Dedication

This thesis would not have been possible without the longstanding support that I have received from my family. In particular, I would like to thank my parents for the numerous opportunities they have afforded to me and the support (both academic and emotional) they have provided me throughout my academic career. In addition, I received constant support from my younger sister, Amy, who is going on to do great things. As a result, I am dedicating this thesis to them.

Acknowledgments

I would like to acknowledge the assistance I have received throughout this process and thank those who supported me. First off, I would like to thank my advisor, Fred Curtis, for his patience and insight. In addition, I would like to thank my committee members, Philip Mundo, Maliha Safri, and Robert Murawski for their helpful input and considerable time exerted on my behalf. Finally, I would like to acknowledge the invaluable support that came from Cassandra Worthington-whose faith in me never faltered.

The Impact of State Level Policies on Residential Solar Panel Installations

A Thesis in Economics

By

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Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor in Arts With Specialized Honors in Economics

May 2015

Abstract

This thesis contributes to ameliorating anthropogenic climate change by making policy recommendations to make solar energy more affordable. First, this thesis discusses the relevant economic lens to evaluate rooftop solar electricity-and its fossil fuel alternatives. Chapter one identifies the Pigovian approach and its application to electricity production. Since fossil fuels impose negative externalities on society, the Pigovian approach calls for increasing the cost of fossil fuels. Meanwhile, since solar electricity offers positive externalities, its price should be lowered.

Chapter two discusses the underlying factors that influence solar panel demand. These relevant variables can be manipulated by policy to make solar panels more appealing to consumers. In chapter three, four states' (Oklahoma, California, New Jersey, and Florida) approaches to rooftop solar policy are examined, critiqued and compared.

Chapter four introduces the policy recommendations produced in this thesis. These recommendations are based on the relevant variables identified in chapter two and the case studies in chapter three. This thesis found that, in order for states to encourage solar panel growth, states must eliminate policies that discourage solar panel purchases and implement taxes on fossil fuel competitors. In addition, states should offer net metering, feed in tariffs, tax incentives, rebates, and programs specifically geared to make rooftop solar more affordable to lower income communities. By implementing these policies, states can improve the environmental and economic sustainability of their electricity portfolios.

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Introduction:

The purpose of this thesis is to assist in addressing the greatest problem facing our planet. The threat presented by anthropogenic climate change is both global in scale and disastrous in consequence. Furthermore, unlike most threats facing our society, we have actively exacerbated anthropogenic climate change instead of solving it. As a result, this threat requires drastic policy change and immediate action. Currently, the United States has not capitalized on its vast solar potential as an alternative to fossil fuels. This thesis presents a series of recommendations based upon both the policies enacted by case studies and the shift factors for solar demand identified in chapter two. These policy measures are all directly tied to key demand factors and will directly increase rooftop solar installations by making them more financially feasible. By adopting these recommended policies, states will be able to replace their irresponsible and unsustainable fossil fuel-based electricity with a sustainable alternative-one that generates positive societal impacts instead of negative ones.

While some remain dubious of its origins and severity, the impacts of climate change are already being felt. In particular, rising sea levels, desertification, and drought have all been experienced on a global scale (IPCC 2009). The social and ecological costs of climate change are disturbing in themselves. It is important, however, to also acknowledge the clear economic threat that climate change imposes on the entire world. The climate shifts, and its subsequent impacts on both public health and weather patterns will present enormous costs to governments and businesses (IPCC 2009).

Given the severity of this issue, it is vital that further academic research is conducted -particularly in regards to how to effectively mitigate anthropogenic contributions to climate change. The purpose of this thesis is to contribute to this broad effort by studying incentives for sustainable alternatives to fossil fuels-namely rooftop panels.

Since the industrial revolution, technology, and the heavy energy usage that accompanies it, has become fully integrated into society. Our civilization has developed substantially since the start of the industrial revolution. The ensuing technological developments have made lives easier, allowed for more leisure, and extended the human lifespan. With this technology, however, came a greater reliance on electricity. As output increased, so did the need to consume electricity. Unfortunately, over 66 percent of our electrical portfolio comes from the combustion of fossil fuels (EIA 2015). Meanwhile, nuclear energy and hydroelectric sources makes up 19 and 7 percent respectively. Wind energy accounts for another four percent, but solar energy still produces less than one percent of electricity used in the U.S. (EIA 2015). While this is disheartening, it also illustrates the enormous untapped potential that rooftop panels offer-if sufficiently supported by incentives.

