken going forward to make renewable solar energy a bigger part of the nation's energy picture.

Brief History of Solar

The solar energy industry has a somewhat tumultuous history, full of brief periods of success, followed by subsequent drop-offs. Its moments of success came from when innovators attempted to address relevant challenges of their times by harnessing the power of the sun. The main factors which impeded upon the growth of the solar industry are lack of investment and lack of government support, both of which are relevant in terms of understanding the challenges

the industry faces today. These are issues which have arisen due to numerous events or socio-political factors that drew major attention away from the solar industry, and instead redirected the eyes of investors and policy makers elsewhere.

People have been successfully utilizing power generated by the sun for thousands of years, with examples of using solar energy to melt debts off of wax tablets in Aristophanes' *The Clouds* as early as 448 BC (Charola 1995, 20-23). Another example comes from 77 BC, when "Pliny the Elder, a multi-skilled Roman statesman, recorded the burning of dead cells using focused light rays: the Classical precursor of laser surgery" (Charola 1995, 20-23). While this is of course not the same modern photovoltaic solar technology that is used today, it is important to acknowledge that humans have understood the sun to be a potential power source for millennia. Usage of solar energy resurfaced once again during the Renaissance period, as there is evidence in 1615 of Europeans using "solar concentration to boil water, set off canons, burn wood and melt metal before gasping crowds" (Charola 1995, 20-23). However even as this technology was present as a novelty item, it was far from serving as a central source of power. Some of this can be attributed to the fact that it appeared as a radically new and different technology, seen more as an oddity than as a realistic path. Coal ended up becoming the dominant energy source, partially due to the "ever-decreasing wood supplies in Europe" and led to unprecedented levels of production, taking any attention away from developing solar energy as a power source (Charola 1995, 20-23).

Meanwhile, in 1861, John Ericsson constructed a solar powered steam engine which was groundbreaking technology at the time. This became overshadowed by the industrialists who had seen how much the coal-fired technology had "propelled an exponential rise in Britain's iron production" (Charola 1995, 20-23). This a trend which has served as an impediment to the

expansion of the solar industry, which is the immediate economic gratification that has been fostered while depending on carbon-based non-renewable resources. As the systems of industrialization had generated such high levels of productivity and economic growth, there was little appeal to making a drastic shift to a new source of energy even as innovations for sustainable alternatives were made.

Large companies had a reluctance to invest in the expansion of solar technology, but small projects allowed for continued research and development. One of these came from Brooklyn born inventor Frank Schumann, who in 1913 created a refurbished solar steam engine with the Eastern Sun Power Co. Ltd, which was successfully used to generate power to pump an irrigation system (Charola 1995, 20-23). Schumann received serious recognition and was written about in *Scientific America*, a very popular magazine at the time, in two different editions in 1911 (Charola 1995, 20-23). Unfortunately, this coincided with the first World War, and Winston Churchill made a strong shift at this time to find a “guaranteed oil supply that gave Britain independence from the US and the fields were cleared for the oil race” (Charola 1995, 20-23). This took away from the investment interest that had been proposed to Schumann, leaving him without the funding needed to further expand upon his work. These political and economic factors pushed Britain away from exploring solar energy options. This is precisely the trend which has impeded the solar industry historically - events which dramatically shift the interests of investors and policymakers to the more pressing priorities at hand.

Part of what makes the solar energy industry a viable alternative to fossil fuels, is that innovations and technological advancements have occurred behind the scenes even as investors and governments turned down opportunities to largely adopt it as a legitimate energy source. Energy systems around the world did shift in this time period, as the 1930s saw tremendous

growth of electrical networks, which quickly replaced the steam-powered alternatives. This was around the same time that Charles Fritts, an American inventor, created what could be “described as the dawn of photovoltaics” (Chalora 1995, 20-23). While it was much less efficient than the photovoltaics that exist today, it marked the beginning of a new era of solar potential. The takeaway from this is that even though solar energy was not yet being adopted as a mainstream energy source, the technology continued to advance.

Fast forward once again, to the 1960s and 1970s, and a new geo-political factor comes into play. OPEC, the Organization of the Petroleum Exporting Countries, was formed in 1960 as a way to keep the world’s most oil-rich nations in control of global oil prices (Britannica 2020). In October of 1973, OPEC formally decided to increase the price of oil by 70%, and then raised an additional 130% in December of that same year (Britannica 2020). From 1973 to 1980, oil prices became ten times more expensive, leaving Western countries including the United States scrambling for fuel sources in what became known as the “oil crisis” of the 1970s (Britannica 2020). This economic pressure opened the door to renewables, as it became clear that there was high value in finding an alternative energy source. While economic factors had worked as an impediment to the expansion of solar in the past, the stark increase in the price of gasoline created room for growth of alternative energy sources such as solar power.

This is perhaps most acutely visible in the connection between American President Jimmy Carter and his profound interest in solar energy. President Carter was the first American president to outwardly embrace the shift to renewable energy sources, and practice this within his own personal energy generation. President Carter implemented a “solar water heater on the White House roof,” a strong message to the nation in support of investment in solar energy (Charola 1995, 20-23). Carter’s commitment did not end there, as he also introduced PURPA, the

Public Utilities Regulatory Policies Act, a groundbreaking effort “which allowed private producers of energy to sell power back to the grid,” quite similar to contemporary policies which have been quite successful in expanding the solar industry (Charola 1995, 20-23). Carter also implemented tax credits on a federal level which “had allowed solar power to attain a competitive selling price” for the first time (Charola 1995, 20-23). This combination of political focus on the expansion of solar, in conjunction with economic factors which for the first time made solar energy more affordable than petroleum, suggested that the industry was on track to take off.

Unfortunately for the progress of the solar industry, President Ronald Reagan came into power in 1980 and almost immediately removed the solar infrastructure Carter had installed on the roof of the White House (Charola 1995, 20-23). This was perhaps most powerful symbolically, in terms of national rhetoric towards renewable energy sources. This was reflected in policy decisions as well, as President Reagan actively chose not to renew the tax exemptions that President Carter had put in place. By 1985, they were no longer offered (Charola 1995, 20-23). Political and economic factors once again seemed to join together as impediments in the path towards solar energy expansion, and the industry did not take off in the way that it had appeared it was ready to.

This same trend has continued for over a century now, and remains relevant today. Without government support in the form of policy, and without investment from either governments or the private sector, consumers will not be compelled to make the transition to solar. The lack of investment also means industry itself will lack the financial stability to make the cost of solar panels cheap enough to be accessible to consumers. Factors of modernization,

mainly urbanization and economic growth, have the potential to change the trends which have impeded upon the growth of the industry historically.

The state of the world today presents hope for the solar industry. What lacked in the past was assurance that solar energy was a strong and reliable enough technology to be an energy source of the future. The skepticism was fair, as there had never been a large region of the world which primarily utilized solar energy, and there was yet to be an example of solar energy being affordable from a consumer standpoint. Investors were hesitant to put trust and financial support into an industry that was essentially grounded in potential, or impressive technology, without ever demonstrating compelling success. On top of that, the knowledge of climate change was not as alarming as it is today. The state of the planet has become more dire over the past half century, and has started to impact more people around the world. As a result, there has emerged a certain urgency regarding environmental degradation that increases the appeal of solar energy.

In 2021, we see leaders from some of the most powerful nations around the world gather to discuss how to effectively combat climate change in the Paris Climate Agreement. This is coupled with some of the world's most successful companies devoting entire campaigns to marketing their environmentally-friendly products and practices, not only because of their interest in mitigating climate change, but also because they know it is a topic relevant to consumers (i.e Hummer, a company known for its large gas guzzling cars, bought a Superbowl ad to promote their new electric vehicle, flashing the words "zero emissions" near the end of the 30 second clip) (Wayland 2020). Climate change is a mainstream topic. This means that governments care about it, companies care about it, and consumers care about it. Members of all three of the previously mentioned groups want to find a way to play their part in this movement. This has opened the door for renewable solar-power energy that the industry has long been

waiting for. Solar photovoltaic technology has never been this efficient, and never been this affordable. The technology is advanced enough to replace fossil fuels and is now accessible to the consumers who wish to make the transition to solar energy.

The future of solar energy in the United States is bright. Climate change has come into the foreground as an important global issue, the recently elected Presidential administration has demonstrated a commitment to using renewable energy, and the solar energy industry is more prepared than ever to take off. Some parts of the United States have already begun to demonstrate just how successful solar energy can be, and the exciting thing is, these parts are cities. The demographic shifts of recent years suggest that cities will play a larger role in the future than they ever have, and for various American cities to meaningfully implement solar energy is a sign of hope for the future. San Jose, California, San Antonio, Texas, and Honolulu, Hawaii have all begun a transition to solar energy. What makes these cities most impressive is they have already demonstrated resilience against adversity that historically would have extinguished any hopes of transitioning to solar.

SECTION IV - American Solar Cities

SAN JOSE, CA California Statewide Energy Overview

California has the largest population and economy of any state in the nation. California leads the U.S. in “agricultural and manufacturing GDP” and if the state was its own country, would have the fifth-largest economy in the world (EIA 2021). The state’s massive population and economy are responsible for California having the second highest state-wide energy consumption in the country (EIA 2021). Of the state’s total energy consumption, 40% comes from the transportation sector. This is caused by the massive land-area of the California, “as it stretches two-thirds of the way up the U.S. West Coast” and the fact that “more motor vehicles are registered and more vehicles are traveled in California than in any other state” (EIA 2021). The industrial sector in California is second in energy consumption to the transportation sector, and uses about 25% of the state’s energy. California is fortunate to have an abundance of energy resources to support these energy-intensive sectors, including vast quantities of crude oil and natural gas.

This luxury of resources can also serve as a burden however, and presents challenges for the state. The large population and high energy consumption put California in position to be one of the nation’s biggest contributors to carbon emissions. This has forced California to efficiently manage their energy systems and resources, as “environmental concerns have led to several state policies to reduce greenhouse gas emissions” (EIA 2021). These policies have demonstrated the state’s commitment to “increase energy efficiency” and “implement alternative technologies” which have slowed down the growth in energy demand (EIA 2021). Today, California “has one of the lowest per capita energy consumption levels” in the country (EIA 2021). This can be

attributed to a variety of factors - mainly demonstrated statewide policy to energy efficiency, and a continuation to implement innovative structures to ensure a greener future for California.