The constant burning of fossil fuels has contributed to an unprecedentedly quick buildup of greenhouse gases in our atmosphere. In 2012, 32% of America's greenhouse gas emissions come directly from electricity production and 38% of carbon dioxide emissions are produced from electricity production (EPA 2013). Our high electricity usage clearly plays a clear role in contributing to anthropogenic climate change.

While there are many disheartening aspects of climate change, a source of hope can be found in alternative energy. A number of different sources of clean energy have developed significantly in recent years and should become fixtures in any electrical portfolio. Solar energy, for example, offers enormous potential because of the vast amount of energy we receive from the sun. Thus far, solar has been deployed both at a small scale on individual rooftops and in large-scale developments referred to as "farms." While both types of production have merit, the deployment of solar panels on rooftops allows consumers to extract energy from previously developed areas. Solar farms, on the other hand, require the development of vast, previously undisturbed ecosystems. This ability to produce electricity without developing additional territories makes rooftop solar panels an ideal solution to our fossil fuel addiction.

Like all new technologies, solar energy has experienced plenty of growing pains. Nonetheless, solar installations have grown rapidly from year to year. In 2010, there was 1,000 MW (1 million KW) of solar capacity installed in the U.S. By 2014, the number had grown to over 7,000 MW of solar energy (SEIA 2014). Unfortunately, despite this rapid growth, solar production remains a fraction of the 4,058 billion kilowatt hours of electricity produced annually (EIA 2014). As the solar industry continues on its path towards becoming a significant player in the electricity sector, the industry continues to rely upon subsidies to compete with fossil fuel based firms.

These currently modest subsidies play an important role in closing the pricing gap between environmentally sustainable sources of energy and their dirtier competitors- which receive <u>generous</u> government subsidies (EIA 2015). This practice of subsidizing fossil fuel-based competitors makes solar panel subsidies (and the efficacy of each incentive program) even more important.

As a result, it is crucial that we employ effective and appealing incentives to bridge this gap. Yet, Congress has largely been unable to pass new legislation- particularly environmental policy. The last two Congressional sessions (113th and 112th) combined only passed a total of 580 laws-far lower than any congress in the last 40 years. Indeed, many of the preceding congresses enacted more laws individually than the 112th and 113th combined (Govtrack 2015). Given this inaction at the federal level, state level policies are far more important than ever before and deserve closer examination.

Some states have created a number of financially appealing programs to incentivize solar panel demand and have seen impressive growth in the industry. Other states, however, have done little -which has resulted in them lagging significantly behind. Chapter three contains four very different states' approaches to the rooftop panel industry. These case studies provide the information necessary to understand what works, and what doesn't, when it comes to encouraging solar growth. The conclusions drawn from these examples are evaluated within the context of highly relevant demand factors identified in chapter two and presented in chapter four as policy recommendations.

This thesis contributes to the process of promoting sustainable solar energy by identifying different types of state level policies useful in stimulating rooftop solar growth. As a result, any policymaker who reads this report will be able to understand what policies most effectively engender residential solar panel demand. Eventually, the successful policies identified and discussed in this body of work will hopefully be adopted at the national level. Based on the research conducted for this thesis, states must eliminate policy obstacles to rooftop solar panels, ensure that taxes are not raised when a consumer purchases a panel, offer rooftop solar panel owners net metering, provide a feed-in tariff, implement special incentives for low income families, offer rebates for the upfront cost of the panel, eliminate subsidies for fossil fuels, and impose a Pigovian tax on fossil fuels.

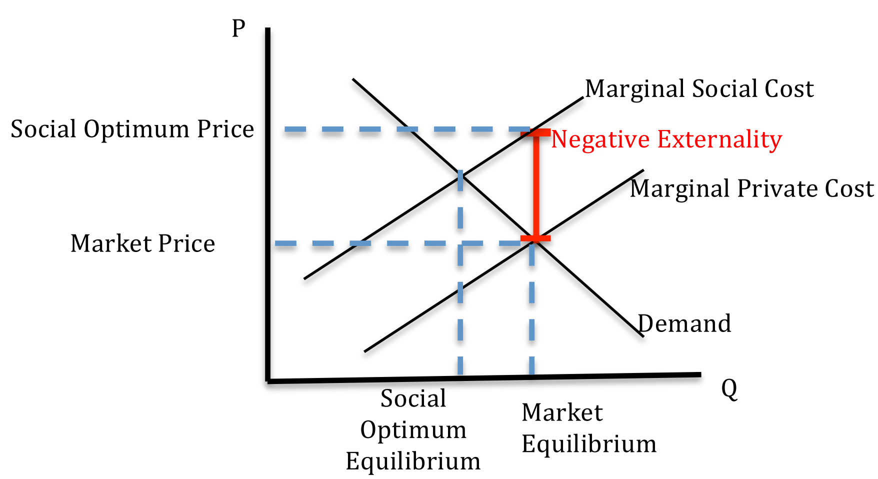
This thesis proceeds by first outlining the economic foundation upon which solar panel incentives rest. This investigation into the underlying economic factors related to energy, the environment and solar energy creates a strong foundation for the ensuing policy recommendations. In the following chapter, the factors that influence rooftop solar panel quantity demanded are enumerated and discussed. By identifying these demand factors, this thesis is able to zero in on what policy tools can be used to shift these factors-which, in turn, will shift solar panel quantity demanded. In chapter three, four states' policy approaches to solar panel incentives are discussed and compared. This provides examples of a wide array of policies and incentives and serves as a proving ground for the economic theory discussed in chapters one and two. Finally, chapter four provides analysis regarding the various policy approaches in the four sample states. In addition, it makes recommendations as to which policies states should implement to stimulate rooftop panel consumption.

Chapter One:

Economic Foundation

A. Fossil Fuel-Based Electricity

If the United States is to significantly reduce its contribution to anthropogenic climate change, drastic changes must be made to how we produce our energy. One of the largest contributors to climate change is the burning of fossil fuels for residential electricity. In fact, in 2013, the U.S. emissions from residential electricity accounted for over 30 percent of American greenhouse gas emissions that year (EPA 2014). This continued reliance on fossil fuel-produced energy imposes significant social costs in the form of negative environmental externalities. Negative externalities are costs imposed on a community from the private production and consumption of a product. The use of fossil fuel-based energy, and subsequent release of greenhouse gases, contributes to ocean acidification, desertification, proliferation of wildfires and storms, increased disease outbreak, ocean desalination and rising sea levels (EPA 2014). As a result, the negative externalities from fossil fuel-based energy harm not only neighbors, but also the entire global community.



Private vs. Social Cost of Fossil Fuels

The preceding graph illustrates the impact that externalities have on consumption levels. The social optimum price and quantity (shown on the chart above) occurs when the marginal social cost of a given product equals the marginal social benefit. As a result, it indicates what the price of the product would be if its negative impacts were shouldered by the individual consumer-instead of his/her community (Curtis). Because the social optimum price includes the additional social costs, it is higher than the market cost for products with negative externalities. This higher price produces a decrease in the quantity of electricity demanded. As a result, the social optimum quantity demanded is lower for products with negative externalities.

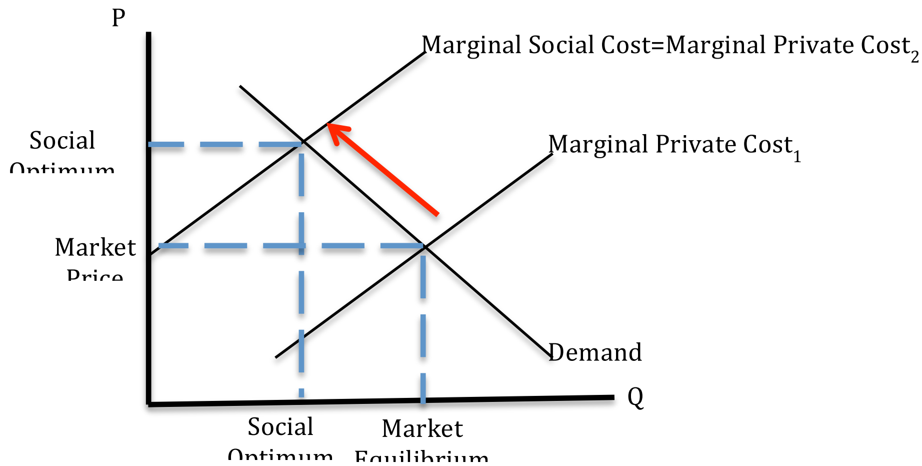
Economists have attempted to quantify the aforementioned negative externalities from climate change by calculating the social cost of carbon (it is important to note that this calculation does not account for the damage inflicted by the emissions of other greenhouse gases produced from the burning of fossil fuels-like methane). This metric calculates the social cost imposed by releasing one additional ton of carbon dioxide. The Environmental Protection Agency estimates that each ton of CO_2 emitted imposes approximately 37 dollars to the public in the form of externalities (2014). The EPA further estimated that 2013 electricity production resulted in approximately 2,040,500,000 metric tons of carbon dioxide (EPA 2015). Based on the externality price determined by the EPA, our reliance on fossil fuel related electricity creates approximately $75,498,500,000 in social costs.