One of these statewide policies came in 2006, when California enacted the Global Warming Solutions Act of 2006. This set the goal of reducing the state's greenhouse gas emissions back to the level that they were in 1990. The timeline included reaching 1990 levels by 2020, then to 40% below 1990 levels by 2030, and finally 80% below 1990 levels in 2050 (EIA 2021). The strategies to fulfill these goals included "identification and adoption of a regulation requiring GHG reporting for industry, adoption of a low carbon fuel standard" and "the establishment of an Environmental Justice Advisory and an Economic and Technology Advancement Advisory Committee" (UN 2006). As a result of the outlined approach, California was able to exceed the goal they had set for 2020.

California also enacted "California's Low Carbon Fuel Standard" (LCFS) in 2009, with the goal of reducing "the carbon intensity of the state's transportation fuels" (EIA 2021). The LCFS enforces the implementation of innovative processes to more efficiently produce fuel sources including ethanol, biodiesel, and renewable diesel (EIA 2021). This creative piece of governance directly addresses the high levels of energy consumed by the transportation sector in California. The LCFS has been largely successful, perhaps most apparent in the fact almost all of the renewable diesel consumed in the U.S. is consumed in California (EIA 2021).

While exhibiting all of the characteristics to be one of the least-environmentally friendly states in the US, including massive economy, massive population, and access to non-renewables, California's commitment to energy efficiency enables it to be amongst the nation's leaders from an environmental perspective. The Global Warming Solutions Act of 2006 and the enactment of the LCFS provide two examples of California's commitment to minimizing their contribution to

environmental degradation. While these two state-level decisions have both been important parts of California's efforts to minimize their carbon emissions, it is California's involvement with renewable solar energy that makes it clear just how committed the state is to energy efficiency.

State Level Connection to Solar

No other state has made as much progress in growing the solar industry as California. California enacted an ambitious renewable portfolio standard (RPS) in 2002, which has been revised several times with even higher goals. In its most current form, it requires that "33% of electricity retail sales in California come from eligible renewable sources by 2020, 60% by 2030, and 100% by 2045" (EIA 2021). This has already led to a flourishing solar energy system with tangible results to show for it.

This is visible in the state's energy breakdown, as California's natural gas and crude oil production have been gradually declining since 1985. In turn, solar energy has taken the place of the fossil fuels that used to provide the state with energy. In 2014, California officially became the "first state in the nation to generate more than 5% of its utility scale electricity from solar energy" (EIA 2021). By 2019 that figure had reached 14% (EIA 2021). When including small-scale solar generation in that metric, one-fifth of California's total net energy generation comes from renewable solar energy (EIA 2021). The solar industry in California is so successful in fact that it produced 40% of the "total solar PV electricity generation" in the entire country (EIA 2021). The industry has continued to grow within California, as by November of 2020, the state had achieved nearly 24,000 megawatts of solar capacity (EIA 2021). For context, no other state had reached above 13,000 megawatts by that time (EIA 2021). California currently has enough solar power installed to power over 8 million homes, and has over 2,000 different solar

companies based in the state (SEIA 2020). The state has a longstanding commitment to growing the solar industry, and has cumulatively invested over \$70 billion in renewable solar power (SEIA 2020).

California appeared early on in the history of solar as one of the few places in the United States with potential for success. When President Reagan made the decision not to renew the federal tax exemptions that President Carter had enacted, “California’s tax exemptions, in addition to US federal tax credits, had allowed solar power to attain a competitive selling price” (Charola 1995, 20-23). This directly translated to success of some of the country’s earliest solar projects. An Israeli company called Luz International Ltd peaked in the 1980s, and operated three “power stations” in California (Chalora, 1995). The largest of these three was a “354MW thermal solar farm” in California’s Mojave Desert, which is not the same PV solar technology we see today, but was early evidence that solar power might be able to work within the United States (Charola 1995, 20-23). Unfortunately the success was quite brief, and Luz International Ltd ended up going under after “building costs finally ran the company into the ground” (Chalora, 1995). This highlights that California has long been in the position to support solar projects, even before the industry itself was prepared. Today the industry itself is prepared, and California’s state level support for the industry remains as strong as it has ever been.

The efforts made by the California state government to promote the success of the solar industry are still in place today, with even newer policies to facilitate further growth. In 2005, then-Governor Arnold Schwarzenegger set the bar high, advocating for the state to implement 1 million solar rooftop installations (Roth, 2019). In 2019 that goal was successfully met. This is attributed to the fact that California “set aside more than \$3 billion for solar rebates” which not only grew the solar energy market, but also decreased the costs of it from a consumer perspective

(Roth, 2019). This made solar energy more accessible, and translated into rapid growth rates for solar installations. From 2006 to 2010, cumulative solar installations in California increased from roughly 19,000 to 70,000, an increase of about 50,000 (Roth, 2019). From 2010 to 2014, cumulative solar installations in California increased from about 70,000 to approximately 283,000, an increase of over 210,000 solar installations in four years (Roth, 2019). This increasing growth rate demonstrates that as the industry grows, it becomes easier for solar projects to find success.

Another policy which has translated to direct success in California is Net Energy Metering. California is one of 41 states which offers Net Energy Metering (NEM), a mechanism which is conducive to growth and success of the renewable energy industry. NEM is a feature which serves as a financial break for renewable energy customers (SEIA 2020). It is primarily applicable to small-scale projects, such as homeowners, as it provides an opportunity for the customer to specifically manage the quantity of electricity that they purchase (SEIA 2020). For example, if a customer's rooftop solar project generates more energy than the customer consumes, net metering allows the customer to sell the excess electricity back to the grid. As some solar installments generate more electricity than is consumed, net metering allows consumers to reduce their future energy bills (SEIA 2020). Net metering increases the accessibility of switching to renewable sources by providing a financial incentive for consumers. This is one of the key strategies which has enabled the state to reach their ambitious solar goals.

While California has been able to successfully grow the solar industry as much as any other part of the country, there are certain cities within California that have displayed particular high levels of success. San Jose is a city which ranks amongst the best in the nation and state in terms of utilization of solar energy by multiple measurements. Focusing on the specific case of

San Jose not only gives a more indepth look on how solar energy can grow on a micro level, but also highlights the importance of the role of cities in expanding solar energy and making it part of the nation's energy picture. The next section will go over the mechanisms which have been most conducive in growing the solar industry specifically in San Jose, California.

Solar in San Jose

As previously stated, San Jose is amongst the nation's most successful cities in terms of solar energy by a few different metrics. According to the Shining Cities Environmental Report of 2020, San Jose is ranked 4th in the nation in Solar PV installed per capita with 217.13 watts per person, and is ranked 7th in the nation in Total Solar PV installed with 223.67 megawatts (Environment America Research and Policy Center 2020). This can be attributed to a combination of municipal level enactments and policy implementations, quite similar to the factors which have led to the success of solar on the state level. The municipal government of San Jose has implemented environmentally friendly, renewable focused projects since the turn of the 21st century.

The first of these was known as Green Vision, which was a "15-year sustainability plan to steer economic growth and reduce greenhouse gas emissions" created entirely by the municipality of San Jose (City of San Jose 2014). Green Vision was effectively set in motion in 2007, and enabled San Jose to make tremendous progress towards becoming one of the nation's leaders in the movement towards sustainability. In less than a decade, Green Vision made large strides towards reaching its goal of continuing the growth of San Jose's economy while minimizing the city's carbon footprint (City of San Jose 2014). By 2014, Green Vision had led to the installation of "9,055 solar photovoltaic systems with a total capacity of approximately 80.8 megawatts" across a series of industrial facilities, businesses, and homes throughout San Jose

(City of San Jose 2014). Green Vision also enabled the city of San Jose to install 30 different solar energy systems with a total generation capacity of 4.8 megawatts at various “city sites” (City of San Jose 2014). The project was also responsible for the launch of the Property Assessed Clean Energy program, which completed 195 residential projects with a cumulative valuation of \$5.3 million (State of California 2014). Along with the strides in clean energy and sustainability, Green Vision was also able to accomplish its goal of “economic growth”, as by 2014, more than “12,008 cleantech jobs in San Jose” had been created (State of California 2014). These accomplishments were all in line with the projections that were set for the 15 year project and were essential steps towards enabling San Jose to reach its position as one of the most sustainable cities in the USA. Green Vision is a successful example of how San Jose’s municipal level involvement has grown the solar energy industry specifically.

In 2017 San Jose began working towards the next set of steps to further their strides towards a sustainable future, highlighting a commitment to renewables and sustainability on the municipal level. This came in the form of Climate Smart San Jose, a new sustainability plan which the city put in place.

Climate Smart San Jose was drafted in 2017 and took off in 2018, effectively succeeding the previous plan of Green Vision. Climate Smart San Jose is made up of a set of ambitious sustainability goals, and with strategies on how to achieve them. One major point of Climate Smart San Jose is an emphasis on its connection to the Paris Climate Agreement, claiming to be “one of the first Paris-aligned pathways of any U.S. city” highlighting a globally recognized commitment to mitigating climate change (City of San Jose 2018). This is expanded upon further by Climate Smart San Jose as they also claim to be “among the first to take the next step in charting a clear-eyed roadmap of the measures and progress needed to achieve compliance with

the Paris Agreement” (City of San Jose 2018). Climate Smart San Jose has a list of goals which fit into one of five categories - one of which is Renewables & Electrification. The most ambitious goal in the Renewables & Electrification section of Climate Smart San Jose is to ensure that “by 2040, San Jose will be the world’s first one [gigawatt] solar city” (City of San Jose 2018). For context, one gigawatt is equal to 1000 megawatts. San Jose currently has achieved slightly more than 20% of that quantity. (Environment America Research and Policy Center 2020). This goal setting demonstrates that San Jose is a global pioneer in incorporating solar energy as a pillar of its energy system.