These costs are often associated with climate change, but also include health degradation from mining (Center for Disease Control 2011) and health issues based on the toxins released from burning of fossil fuels-such as mercury and arsenic (Yudovic and Ketris 2005).

Pigovian Disincentives

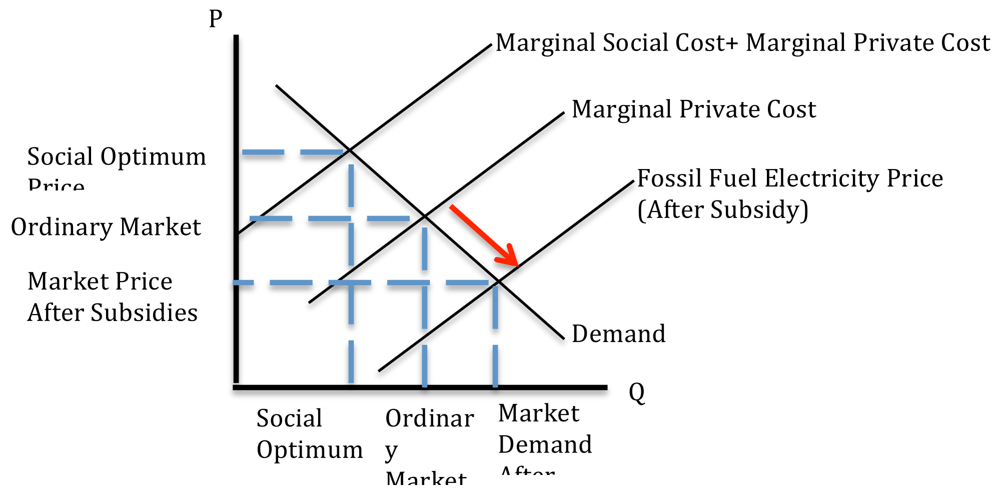
The existence of social costs, referred to by many economists as negative externalities, also results in a quantity of demand level is greater than the social optimum demand. As explained in the previous section, when a negative externality occurs, the costs are imposed on the public and the environment, rather than the consumer. As a result, there is overconsumption of the product.

This discrepancy between actual social cost and consumer price can be addressed through a system of Pigovian incentives and disincentives. The per unit Pigovian tax seeks to internalize externalities by imposing the public costs on the private producers and consumers. This results in a shift of the equilibrium along the demand curve for a product with negative externalities (illustrated below). This approach increases the private costs of fossil fuel based electricity and, consequently, decreases the quantity demanded for “dirty” electricity sources (Goodstein 2010). In doing so, demand and price can be brought to levels of social optimum-thus eliminating overconsumption.



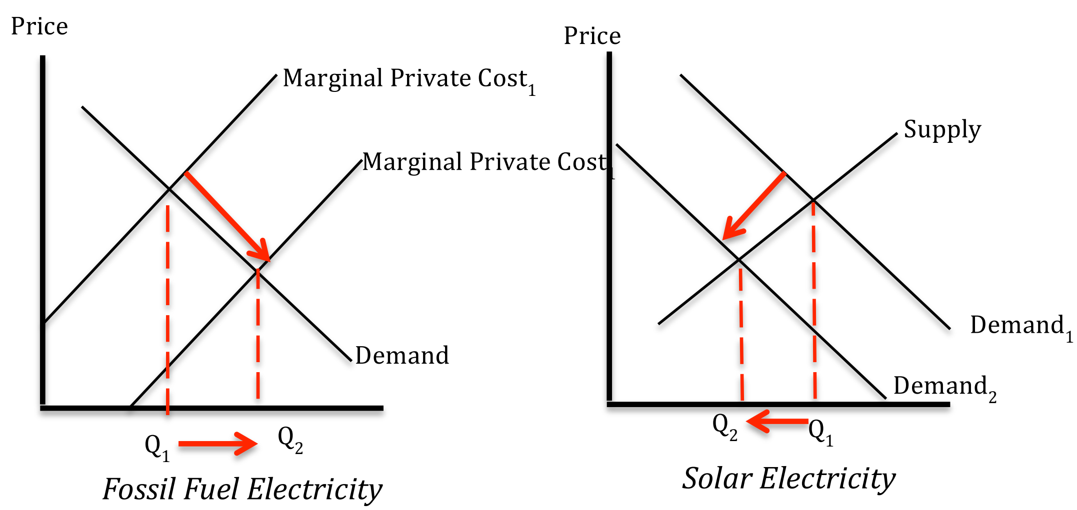
Impact of a Pigovian Tax on Internalizing Externalities

Unfortunately, rather than internalizing the social costs imposed by America's utilization of fossil fuels, the United States subsidizes fossil fuels and moves the market price further away from the social optimum. In 2011, the United States' subsidies for coal and natural gas cost the United States revenue equaling approximately .91% of American gross domestic product. By lowering "dirty" electricity prices, these subsidies have resulted in even greater demand for fossil fuel produced electricity (IMF 2013). This results in further movement of market demand away from the social optimum and increased environmental externalities imposed on our planet.



Digging the Hole Deeper by Subsidizing Fossil Fuels

According to the IMF, “Subsidies cause over- consumption of petroleum products, coal, and natural gas.” By supporting solar energy’s competitors, policymakers are undermining both investment in, and consumption of, renewable energy (2013).

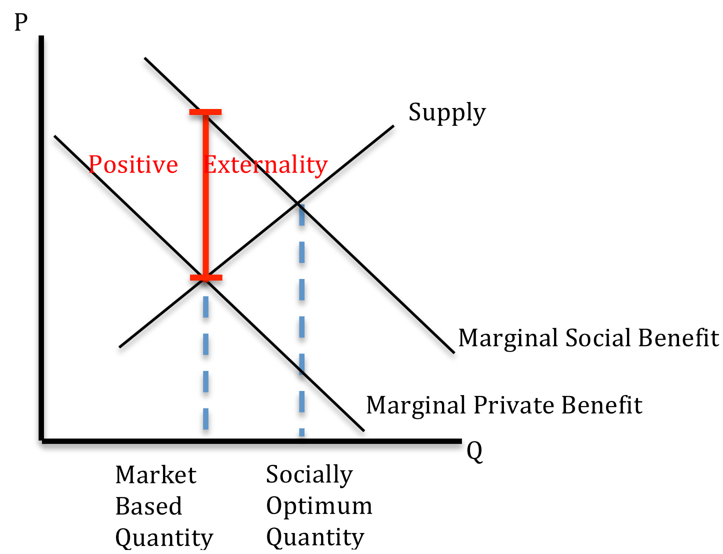


Impact of Fossil Fuel Subsidies on Market Prices and Solar Panel Demand

This problem is displayed in the above graphs. The left graph depicts pricing and subsequent demand for fossil fuel based electricity. The graph on the right illustrates pricing and demand for solar-produced electricity. When fossil fuel energy sources are subsidized, costs become lower and the consumption of this good increases. Unsurprisingly, as consumption increases, the quantity of negative externalities imposed on society increases as well. Meanwhile, since fossil fuels are a substitute for solar energy, a change in fossil fuel–generated electricity prices impacts demand for solar electricity. A decrease in fossil fuel pricing will result in a decline in demand for solar energy. As a result, the social optimum is impacted negatively for both markets.

B. Solar Photovoltaic-Based Electricity

The Pigovian approach also calls for policymakers to support products with positive externalities-like rooftop solar panels. This policy support increases consumption-thus increasing the total amount of public benefit. In this paper, I will focus on solar photovoltaic panels installed on residential units. In switching to PV panels, the public costs associated with fossil fuel extraction and combustion can be avoided (Goodstein 2010). As stated beforehand, this results in less contribution to climate change, fewer dangerous chemicals in the air, and fewer health costs associated with extracting fossil fuels. Furthermore, the production of electricity from solar panels can prevent grid demand from exceeding supply and causing brownouts (NRDC 2015). As a result, its usage represents a positive social benefit. The use of solar panels, therefore, engenders a net positive externality and should have its consumption maximized.