Climate Smart has also publicly released the strategies by which they plan on reaching their goals, providing transparency on the steps that the city of San Jose plans on taking on the path towards a sustainable future. One of the strategies that Climate Smart San Jose has begun to implement is offering “group purchasing [of] renewable energy” which would allow “individuals, businesses, and municipalities to greatly reduce the cost of installing clean energy capacity” (City of San Jose 2018). This would translate into savings for all parties involved in the group purchasing, as it entails “pooling collective energy demand” which enables “many entities or individuals secure discounted pricing by buying in bulk” and even gives group buyers the ability to “install solar at little to no upfront cost” (City of San Jose 2018). The distributed generation of rooftop solar projects is a specific metric Climate Smart San Jose plans on expanding, with the goal of 231 megawatts by 2030, 430 megawatts by 2040, and 636 megawatts by 2050 (City of San Jose 2018). Climate Smart San Jose has also partnered with organizations such as Grid Alternatives to increase the accessibility of solar energy to “low-income customers” through a combination of tariffs and state financing (City of San Jose 2018). The commitment to increasing the accessibility of solar is a major component of Climate Smart San Jose and will be

a fundamental part of achieving the ambitious goal of turning San Jose into “the world’s first one [gigawatt] solar city” (City of San Jose 2018).

The implementation of these complex outlines for the future (Green Vision and Climate Smart San Jose) on the municipal level in San Jose demonstrates a city-wide commitment to sustainability that matches the state-level commitment demonstrated by California. While neither Green Vision or Climate Smart San Jose are exclusively focused on renewable energy or solar power, both have highlighted the shift to renewables as an imperative part of their plans. This not only builds confidence in the investors who may be putting money into the renewable sector, but also has had immediate economic impacts on the city itself. The thousands of jobs created by these two municipally-run plans, along with the various specific proposals which translate to customer savings, provides a community-wide financial gain from the city-wide commitment to sustainability. This makes the shift to renewables appealing from an economic standpoint, as well as from an environmental perspective. The ability of San Jose to frame the transition to renewables as beneficial financially and environmentally is a major factor in their success with the expansion of solar.

Demonstrated Resilience

San Jose’s solar energy success was tested by the economic downturn of the Covid-19 pandemic, beginning in March of 2020. Just like most industries, the solar industry was hit hard by the global Covid-19 pandemic. Despite consecutive years of growth, there were significant downtrends in solar installations as a result of the virus. The impact was felt across the nation, as in a five month period from March of 2020 to July of 2020, “residential solar permit applications in the United States fell more than 40%” (Parsons and Josefowitz 2020, 1-6). The two month

period of May and June were so detrimental to the solar industry that they eliminated the equivalent of all of the solar jobs that had been created over the previous five years (Parsons and Josefowitz 2020, 1-6). The shelter-in-place orders that took place in the spring led to the “largest quarterly decline in history” for the solar industry, during 2020’s second quarter (Parsons and Josefowitz 2020, 1-6). The solar industry has thankfully already bounced back tremendously, and is once again growing at rapid rates. Even though this is an industry on track for success, it is the locations which come up with innovative solutions that can continue to function during times of economic downturn. San Jose, California is one of those places, and demonstrated that even in the face of one of the most chaotic periods in recent history, the solar industry can be resilient.

One specific innovative measure started in 2015, when San Jose pushed the boundaries of a policy already set in place on a state-wide level (Parsons and Josefowitz 2020, 1-6). California had approved a piece of legislation known as *AB 2188*, which “required local governments to create a streamlined permitting process for small (under 10 kilowatt) rooftop solar systems” (Fuller and Guo 2017, 3-19). This enactment effectively made the process of purchasing and installing rooftop solar systems much more accessible and efficient for homeowners. The purpose of this legislation is to confront the obstacles of the permitting and building inspection processes which unfortunately have a profound impact on growth of the solar industry. The permitting and inspection processes cannot be overstated, as they are imperative components of creating new solar projects and expanding the industry. Delays in these areas can obstruct entire projects, and prevent industry growth in an entire state or city.

In California every household rooftop solar system needs to have a state-approved building permit. Yet before the permit can be granted to begin the installation process, a fee which can reach up to \$450 must be paid in order for the application to even review the

application (Parsons and Josefowitz 2020, 1-6). This application is to “ensure the system meets building code requirements” which are set on the state-level (Parsons and Josefowitz 2020, 1-6). However this is even further complicated by the fact that the same building code is interpreted differently in different cities within California, leading to approximately 30% of all submitted applications being either incomplete or incorrectly filled out (Parsons and Josefowitz, 2020). This variability that exists from city to city also means that “the time from permit application to successful building inspection can vary by up to two months” (Parsons and Josefowitz 2020, 1-6). The price and inconsistency of these processes work as impediments against the solar industry’s growth.

This lack of stability not only turns away potential customers and applicants, but also leads to increases in costs as a result of a “meaningful number of customer cancellations” (Parsons and Josefowitz 2020, 1-6). Yet the trouble continues - even if a permit is properly submitted and approved, and then properly installed, there is still a mandatory onsite inspection. This inspection process is also quite flawed, and once again is a state-wide regulation which has variability from city to city (Parsons and Josefowitz 2020, 1-6). These inspections require scheduling between contractors and the inspectors, and commonly lead to delays in effectively using a rooftop solar system even if it has already been installed and approved at previous stages of the process. Even though California is arguably the nation’s most advanced state in terms of success with solar expansion, “average wait times between when a permit has been submitted and a successful building inspection have remained consistent at 45 to 50 days over the last decade” (Parsons and Josefowitz 2020, 1-6).

These processes may have successfully functioned at a time in which solar was a fringe industry, but as it continues to grow, updates and innovations are needed. Features such as the

permitting, installation, and inspection processes are referred to as “soft costs” and in some instances “can account for more than half the price of getting small solar systems off the ground and onto roofs” (Parsons and Josefowitz 2020, 1-6). These systems exist with the intention of limiting accidents and ensuring safety, but at this point serve more as a hindrance for small-scale projects which have quite a low chance of presenting any threat. One specific study of installed solar PV safety showed that out of 1.7 million rooftop solar installations, there were only 210 instances which led to a fire (Parsons and Josefowitz 2020, 1-6). That comes out to about 0.0001% chance of a threat from a solar installation. Soft costs in California can amount to “an additional \$3,000 per installation”, a price which certainly turns potential customers away, all for an inefficient and outdated inspection process (Parsons and Josefowitz 2020, 1-6). These are some of the roadblocks which have prevented solar from expanding and providing energy for more of the country.

The city of San Jose has been able to find innovative ways to bypass these impediments, and ensure the same levels of customer safety while drastically increasing the efficiency of implementation and approval processes. As previously mentioned, California already acknowledged and attempted to address the flaws in the inspection and permitting processes when they passed legislation to expedite these systems for small-scale rooftop solar projects. San Jose was able to take this a step further than the rest of the state by expanding upon AB 2188 (the state-wide legislation to expedite inspectional and approval processes), and implementing a system that allowed for online permit submissions, as well as an opportunity for “instant online permit approvals” (Parsons and Josefowitz 2020, 1-6). This proved to be immediately beneficial, as by the following year residential rooftop solar permits had increased by a staggering 600% (Parsons and Josefowitz 2020, 1-6). Not only did this maintain the same structures to ensure

proper safety protocols, but this made the logistics of these processes much more efficient in terms of cost and time. Most importantly, the changes of cost and time to implement a project increased accessibility of solar. This example of technological innovation has been proven to be imperative in the expansion of the solar industry, and is not seen in most American cities.

The dividends from San Jose's addendum continue to pay off, as the transition to virtual inspection and approvals processes were able to minimize the downturns caused by the Covid-19 outbreak. Places such as San Jose demonstrate that even during periods of anomie, the solar industry can continue to grow with the proper conditions. The virtual inspection and approval processes of San Jose are still feasible even with lockdown and stay-at-home orders caused by the Covid-19 pandemic, demonstrating both resiliency and ingenuity which San Jose has so successfully turned into a greener future. This innovation combined with state and municipal commitment to solar growth have been successful in elevating San Jose to one of the nation's brightest solar cities.

SAN ANTONIO, TX **Texas Statewide Energy Overview**

Texas has the luxury of an abundance of resources, which is partially a product of the fact that it has the most total land area of any state in the continental US, second only to Alaska when considering all 50 (EIA 2021). Texas leads the nation in total energy production, accounting for energy generated through renewables, crude oil, natural gas, and coal (EIA 2021).

The energy generation of Texas is connected to the fact that the state has the nation's second largest economy (EIA 2021). Electricity production in Texas is much like other forms of energy in the state, amongst the top in the nation (EIA 2021). Texas generates almost twice as much electricity annually than second place Florida, getting most of it from natural-gas powered

plants, and a significant amount from renewable wind-power as well (EIA 2021). Texas also has the nation's second largest population, and consumes more energy than any other state. The energy consumption of Texas is so large that it in fact accounts for one-seventh of the country's entire energy consumption (EIA 2021). With that said, Texas is sixth in the nation in energy consumption per capita, signifying that there is a level of efficiency at play (EIA 2021). The largest consumer of energy in Texas comes from the "petroleum refining and chemical manufacturing industries" which is responsible for about half of the state's energy consumption (EIA 2021). Texas is also the nation's leader in residential energy consumption, in large part because of the state's population, and the extreme temperatures (summer temperatures average above 90°F, can reach freezing temperatures at night) (EIA 2021). However despite the high usage, Texas still ranks in the top ten most efficient states in per capita residential energy consumption (EIA 2021). These statistics signify that even though Texas leads the nation in the production and consumption of energy, there are structures in place that allow Texas to do so efficiently, as visible in the top 10 rankings for both energy consumption per capita, and residential energy consumption per capita (EIA 2021).

Texas is the energy state of the nation - first in production and consumption (EIA 2021). For this reason, it is not a huge surprise that they also have one of the most unique electricity grids in the nation. Out of the continental United States, it is the only one of 48 states to have a "stand-alone electricity grid" (EIA 2021). This grid is operated by the Electricity Reliability Council of Texas (ERCOT) and is responsible for about 75% of the state's energy (EIA 2021). This grid is quite isolated from other electricity grids which serve the rest of the nation, and is not subject to federal oversight (EIA 2021). This means that the ERCOT grid is exclusively dependent on resources from Texas to meet the electricity needs of the state. While energy

production has been growing annually, so has energy demand. The isolationist approach for the ERCOT electricity grid is effective as long as the state is able to keep up with electricity demands, but can quickly turn problematic. At any point if the ERCOT grid fails to provide the demanded quantity, or runs into a crisis or emergency situation, the population which relies on it will have no support system to fall back on. This is important to keep in mind as this kind of energy failure or crisis regarding the ERCOT grid would be significant enough to force the state to potentially rethink their existing energy structures.

The state of Texas has historically been quite closely connected to non-renewable, carbon based energy sources - particularly to the oil industry. The beginning of this connection occurred in 1901, when the Spindletop Oil Field was discovered in southeast Texas (EIA 2021). Since 1970, there has only been one year in which Texas did not lead the nation in crude oil production (EIA 2021). Crude oil production continues to increase in Texas, as in 2019 the state accumulated to over 1.8 billion barrels (EIA 2021). Texas produces two-fifths, almost half, of the nation's crude oil, and leads the nation in crude oil refining (EIA 2021). Texas also leads the nation in petroleum consumption, however most of that can be attributed to the industrial sector. The commercial and residential sectors combined account for less than 1% of the petroleum consumed in Texas on a yearly basis (EIA 2021). Another non-renewable which plays a big role in the state's energy picture is coal, as the state is the largest lignite producer in the nation (EIA 2021). Lignite is a form of coal which is used almost only for generating power, and is found all around the state. Texas consumes all of the lignite that it mines, using it to generate the state's electricity instead of exporting it (EIA 2021).

Texas is also amongst the nation's leaders in production of and consumption of natural gas, another non-renewable energy source (EIA 2021). Texas has over 18,000 miles of interstate

natural gas pipelines, and both ships out and receives large quantities of natural gas (EIA 2021). They export more than they import, and have networks which span throughout the US and even into Mexico. Texas accounts for about 15% of the nation's total natural gas consumption, and more than one-third of all households in Texas rely on natural gas as their primary source for heating (EIA 2021). However once again, Texas ranks in the bottom 10 states in the nation in residential natural gas consumption per capita, displaying a level of efficiency (EIA 2021).

State Level Connection to Solar

In recent years, parts of Texas have shifted away from coal-fired generation and made the transition more towards renewables. This transition is not leaning primarily into solar energy, but focusing on the expansion of the wind power industry. Regardless it is a sign of a renewed statewide focus on renewables, and raises some fascinating questions about how a certain city in Texas has been able to become one of the nation's leaders in solar energy.

The emergence of the renewable sector in Texas is much different than that of California, as there has not been a state-wide support for the solar industry (EIA 2021). Instead there are small pockets of Texas which have made the commitment to solar, while the rest of the state continues to rely upon non-renewables, or invest in wind power. As a result, Texas has become the nation's leader in wind-powered renewable energy (EIA 2021). In 2011, Texas became the first state to reach 10,000 megawatts of installed wind generating capacity (EIA 2021). By the end of 2019, that value had reached 28,800 megawatts (EIA 2021). Almost all of the electricity that Texas generates from renewables comes from wind energy, a quantity so large it is in fact 30% of the nation's total of energy generated from renewable wind power (EIA 2021). Texas has been able to so successfully implement wind-powered energy because of a series of state-authorized transmission lines which transmit electricity from "wind farms to urban centers"

(EIA 2021). The expansion of the wind industry is relevant as it demonstrates that there is potential for growth of renewable energy sectors in Texas, and because it begs the question of how the city of San Antonio has established itself as one of the nation's leading solar cities in a state which does not match its levels of commitment to solar expansion.

With that said, Texas has begun to show levels of emerging solar success in recent years. Texas in 2019 was the sixth largest producer of solar power in the US, and has seen a lot of growth in this industry over recent years (EIA 2021). Between 2017 and 2019, installed solar capacity doubled, with over 3,000 megawatts produced in 2019 (EIA 2021). Texas does have some of the greatest potential for solar energy of any state in the nation, due to its large population, large total area, and the access to an abundance of sunlight compared to other states. As the cost of solar panels continues to decrease, there is no reason why solar should not also be able to flourish in the state of Texas.

Solar in San Antonio

As previously alluded to however, the city of San Antonio is one part of Texas that has truly leaned into the transition to solar energy. Out of every city in the USA, San Antonio, Texas is ranked sixth in total solar PV installed per capita, and fifth in total solar PV installed (Environment America Research and Policy Center 2020). The only other city within the state that ranks within the top 25 of solar PV installed per capita is Austin, Texas, which has 64.14 watts per person (Environment America Research and Policy Center 2020). For context, the value in San Antonio which earned them the sixth place national ranking is 166.08 watts per person, more than double that of Austin, Texas, the second most in-state city. (Environment America Research and Policy Center 2020). This raises the questions of why and how San

Antonio has been so successful in turning itself into one of the nation's leading solar cities, specifically in a state which has not shown any meaningful commitment or investment to the solar industry. This can be used as a point of praise for the city of San Antonio, which has been able to reach similar levels of success with solar as the city of San Jose, California which has the benefit of exponentially more state-level support for the solar industry.

The main reason for San Antonio's booming solar industry in an otherwise unexceptional solar state is the presence of CPS Energy. CPS Energy is the "nation's largest municipally owned energy company" and works to provide energy to the residents of San Antonio (CPS Energy 2021). This means that CPS Energy is owned and operated by the local government, and therefore is not only exclusively focused on the city of San Antonio, but also uniquely in touch with the dynamics of the city. CPS Energy is also oriented around the ideas of "clean energy, innovation, and energy efficiency" which has made them very successful in the movement to solar energy (CPS Energy 2021).

CPS Energy remains committed to a greener future for San Antonio, and has results to show for it. CPS Energy has been able to organize the New Energy Economy (NEE) across a series of partnerships with various businesses which share the "vision for clean energy, innovation, and energy efficiency" (CPS Energy 2021) These various partners which make up the NEE have already invested and committed to a greener future in San Antonio, with "more than \$23 million in support of local educational programs, over 900 new jobs, and over \$200 million in investments to fuel [San Antonio's] local economy" (CPS Energy 2021). These goals all culminate in the primary focus, which is to establish "San Antonio as a hub for clean energy and innovation" (CPS Energy 2021) As mentioned in the title of the project, the New Energy Economy is working to effectively combine clean energy growth with economic growth, creating

a further incentive for investment into clean energy. With CPS Energy's NEE, any support for clean energy is also financial support for San Antonio's economy which has seemingly spiked interest and success in the solar industry. On the economic side of things, the NEE has resulted in millions of dollars in investments towards creating jobs and educational programs (CPS Energy 2021). From an environmental standpoint, the NEE has set ambitious goals such as making 20% of San Antonio's energy generation sourced from renewables, along with carbon emission reduction of power plants so drastic that it would equate to having almost 700,000 less vehicles on the road (CPS Energy 2021). Similar to the policies such as Green Vision and Climate Smart in San Jose, the NEE is focused on providing a better economic future as well as environmental future, which remains an essential component of making a meaningful impact in facilitating the transition to solar.

The New Energy Economy has formed partnerships connecting San Antonio's municipally owned energy company, CPS Energy, with some incredibly innovative groups. One of those is Go Smart Solar, which claims to "exist to drive the rapid adoption of solar." At Go Smart Solar, they believe that "only two things are holding the conversion to clean energy back: Knowledge and Price" (Go Smart Solar 2021) Those are guiding principles for Go Smart Solar and they have implemented creative methods to grow the solar industry while simplifying concepts which may turn away customers. One of those specific approaches is effectively run by Big Sun Community Solar, a collaborative organization between Go Smart Solar and CPS Energy which enables customers to purchase solar energy without the hassle, fees, and complications of the installation processes (Big Sun Solar 2020). Big Sun Community Solar advertise themselves as a group which "builds, manages, maintains and insures your offsite solar

system while you lower your monthly electric bill and claim the tax savings” (Big Sun Solar 2020).

Big Sun Community Solar takes an innovative approach by selling “offsite” solar projects (Big Sun Solar 2020). What they do is build and manage a solar project in a sunny part of San Antonio, while the customer still gets to own the energy that the project generates. The electricity that is generated by this project, which is funded by the customer, is then sent directly into the CPS Energy power grid. The energy that is sent into the CPS Energy power grid is then attributed to the customer, who acquires solar credits which automatically lower their monthly CPS Energy bill (Big Sun Solar 2020). This is a method in which a customer can have all of the benefits that come with a residential rooftop solar system, but no concern regarding the operations, maintenance, insurance, or potential damage from accidents. There are a plethora of added benefits from using this innovative approach, as the solar project will be constructed in a location with “optimal sunlight exposure” and the customer will never have “to worry about dirty solar systems or leaky roofs” as they would if it was a rooftop solar project (Big Sun Solar 2020). Not only does this remove the complications of “soft-cost processes”, but it also simplifies the process of energy generation for customers. All they need to do is pay the bill, and receive their energy, without ever fretting about the logistics of the solar panels themselves.

Big Sun Community Solar is most valuable from an accessibility standpoint. With the community solar model, anyone in San Antonio can make the transition to solar regardless of the conditions of their residency. Offsite locations can generate energy and be directly applied to home power bills (Big Sun Community Solar 2020). If the offsite location is somehow damaged or begins to deteriorate, it is up to Big Sun Community Solar to fund the replacement and they do not charge the customer any extra (Big Sun Solar 2020). Even if someone in San Antonio is

to move into a new home, there is no extra labor required to adjust or restructure their energy source - the agreement with Big Sun Community Solar applies to any residency in San Antonio (Big Sun Solar 2020). This innovative business model has also increased access from a financial standpoint, as they claim to have been able to drastically reduce the cost of small-scale solar, as community solar is 39% cheaper than it would be through the avenue of rooftop solar (Big Sun Solar 2020). In order to grow an industry, it is essential that it is accessible both financially and logistically. Big Sun Community Solar is a company which has committed themselves to just that, and is the kind of company that will get the solar industry to truly take off. It removes all questions regarding technicalities as they take the burden of constructing and maintaining the infrastructure, and they provide this cleaner energy at one of the cheapest prices on the market, regardless of where in San Antonio the residency or home is located. Just as in the case of San Jose, the policies and initiatives in place in San Antonio are truly effective because they make solar more accessible.