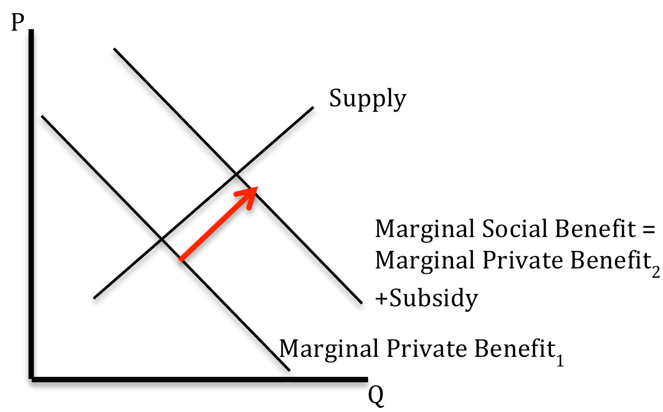


Solar PV as a Positive Externality

In fact, economists have calculated the social benefits of solar. The Minnesota Department of Commerce, for instance, has calculated that each kilowatt-hour derived from PV panels produces as much as .025 dollars in environmental externality savings (2013). This is especially impressive given the fact that solar installed at the end of 2013 costs approximately .12 per kwh (U.S. Department of Energy 2014). The public benefits from the usage of solar panels are substantial (particularly in relation to the benefits achieved by consumers). Given the impressive public benefit that accompanies its consumption, residential solar adoption has huge implications for environmental sustainability.

<u>Pigovian Incentives</u>

The Pigovian approach calls for incentives to lower the cost of goods with positive externalities (like solar photovoltaic cells) in order to encourage more purchases for these goods. In subsidizing these goods, the actual consumers of the product benefit-in addition to the society as a whole receiving greater positive externalities. This, in turn, stimulates more consumption of solar panels and results in more public benefit. By implementing a Pigovian approach to this issue, policymakers can increase the Marginal Private Benefit to the level of Marginal Social Benefit. In doing so, the demand for solar panels, and the positive externalities that come with their usage, is increased (Goodstein 2010).



Impact of Pigovian Incentives on Solar Panel

Having discussed the theoretical underpinnings of solar panel incentives, chapter three will explore the practical implications. Before doing so, however, thesis will evaluate how the aforementioned academic categorizations relate residential solar panels. As stated above, fossil fuel-based utility electricity imposes a number of costs on society in the form of environmental externalities. As a result, economic theory calls for a decrease in its consumption. As a competitor to utility electricity, solar panels offer public benefits by producing electricity without contributing to anthropogenic climate change, chemicals released into the air, and health damages to those working in the field.

Furthermore, as stated earlier, solar panels provide a public benefit by reducing brownouts.

Ideally, fossil fuel based electricity would have its social costs internalized to increase its market price. At the same time solar panel usage should be incentivized with lower prices. The failure of government to tax fossil fuel generated electricity, however, makes the incentives for solar all the more important. As illustrated on the previous graph, these incentives increase solar consumption and, consequently, the overall benefits enjoyed by the public.

Chapter Two:

The Factors That Influence Residential Solar Panel Demand

While the cost of solar panels has fallen by more than half since 1998 (Feldman et al. 2012), home solar-generated electricity is still not yet cost competitive with fossil fuel based utility electricity. This is especially significant considering the subsidies provided to fossil fuels in America. The EIA estimates that, even in the year 2019, traditional coal will cost approximately $96 per MWh and traditional natural gas will cost approximately $66/MWh. Meanwhile, solar electricity will cost approximately $118/MWh (EIA 2014). This puts solar electricity at a significant pricing disadvantage. In the absence of strong environmental preferences among consumers, residential solar demand is reliant upon government policies to incentivize its adoption.

While this thesis centers on state level policy, it also takes federal incentives into account when analyzing state level performance. In 2008, the national government created the Solar Investment Tax Credit, which allows individuals or businesses to deduct 30% of their systems' cost (EIA 2014). Even with this continued tax benefit, residential solar energy is not yet cost competitive with utility substitutes. As a result, some states have utilized a broad array of policies to close the pricing gap. In order to make policy recommendations, this thesis will determine which of these policies create the most compelling and effective incentives for solar panel consumption. In order to determine the efficacy of these localized efforts, the various shift factors influencing demand for solar panels are identified below. In order to understand and compare the various influential factors, this chapter presents a demand function and explores the shift factors that are included within it. This economic model captures the different variables affecting Qd.