Another company that has partnered with CPS Energy to form the NEE is OCI Solar Power. OCI Solar Power focuses on developing, constructing, financing, and operating solar projects throughout the country (OCI Solar Power 2019). They are based in San Antonio, and most of their work is focused in Texas. They generate solar power for more than 112,000 homes within the state (OCI Solar Power 2019). OCI Solar in 2011 became the first developer to “bring utility scale solar to Texas by signing a Power Purchase Agreement with the City of San Antonio” by working through CPS energy (OCI Solar Power 2019). Over the course of the 2010s, OCISP has completed various projects throughout Texas, all of which were directly for CPS Energy. One of these projects was built within the city of San Antonio, but most of them were built in nearby areas. The most significant of these projects was constructed in 2016, which

was built in McCamey, Texas (OCI Solar Power 2019). This project, titled Alamo 6, “is the largest dual-axis solar farm in the US,” with a capacity of 110MW (OCI Solar Power 2019). Another major development of OCI Solar Power was the opening of the Mission Solar Energy module manufacturing plant, which was built in San Antonio “with the capability of producing 200MW of N-Type and P-Type PV cells and modulus for utility customers (OCI Solar Power 2019). OCI Solar Power has completed a solar project directly connected to CPS Energy almost every year since 2011, and is a fundamental member of the NEE.

Texas lacks state-level government regulation in the energy sector, considering it is the only state in the continental US to rely almost exclusively upon its own isolated ERCOT grid (EIA 2021). This gives an opportunity for private companies such as OCI Solar and Go Smart Solar to truly flourish, as there are no government projects or regulations impeding upon their success. This is a drastic difference from a city such as San Jose, which has been very successful in the transition in large part due to the specific outlined plans such as Green Vision and Climate Smart. Both approaches have proven to be successful in their respective cities, as both government involvement on the state and city level have been instrumental in San Jose, and San Antonio has been able to make all of their progress with extensive municipal policy and a lack of state-level regulation.

One common thread however, that proves to be imperative in both cities, is a level of technological innovation which can increase access to solar energy projects. In San Antonio this is apparent in Big Sun Community Solar, and in San Jose this is apparent in municipal legislation which removed various roadblocks such as installation and application processes by converting them from in-person to virtual. This proves to be a constant in both of these cities as they are both standouts on a national level in terms of solar energy growth, and have been able to figure

out how to meaningfully implement solar energy faster than the rest of the nation. While in San Jose that came from local government involvement in the form of publicized eco-friendly initiatives, in San Antonio that came from the largest municipally owned electric utility in the nation in CPS Energy. In both cases, municipal level decision making in the form of innovative policy addendums, or partnerships and investments with innovative business models, have directly translated into the growth of the solar industry, even in states with drastically different levels of attention to solar energy generation. The key component in both cities is a focus on increasing accessibility to solar by making it easier for consumers to make the transition to solar energy without navigating the logistical complexities that come with it.

Demonstrated Resilience

The success of the solar energy industry in San Antonio has demonstrated resilience through a period of crisis just as was paralleled with San Jose through the economic downturn from the Covid-19 outbreak. The hardship that San Antonio endured was a result of the severe winter storms that struck the various parts of the United States in February of 2021. These winter storms brought challenges to Texas that were almost unthinkable - as “the nation’s leading energy-producing state, seemed like the last place on Earth that could run out of energy” (Krauss et al. 2021). As these winter storms ravaged the nation, Texas was uniquely unprepared, as their energy grid is completely isolated from any federal level regulations. As of February 17th 2021, 31 people had died nationwide, some due to icy roads, and others due to extreme cold weather or risky efforts to find warmth (Moya et al. 2021). 150,000 homes in Oregon lost power, 111,000 homes in Louisiana lost power, and 88,000 homes in Kentucky lost power - all of which are minimal in comparison to Texas, which had restored 700,000 homes by mid-February, out of a

total of 2.6 million customers who lost power according to ERCOT (Moya et al. 2021). The problems go further, as nearly 7 million Texans went under a boil water advisory. 911 and other law enforcement were receiving calls at “three times the normal rate” regarding concerns of hypothermia symptoms and advice for burst pipes (Moyan et al. 2021).

The decision to deregulate came in 1999, when the state governor at the time, George W. Bush claimed that it would “benefit Texans by reducing monthly rates and offering consumers more choices about the power they use” (Krauss et al. 2021). This had the potential to succeed in Texas due to the vast amounts of energy resources within the state, from oil reserves to natural gas to lignite reserves. While that may have been the case, the complete isolation of the ERCOT power grid is also why the state of Texas was impacted so harshly by the winter storms of February 2021. The operators of the various energy sources in the ERCOT power grid “neglected to spend the money to weatherize their instruments, pipelines and electrical lines to resist frigid weather” simply because there was no state mandated regulation which required them to do so (Rojas 2021). As a result, the weather conditions compromised the entire energy system as “power plants were knocked offline and pumps used to produce the natural gas needed to fuel them froze over” (Rojas 2021). The extreme cold conditions highlighted just how unprepared the energy infrastructure in Texas was as a result of this deregulation, something which will only be increasingly problematic as climate change increases the regularity and unpredictability of extreme weather events. The failure of the power grid in Texas is blamed for the tragic collapse which occurred, as the ERCOT is responsible for “the flow of power for more than 26 million people in the state” (Rojas 2021). The widespread outages have prompted “the governor, lawmakers and federal officials to begin inquiries into the system’s failures, particularly in preparation for cold weather” (Rojas 2021). The power system failure not only led to unsafe

conditions for millions of Texans, but also spiked electricity prices to \$9,000 per megawatt-hour from the prior rate of \$1,200 per megawatt-hour. This magnitude of a failure led to the resignation of five board members of the ERCOT power grid, who in a public statement attributed their resignation “to allow state leaders a free hand with future direction and to eliminate distractions” (Rojas 2021). The ERCOT power grid took a risk when deciding to establish themselves as a stand-alone energy system, and this is exactly the consequence that comes with a decision to fully isolate. Thankfully for some San Antonio residents however, the CPS energy grid was available during these times of crisis.

Out of the 151 Texans who died as a result of the extreme winter storms of February 2021, 9 of those deaths occurred in Bexar County, which encompasses the city of San Antonio (Texas Health and Human Services 2021). Despite having a small fraction of the state-wide mortalities, San Antonians were still impacted - including 33 year old Justin Chavez, who went days without power in his home with his wife and eight children. The conditions they endured were abysmal, using towels under the doors to limit the cold drafts coming inside the home, and the family’s four pet fish freezing to death due to the lack of heating in the home (Moya et al. 2021). CPS Energy and the city of San Antonio did show signs of resilience during these dark times however, as they almost immediately did their part to hold the ERCOT accountable for their failure, and provided mechanisms for their own customers to deal with the state-wide adversity.

CPS Energy filed a lawsuit against ERCOT, “suing ERCOT for breach of contract, negligence, and violation of the Texas constitution” (CPS Energy 2021). This demonstrates that the nation’s largest municipally owned energy utility is doing its part in protecting its customers and city residents against a period of anomie and crisis. The localized municipal level power and

control of CPS Energy leads to greater advocacy for all consumers involved. The lawsuit being filed by CPS Energy against ERCOT is regarding accessibility to energy, the fundamental connection between successful energy policies in growing the solar sector. The specific words used in the news conference on March 12th, 2021 were that CPS was acting against the “injustice of imposing erroneous, excessive, and unlawful costs of San Antonians who suffered during this storm” (CPS Energy 2021). In the same conference, representatives from CPS Energy went on to claim that “ERCOT and state regulators are presiding over one of the largest illegal transfers of wealth in the history of Texas” (CPS Energy 2021). The efforts to hold ERCOT accountable proves the resilience of San Antonio’s CPS Energy utility company, and the commitment to their own residents does not stop there.

On the official CPS website, they have a section devoted exclusively to providing updates to the February 2021 Winter Storm. On this page, the first text on the screen reads -

“**Resiliency** is the ability to recover quickly. **Resiliency** is important as our world can change in an instant. While we are taking steps to recover from outages, please know that even when working through new challenges, your energy utility systems and team members are focused on **Safety** and **Reliability**.” (CPS Energy 2021)

This commitment to customers and residents of San Antonio is self-described as a showing of “resiliency”, the crucial component that solar projects lacked historically in the face of harsh economic conditions. The promises of CPS Energy go further than simply rhetoric, as they have already outlined various ways in which they will be able to mediate some of the hardship caused by the extreme winter storms of February 2021.

The first step taken by CPS Energy announced on March 2nd claimed they “will proactively protect customers to keep their bills affordable” while they simultaneously “pursue prudent business practices that keep the utility and San Antonio financially stable and strong”

(CPS Energy Newsroom 2021). The following step, announced on March 5th, was to ensure that “CPS Energy officials suspended billing for customers on February 19th” meaning that “February bills do not include any additional exorbitant fuel or purchased power charges from the winter storm” (CPS Energy Newsroom 2021). This was then followed by the CPS lawsuit filed on March 12th, against ERCOT in order to “protect its customers from excessive, illegitimate and illegal prices” (CPS Energy Newsroom 2021). The next step taken by CPS Energy was the announcement on March 18th that the San Antonio City Council had “passed a resolution supporting CPS Energy’s multi-faceted strategic plan to keep customer bills affordable” through options “such as seeking federal and state financial and policy assistance; regulatory intervention; and other avenues, including negotiations” (CPS Energy Newsroom 2021). This was coupled with an announcement from Paula Gold-Williams, the President and CEO of CPS Energy, who claimed that “a primary focus remains on seeking federal and state financial and policy assistance for our community” while maintaining a plan to protect CPS customers (CPS Energy Newsroom 2021). The last update given by CPS Energy, released on April 7th, was the announcement that “a total of approximately \$3.5 million will be credited to customers’ accounts” including a follow up that “customers do not need to take any action to receive the credits” as they would “automatically be applied to customer accounts on April 10 and will be immediately reflected in the balance due” (CPS Energy Newsroom 2021). This extensive list of updates by CPS Energy highlights the strength of the utility company, and the resilience that they have been able to demonstrate while the larger ERCOT grid is falling apart around them.

These points in turn also reflect the resilience of the solar industry in San Antonio, as it is effectively entangled with the success of CPS Energy and the NEE. If CPS Energy can prove

their ability to remain organized and focused on maintaining the well-being of their customers, as well as their access to affordable energy, in the face of an unthinkable disaster, it is a positive sign for the state of solar energy in San Antonio. The fact that the San Antonio City Council is on board with the policy approvals submitted by CPS Energy highlights the imperative connection between policy-making and accessibility in terms of determining the success of the solar industry in any respective location. While San Antonio is faced with the harsh reality of not having the same state level support for solar that exists within San Jose from California, this does point to an exciting takeaway. This proves that even in cities that lack state level support, and have a historical connection to fossil fuel industries and natural gas supplies, there is still potential for a booming solar industry. This bodes well for the future of solar energy across the nation, as cities are projected to play a bigger role than they ever have historically, and will play a fundamental role in implementing a greener future for all humanity in the fight against environmental degradation. The fact that the solar energy industries in both San Jose and San Antonio are able to demonstrate resilience against adversity, especially given extraordinarily different state-level circumstances, proves that the solar energy industry may be prepared to take the next step forward. The city covered in the next section highlights exactly how far that success can go.

HONOLULU, HI

Hawaii Statewide Energy Overview

Hawaii is one of the most unique states in the nation largely because of its geography. Hawaii is the largest island in the Hawaiian archipelago, and is about 2,500 miles from California, and about 4,000 miles from Japan, making it quite remote from any continental land mass (EIA 2021). This isolation provides certain challenges for the state of Hawaii that other parts of the nation don't have to endure, such as the difficulty to import or export essential goods. This is directly visible in the state's energy infrastructure, as importing a fuel source such as petroleum costs more for Hawaii than it does for any other state in the US. Hawaii also is faced with the reality of consuming "about 11 times more energy than it produces" meaning that Hawaii is not able to produce enough energy for their population, and is instead forced to pay higher prices for the energy they need to purchase in order to supply their population (EIA 2021). About 80% of Hawaii's energy consumption is generated from petroleum, the highest percentage of any of the 50 states (EIA 2021). The magnitude of this issue is quite severe, and the remote location of Hawaii means that they have to endure an additional financial burden to import the required fuel to power the state. This is compounded by the lack of oil, coal, and natural gas reserves in the state, meaning that all carbon-based energy sources can only serve Hawaii if they are imported from elsewhere (EIA 2021).

Petroleum has historically been the energy source which powers Hawaii, and is still a large part of the state's energy picture to this day. Hawaii does have quite a large crude oil refinery, to which much of the imported crude oil is sent. There were two major oil refineries which served the state in the past, however the larger one purchased the smaller one in late 2018 (EIA 2021). Now that they are combined, they have the ability to process about 148,000 barrels

in a single day. They are both located in the port area of Honolulu, on the island of O’ahu (EIA 2021). These refineries turn the vast quantity of imported crude oil directly into petroleum products. In 2019, the majority of that crude oil was imported from Libya and Russia, both of which are over 5,000 miles away (EIA 2021). While the refinery is responsible for managing a lot of the imported crude oil, the refinery still does have its limitations. Many refined petroleum products, such as propane, low-sulfur diesel fuel, and jet fuel, still need to be imported from all around the globe to Hawaii. These products are imported from various continents - parts of Asia, the Caribbean, and South America (EIA 2021). The crude oil is offloaded in the “O’ahu refinery area” and the refined products are then “loaded at Honolulu harbor terminals onto fuel barges for distribution to other islands” (EIA 2021). While Hawaii does have pipeline systems on certain islands to get the products to the customers, the state lacks pipeline infrastructure connecting the various islands, meaning that each island has to receive a separate shipment of refined products. This lack of infrastructure only increases the financial burden that the state faces in the transportation of petroleum, both the non-refined from across the world, and then refined products across the archipelago.

Most of these products end up serving the transportation sector, which accounts for two-thirds of Hawaii’s petroleum consumption. Another 25% of the state’s petroleum consumption goes to the electric power sector. Interestingly enough, jet fuel itself is responsible for over 50% “of all petroleum products consumed in the state” (EIA 2021). The tourism industry, as well as military installations, are largely why jet fuel “makes up a larger share of total petroleum consumption” of Hawaii than of any other state except for Alaska (EIA 2021). The military in Hawaii requires jet fuel for various projects, and the tourism industry requires jet

fuel for commercial flights. These statistics highlight that Hawaii has been operating as one of the least modernized energy systems in the nation.

Hawaii is a state which has been able to last this long with such an unpolished energy system due to the fact that it does not have particularly high levels of energy consumption relative to the rest of the country. This has served as a blessing and a curse at the same time. While the state is fortunate to benefit from a mild climate, which leads to the state's "residential sector energy consumption being the lowest in the nation" and a non-energy intensive economy, qualifying Hawaii as one of "five states that use the least amount of energy to produce one dollar of gross domestic product" this enables Hawaii to function at a level of complacency with an expensive energy system (EIA 2021). Minimal efforts to transition out of a petroleum heavy system were unsuccessful, as in 2006 the state mandated "all motor gasoline to be blended with 10% ethanol" with the hopes of creating a locally-sourced ethanol industry (EIA 2021). No ethanol refineries have been built in Hawaii to this day, and the "ethanol blending requirement" was called off in 2016 (EIA 2021).

This lack of innovation in the state's energy infrastructure has directly impacted the residents of Hawaii, as the outdated forms of energy generation have made the costs of electricity in Hawaii the most expensive of any of the 50 states (Coffman 2014). This all stems from the fact that Hawaii is forced to spend so much money on imported energy sources. The price of electricity in Hawaii from the consumer perspective is "about three times the national average, and the gap is widening" (Coffman 2014). This is a staggering figure, and over time can compound and result in an extremely expensive cost of living in Hawaii. If Hawaii was able to generate energy locally however, this financial burden would be greatly alleviated. Not only would the residents of Hawaii be able to cut their annual electricity spending two or three times

over, but the state itself would be able to save money and instead invest in their own local economy.

For these reasons, Hawaii has over recent years been able to make one of the most rapid transitions to solar energy of any state in the nation. It is arguably the perfect state to look at from a solar standpoint, as it has all of the conditions (complete lack of carbon-based resources, expensive energy prices due to necessity to import, vulnerability to climate change) that would drive a location to make the shift to renewable energy. Hawaii's transition to solar has been motivated by urgency to maintain an affordable cost of living, and minimize the impacts of climate change which have already begun to make parts of the state uninhabitable. 78% of inhabitants on the state's largest island, O'ahu, believe that climate change is going to impact them personally (O'ahu Office of Climate Change, Sustainability, and Resiliency 2019).

State Level Connection to Solar

The strides that Hawaii has been able to make in a transition to renewable sources, primarily solar, is evidence of how effective solar energy can truly be with the right levels of policy and commitment. One of the earliest notable pieces of this transition came in 2001, when Net Energy Metering (NEM), the same policy which exists in California that allows customers to sell excess energy back to the grid, was introduced to the state of Hawaii. It was a remarkably successful adjustment at the state level to facilitate the growth of the renewable energy sector. From its inception in 2001, over 60,000 customers utilized the NEM policy for their own renewable projects, spanning across the state, in O'ahu, Maui County, and Hawaii Island (Hawaiian Electric 2021). The NEM program continued to gain traction and popularity as the years went on, and solar energy in Hawaii grew along with it. This rapid growth of the solar

industry, much of which can be attributed to the enforcement of NEM and the work of Hawaii Electric, the utility company which provides electricity for 95% of the state, gained recognition on the national and global level. The implementation of NEM was so successful in fact that both the state and utility both received recognition from the Solar Electric Power Association (SEPA), one of the world's leading solar organizations (Hawaiian Electric 2021).

Further progress came in 2008, when the State of Hawaii joined with the U.S. Department of Energy to form a partnership under the pretense of a “groundbreaking Memorandum of Understanding to collaborate on the reduction of Hawaii’s heavy dependence on imported fossil fuels” (Hawaii State Energy Office 2021). This culminated in the launch of the Hawaii Clean Energy Initiative, also known as the HCEI, which claims to be “transforming the financial, regulatory, legal, and institutional systems that govern energy planning and delivery within the state” (Hawaii State Energy Office 2021). This was exactly what the state needed, and was followed by a set of ambitious plans. The original goal set by the HCEI was for the state to reach 70% of “total energy needs with clean and renewable energy resources,” yet this was quickly amended and taken a step further after excellent early results. In 2015, Hawaii became the first state in the country to declare a “total transition to renewable energy” (EIA 2021). By 2017 the state had reached 28% utility sales from renewables. By 2019, Hawaii generated a record high 29.8% of energy from renewable resources (Hawaii State Energy Office 2021). This shifted from a goal of 70% generation from renewables, to a full 100% coming from renewable sources by the year 2045 (Hawaii State Energy Office 2021).

In 2019, 60% of the state’s renewable energy generation came from solar energy. This came mainly from the expansion of “small-scale, customer-sited solar panel generation, which has more than doubled since 2015” (EIA 2021). Those small-scale projects are exactly the kind

which benefit most from the implementation of NEM. The state also generated 15.83% of its total electricity from renewable solar energy in 2020, making it one of the top 3 states in the nation in percentage of total electricity from solar (SEIA 2020). As the industry has grown, it has become easier for consumers to make the shift to solar. This has been beneficial from an accessibility standpoint, as solar prices have dropped 45% in the past five years (SEIA 2020). The industry is projected to keep growing at a high level, with an estimated increase of 1,576.30 MW over the next five years. For context, the state currently has 1,413.23 MW, meaning that the solar industry is expected to slightly more than double over the next half decade (SEIA 2020). These rates of growth are inspiring, as Hawaii has rapidly moved from an out-dated fossil-fuel based state, to one of the most successful solar states in the country. The most exciting aspect when considering the status of solar in Hawaii however comes from a slightly closer look, specifically at the state's capital, Honolulu. The metrics of solar success on the state-level seem minimal when looking at the success that Honolulu has been able to achieve, as the leading solar city in the nation.

Solar in Honolulu

Honolulu is the nation's closest thing to a solar city. Honolulu is ranked 3rd in the nation in Total Solar Installed, and is ranked 1st in the nation in Per Capita Solar PV (Environment America Research and Policy Center 2020). The second statistic is the more significant one in this instance, as Honolulu is the frontrunner of the Per Capita Solar PV, with no other city even remotely close to their value. In Honolulu, there are 840.88 watts DC per person generated by solar PV (Environment America Research and Policy Center 2020). The second place city has a

value of 294.8 watts DC per person, about a third of the value of first place Honolulu (Environment America Research and Policy Center 2020). This goes to show that Honolulu has been able to accomplish levels of success in transitioning to solar that other cities have not even been able to approach. The ability for Honolulu, the state's capital, to become the nation's leading city in arguably the most important solar statistic is astounding. This is particularly impressive considering how historically dependent Hawaii has been as a state on non-renewable resources.

The exciting thing about Honolulu is that these numbers continue to increase, as in 2018 they were also first in the country in terms of Solar PV per Capita with a value of 606.4 watts per person (Environment America Research and Policy Center 2018). This means Honolulu has continued to improve on their already leading solar infrastructure, a trend which all signs suggest will continue going forward. For further context, in 2018 when Honolulu was first with a value of 606.4 watts per person, the nation's second place city was still far behind with a value of 204.1 watts per person (Environment America Research and Policy Center 2018).

On some level it is not a surprise that the city of Honolulu has found so much success with solar energy as it is the capital city in one of the nation's most ambitious solar states. This is especially true given a population breakdown of the counties within Hawaii which prove that Honolulu is by far the most populated part in the state. The city and county of Honolulu combine to have a population of 974,563, nearly a million (State of Hawaii Census 2019). The second and third largest counties, Hawaii County and Maui County, have populations of 201,513 and 167,503 respectively, a small fraction of Honolulu city and county's population (State of Hawaii Census 2019). What this means is that the policies implemented on the state-level impact

Honolulu the most heavily of any Hawaiiin city, meaning that it is also Honolulu which receives the most benefits and has the most to show from those implemented policies.

While the percentage of the state's population is certainly a relevant factor as to why Honolulu has experienced such success with solar, the municipal level policy making has been just as ambitious as it is on the state level. The City and County of Honolulu has detailed this in their Climate Action Plan for 2020-2025, which outlines their role in the growth of the industry. One of these approaches is quite similar to what led to the success of the growth of solar in San Jose, with a fully streamlined permitting process for residential rooftop solar projects. In 2012 this process was made fully virtual, allowing for much faster approvals of "routine residential projects," something which has allowed Honolulu to become the nation's leader in per capita rooftop solar penetration (O'ahu Office of Climate Change, Sustainability and Resiliency 2019).

The municipal level policy implementations have been acutely in touch with the city's residents, and have allowed the concerns of the community to help shape more effective strategies. The natural environment of Honolulu is greatly valued, which has led to "major concerns around how large scale projects impact land use and surrounding communities" (O'ahu Office of Climate Change, Sustainability and Resiliency 2019). The City and County of Honolulu heard from community members in forums such as virtual open houses, where one particular participant shared that "being an island community, we see the effects of climate change everyday, slowly deteriorating the place we love so much. I want to do everything in my power to preserve our island from climate change so that future generations can enjoy our home as well" (O'ahu Office of Climate Change, Sustainability and Resiliency 2019). That sentiment not only attests to the urgency with which Hawaii and Honolulu must work to transition away from fossil-fuels, but also to the reality that Honolulu is forced to find ways to meaningfully

implement solar energy without the luxury of space for large-scale projects that other parts of the nation are able to work with.

Honolulu has been able to successfully do so, as in 2019, 18% of the electricity generation on the island of O’ahu, the island in which Honolulu is located, was sourced from renewables (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). The city has engaged in various ESPCs, energy saving performance contracts, to implement more energy efficient forms of infrastructure, including “installation of solar PV at the Kailua Wastewater Treatment Plant for the Department of Environmental Services” (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). This is the sort of project which does not require additional construction, but can rework existing infrastructure to make it more efficient and cleaner.

Another crucial and innovative piece of the city’s climate strategies involves a radical shift to electronic vehicles. As transportation accounts for a large portion of the carbon emissions coming from Honolulu, a shift to EVs would do a lot of good for the city from an environmental standpoint. Due to the existing solar infrastructure in Honolulu, the transition to EVs can happen fairly quickly, and Honolulu is working to make that happen as fast as possible. The City and County of Honolulu claim that “if an EV driver has solar panels on their roof at home, an EV can even be a nearly zero emissions mode of transport” (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). The efforts to increase the usage of EVs relates to accessibility, and the Climate Action Plan claims to make EVs “cleaner and more affordable for O’ahu residents” (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). This is made clear by a recent step taken in June of 2020, when the city of Honolulu announced a new requirement for “new parking spaces to be pre-wired with the necessary electrical capacity to add

EV charging without a costly retrofit” (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). As residents of O’ahu are provided the opportunity to personally make the shift to solar, they also become aware of other modifications in their behavior and consumption practices that can increase the island’s sustainability. The emphasis on EVs is an innovative method to encourage the use of clean energy and renewable solar power while being mindful of the unique characteristics of O’ahu and Honolulu.

The processes which have led to the tremendous success of solar in Honolulu come down to the fact that policies have been catered specifically to the city. The focus on facilitating small-scale projects, refurbishing and renewing existing structures, and pushing a transition to electric vehicles, has made Honolulu able to deal with the urgent financial and environmental pressures by making solar energy more accessible. The city and state have also been able to demonstrate resilience in this transition to solar, which bodes well for the trajectory of the industry going forward.

Demonstrated Resilience

Interestingly enough, as the success of solar has increased in Hawaii, there have been a few pivotal changes in state-wide policy. One of those changes is the state’s stance on NEM, the net energy metering policy which 41 of the 50 states offer. As previously mentioned, NEM is a policy which provides a source of financial relief for customers who make the switch to renewable energy. Any customer who utilizes a renewable energy source for their electricity is able to sell their excess energy, electricity that they have generated but do not consume, back to their respective energy grid, and use that to acquire credits for future energy bills. This is a policy which works as a great source of financial alleviation, and is a tremendous incentive for

individuals by making it more accessible to switch to using renewable energy sources for their own electricity generation.

However as the solar industry continued to ascend within the state of Hawaii, and the city of Honolulu continued to rise up the ranks of the nation's solar cities, there was a decision made to remove the NEM option for residents of Hawaii (Hawaiian Electric 2021).

This move appears to be somewhat counterproductive at first glance, as there is a lack of clarity regarding how removing a proven financial incentive could work to grow the solar industry, as opposed to hindering it. Yet in 2015, it was the decision made (Hawaiian Electric, 2021). The state in fact reached a fascinating point in their process of expanding solar energy, one in which it was detrimental to growth of the industry to continue to allow residents to reap the benefits of the NEM policy. In 2015, the Hawaii Public Utilities Commission "filed a ruling to close Hawaii Electric Companies' net metering program to new participants." This means that the 60,000 plus residents who were able to already establish their connection to the NEM program will be able to retain their privileges, yet all newcomers to utilizing solar energy will not be able to share the same financial relief (Hawaiian Electric 2021). This was caused by an overload of energy being sent back to the grid, a result of too many customers utilizing the NEM offer (Hawaiian Electric, 2021). As said by the Solar Energy Industries Association, one of the most highly regarded voices on solar energy, "Hawaii is an ideal solar market. However interconnection continues to be an issue as Hawaiian utilities have imposed restrictions to avoid solar generators' loads on their systems" (SEIA 2020). The rapid success of solar growth in Hawaii has become a challenge for the state's energy infrastructure. As a result, the Hawaiian state government has been forced into action to restructure existing policy models.

The rationale behind this comes from the state's regulators who claim it is "essential" as the state has already achieved very high levels of redistributed energy. This is followed by a statement which suggests that it is in fact imperative to remove the offer of NEM to new solar customers, "in order to ensure a smooth transition to redesigned market" which would be capable of managing the growing population of residents in Hawaii who make the switch to renewable energy (Public Utilities Commission 2015). Hawaii Electric's senior vice president of customer service, Jim Alberts, said "we appreciate the [Hawaii Public Utilities Company's] thorough review of the complex issues that need to be balanced," acknowledging merit to the decision to remove the offer of NEM (Hawaiian Electric 2021).

This decision in 2015 did not have a negative impact on the solar industry on the state level, or on the city level when looking at Honolulu. The growth that Honolulu experienced in Solar PV Per Capita from 2018 to 2020, from 606.4 watts DC to per person to 840.88 watts DC per person is a 27.8% increase, a drastic increase over a two year span, even after NEM was removed as an incentive for new customers (Environment America Research and Policy Center 2020, 2018). This can be attributed to new options that the state approved for individuals who made the transition to solar energy after 2015, one of which is described as "self-supply" and the other which is "grid-supply" (Hawaiian Electric 2021). Both of these options work as tariffs for customers to send excess generated electricity back to the Hawaii Electric grid, providing some relief for the customers who can no longer access NEM. When using the self-supply option, customers "are eligible for expedited review and approval of their systems in areas of high PV penetration," however they are limited in the amount of electricity they are able to send back to the grid, and do not have a chance of receiving any financial alleviation for the energy that they send back to the Hawaii Electric grid (Hawaiian Electric 2021). When using the grid-supply

option, customers are able to directly send their excess electricity to the HECO grid, yet they receive a much lower rate for the energy that they provide (Hawaii Electric 2021). While this option provides a reduction of the financial compensation provided by NEM, it highlights the impressive flexibility of Hawaii's state level solar policies.

This highlights that Hawaii has demonstrated an ability to restructure their solar policies and adapt to the results of their prior policy implementations. This adaptability on the state level is an essential piece of the puzzle if Hawaii wants to maintain the rapid success they have been able to achieve with solar energy. While this may present concerns regarding how well Hawaii will be able to manage the quickly increasing number of residents who are utilizing solar energy, the decision to close the NEM program to new participants is evidence of attentive and adaptable policy-making. This is a sign of resilience, as the state level policies have shifted as a result of an unanticipated challenge.

Regardless of the shortcomings of the self-supply and grid-supply alternatives, they have been successful in the sense that they have been able to serve as a bridge from NEM. Even as the incentives have diminished in return, the solar industry in Hawaii has not suffered at all. In fact, the solar industry has continued to flourish and is projected to continue to grow in Hawaii as it does around the rest of the country. This level of resilience in the face of a systematic problem, by innovatively reorganizing financial structures to make solar financially enticing and accessible, is proof that the state of Hawaii has been able to adequately navigate the challenges that come with solar energy.

On a city level, Honolulu has also demonstrated resilience in their fight to mitigate environmental degradation and hold accountable the fossil-fuel companies who for so long profited off of the city's isolated geography as an island, and the resulting exorbitant energy

costs. On November 12, 2019, the Honolulu City Council unanimously passed Resolution 19-283. This authorized the Department of the Corporation Counsel to “initiate legal action against fossil fuel companies to recover climate crisis-related costs” (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). The purpose of this legal action is to “recover damages” from the fossil-fuel corporations which were able to profit from the historic oil sales to Hawaii, and did not accurately “disclose the dangers of their products” (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). The City Council announced that any proceeds from this litigation would exclusively be used to “defray costs associated with adapting to sea level rise and other impacts of climate change” (O’ahu Office of Climate Change, Sustainability and Resiliency 2019). This move by the city of Honolulu is a sign of resilience of the solar industry, as the legal battle will not only fray the existing relationship between the city and the oil companies it worked with in the past, but also further push the city into its commitment to transitioning to solar. By holding the fossil fuel industry accountable it proves that the city of Honolulu is confident in their own solar industry, and will no longer need to maintain a working connection to the suppliers of petroleum that had dictated the energy structures of the state and city historically.

However perhaps the greatest sign of resilience for the solar industry in the state of Hawaii and city of Honolulu is the fact that this transition was even possible at all. In the instances of San Jose and San Antonio, the solar industry demonstrated resilience by surviving through periods of crisis - the economic downturn caused by the covid-19 outbreak in San Jose, and the extreme winter storms of February 2021 in San Antonio. While these are both tremendous examples of durability and strength, as what used to be a fringe industry had the foundation to surpass times of difficulty, the case of solar in Hawaii actually serves as the

solution to the time of difficulty. This distinction is key - solar energy survived during times of economic and environmental pressure in San Jose and San Antonio, whereas solar energy solved the times of economic and environmental pressure in Honolulu. Solar energy is no longer just an industry which may collapse under pressure, but the case of Hawaii and Honolulu demonstrates it is an industry with the potential to alleviate pressure entirely. Hawaii was in desperate need of a cheaper source of energy, and a way to save their natural environment. Solar energy was able to do just that.

In a short two decade span, Hawaii went from having one of the nation's most flawed and problematic energy systems, to perhaps the greatest solar energy system in the country. This is a level of strength and resilience of solar that has not been observed historically, and shows the true potential of how successful this industry really can be. While of course the solar energy system in Hawaii is not perfect, it will continue to improve. The success that solar has had in Hawaii, and how quickly it has been adopted on the city and state level, will be a boost of confidence for investors and governments around the country who may be on the fence regarding the efficacy and accessibility of solar as a legitimate energy source.

SECTION V - The Time is Now

The three cities of San Jose, California; San Antonio, Texas; and Honolulu, Hawaii all demonstrate an ability to achieve previously unseen levels of success with solar energy. There are many exciting takeaways from the three cases, but maybe most important is that they are all very different cities, within very different states. Any American city in any part of the country has the capacity and potential to transition to solar energy if the local policymakers in power ensure ways to make it accessible (Rogers and Wisland, 2014).

There are still legitimate concerns regarding what the future of solar energy will look like, as even successful cases such as Honolulu, Hawaii ran into the issue of an overloaded energy infrastructure leading to the removal of NEM for new customers (Hawaiian Electric, 2021). It is challenges like these that will lead to the further development of solar technology and innovative new ways to manage it. One clear take away from all three case studies is that the organization of the city-wide energy systems is just as important as the technology itself. Municipal level involvement focused on increasing the accessibility of solar energy has perhaps been most conducive to the growth of the industry. All three cities have offered their customers some combination of group purchasing/community solar opportunities or instant-approval online permitting processes. The specific focus on making it easier for individuals to shift from fossil fuels to solar power through creative municipal projects is just as important as the technological development of solar itself. Even with varying levels of state-wide support for solar energy, the removal of logistical impediments and soft-costs has led to the growth of solar in all three cities.

This proves that it is not necessary to completely restructure existing energy systems in order to facilitate the growth of solar, as the implementation of creative programs oriented around increasing accessibility can shift a community away from fossil-fuels and towards renewables. The three case studies highlight a foundational strength to the solar energy industry that was lacking in the past. The brightest part is, in all reality, the best we have seen of the solar industry is yet to come.

As the solar energy industry continues to grow, just as it is projected to, prices for small-scale solar projects will decrease (Rogers and Wisland 2014). As it becomes more affordable for individuals, communities, and cities to transition to solar energy, the growth of the industry will increase at even faster rates. As ecological modernization theorists would argue, the technology will also become more efficient. Competing producers will strive to create the most desired-product, and market mechanisms will inevitably lead to further innovation. With the combination of technological progress and increasing accessibility, solar energy will continue to improve and be more commonly utilized. It will soon become solidified as more than an alternative energy source for those who are environmentally-savvy, but instead simply a cleaner, more affordable energy source. From 2010 to 2013, the “price of a typical household system dropped by almost 30 percent, while the capacity of such systems across the United States more than tripled” (Rogers and Wisland 2014). This paid dividends for the industry, as the quantity of installed solar power grew 485% nationwide in the three year span from 2010 to 2013 (Rogers and Wisland 2014). Just imagine what that growth figure would look like with a more established industry .

One factor which is also instrumental in the growth of renewable solar energy is federal level legislation. This was not something discussed in the case studies for the purpose of

highlighting the importance of state and municipal level decision making, however the Presidential Administration can have a big impact on the way consumers view alternative energy sources. President Donald Trump, during his term in office from 2016 to 2020, did significant damage to the renewable sector, specifically solar energy (Jinjoo 2020). Former President Trump frequently displayed his “public skepticism” regarding environmental agendas and alternative energy sources, as well as making various “efforts to revive coal” in the United States, as well as officially removing the United States from the Paris Climate Accord (Jinjoo, 2020). This was coupled with heavy tariffs that former President Trump placed on imported solar panels which are a fundamental piece of the United States’ solar industry. Some of these tariffs were as high “as 30 percent on solar equipment made abroad” which was a significant handicap on an industry which “relies on parts made abroad for 80 percent of its supply” (Eckhouse et al. 2018). This resulted in the loss of over 20,000 solar energy jobs, a significant blow to the budding industry (Ellsmor 2019). Just as important as the anti-environmental policies that Trump enacted, was the overall rhetoric and symbolism that swept over the nation. For an average american consumer with minimal knowledge of alternative energy sources, to see that the nation’s elected representative was so anti-solar, seemingly suggested that it was not worth investing in or transitioning to. President Joseph Biden however has quickly changed the narrative on solar energy from the Oval Office.

He has not only rejoined the United States in the Paris Climate Accord, but has also outlined several plans to jumpstart the renewable energy sector. President Biden’s agenda and infrastructure plan would “turbocharge the country’s transition from fossil fuels” and “speed the growth of solar and wind energy” (Mufson and Eilpiren 2021). Part of this agenda is a proposal for \$400 billion in tax credits over the next ten years, part of which would be used “to bolster

projects such as solar panels on residential homes” (Mufson and Eilpiren 2021). This shift in attitude toward solar energy from the President reinforces the notion that solar energy is no longer a fringe industry, relevant exclusively to environmentalists, but instead a fundamental part of the nation’s infrastructure of the present and future. This will only increase the interests of investors who observe solar energy becoming a mainstream topic and commonly utilized energy source. Solar energy is no longer struggling to survive the roadblocks it faced in the past, but is now ready to fix the global challenges of the future.

Additionally, climate change is as bad as it has ever been, and the global population continues to increase while relying upon finite resources for their source of energy. This is a devastating combination with a very dark ending. The planet is falling apart and people are moving further away from any semblance of natural environment with the rising trends of urbanization. TOP advocates would argue that these trends of modernization are largely responsible for global warming and the tragedies that have come with it. One example of this is the ERCOT grid in Texas, which was established with the hopes of facilitating economic growth and allowing Texas to maximize its abundance of energy resources. The ERCOT grid ultimately resulted in an unprepared energy infrastructure and cataclysmic turn of events leading to the deaths of hundreds of people. This proves that in many ways TOP advocates are correct, as economic growth along with urbanization have been tremendously detrimental to the planet. One could argue these processes of modernization are creating problems while attempting to solve them, leading to the vast consumption of carbon-based energy sources and in turn the massive output of carbon emissions into the atmosphere.

With that said, urbanization is a certified trend of the future, and one with no signs of slowing down. The idea of a 21st century world without continuously growing cities is difficult

to picture, as even the outbreak of a deadly respiratory virus which caused a global pandemic could not do much to slow down the growth rates of urban areas (Patino, 2020). If people are to shift into cities, then the only hope of meaningfully mitigating environmental degradation is by working within the existing economic confines and shifting demographics. In all three of the case studies, the impacts of environmental degradation are already visible. In Texas, the extreme weather events of February 2021 proved that unpredictable weather patterns caused by climate change are already upon us. The state of California has been so committed to sustainability largely because of the droughts and forest fires which have already been exacerbated by global warming. The whole state of Hawaii is vulnerable to environmental degradation, as entire communities have voiced their concerns on how they might be personally affected by climate change. These conditions of urgency have pushed the three locations to lean further into renewable solar energy. All three locations need strategies to minimize their carbon footprint, as the threat of climate change continues to loom larger and larger. As the effects of climate change increase and more locations and communities become impacted by it, a growing number of people and places will want to find a way to contribute in the efforts against global warming.

Solar energy provides the opportunity to do so, and has proven to be successful in the instances of the three American cities San Jose, San Antonio, and Honolulu. The transition to solar energy is not only something that can happen with other American cities, but something which has to happen. It is a technological breakthrough which lines up perfectly with the trends of the future - as it can function within urban centers as well as any energy source if not better, and presents a major piece in the fight against environmental degradation. The future of the solar energy industry is bright, as the industry is as strong as it ever has been, with all signs pointing in

the direction that it will only continue to grow. Solar energy can be the energy source of the future, and has proven ready to be the energy source of today.

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