Qd=f(-panel cost, inverter cost, -installation/permitting cost, + prices of utility-based electricity, + technical potential, +population, +political orientation, +income, , +tax incentives, +net metering program ,+feed-in tariff, -solar disincentives)

Factors

The factors listed above influence demand for rooftop units in a variety of ways. The most obvious factor in determining residential solar panel demand is the price of photovoltaic panels themselves. The Solar Energy Industry Association estimates that solar panels cost between $3 and $7 per watt (2014). The market price for panels indicates the amount of upfront cost that buyers will have to pay in exchange for later benefits.

The use of residential solar panels also requires the purchasing and installation of an inverter. Most houses in the U.S. utilize alternating current. Solar panels, however, produce direct current electricity. Therefore, an inverter is needed to transfer the electricity appropriately. Inverters range substantially in cost but the average is approximately $ 15,000 per unit (Wholesale Solar 2015). Finally, there are installation and permitting costs (Barbose et al. 2013). These expenses are all factors for consumers when calculating the gross cost of installing their own panels. These up front cost can be influenced by Pigovian tax incentives. An example of this is the federal Solar Investment Tax Credit, which allows consumers to deduct their system’s cost from their next year’s income taxes.

Another basic factor in determining demand can be found in the price of utility based electricity (produced from the burning of fossil fuels). The price of fossil fuel generated electricity has a clear impact on the decision to switch to solar energy because it is a substitute for solar electricity generated on rooftops. As a result, increases in utility prices will encourage solar panel consumption and decreases in price will undercut the solar market (NREL 2009).

The price of utility-based energy can be influenced by policy tools. Carbon taxes and tradable permit systems actively discourage the consumption of fossil fuels by attaching a Pigovian disincentive for fossil fuel-based electricity. As a result, the price of fossil fuel based electricity is increased relative to clean energy (Farber 2012). These policies increase the cost of polluting utility-based competitors and present clean energy sources with a pricing advantage. In doing so, the payback period for solar panels is reduced and the financial incentive to purchase a rooftop photovoltaic unit is increased.

While pricing plays a role, not all states receive as much direct sunlight as others. States with more sunlight hours will generate more electricity than their counterparts in states with less sunlight. This decreases the payback period and increases the financial incentives to purchase rooftop panels. For the purposes of this examination, sunlight hours are defined by the variable "technical potential" (Lopez et al. 2012). Technical potential is a calculation of total rooftop capacity based upon the amount of rooftop space and sunlight hours.

In addition, population size plays a major role in determining market demand. The greater a state's population, the larger total area of rooftop for panels. Therefore, when determining residential solar potential, population size is just as important as total sunlight hours. It would be impossible for the state of Wyoming to have the same rooftop output as California-regardless of policies or incentives utilized.

Demand for solar panels is also influenced by environmental awareness. A population's support for environmental sustainability influences its willingness to spend on a solar panel-particularly in cases when it is not cost competitive with fossil fuel alternatives. While this factor does not influence the financial costs of solar panel adoption, it has a clear impact on a consumer's "willingness to pay"-and the demand function as a whole. Communities that are less environmentally aware will demand more financial payback when considering purchasing solar panels. This also means that customers would be willing to purchase panels even with a lower return on investment. The support for environmental sustainability will be measured by political affiliation (Sarzynski, 2009).

The disposable income available to residents also influences their likelihood of purchasing panels. Consumers cannot contribute to rooftop solar capacity unless they have the financial resources to purchase the panels. As a result, disposable income strongly influences the amount of demand for solar panels from state to state (Zhao et al. 2012). The role of disposable income in influencing solar panel demand has key ties to various policymaking approaches.

Tax breaks for solar consumption represent a key policy tool used to encourage solar panel purchases. While there is a federal income tax break for solar panel adoption

(Department of Energy), this thesis focuses on state level tax incentives. These include reductions in income, sales and property taxes at the state level.

The existence of net metering, and the stipulations associated with it, also influence solar panel demand. This policy is of particular importance given current issues involving energy storage. As of right now, battery technology for wind and solar energy is inefficient and expensive (Burkart and Arguea 2012). Without a connection to the grid, unused solar photovoltaic energy is largely wasted. Net metering requires utility firms to connect residential solar panels to the electricity grid. As a result, individuals with residential solar units can sell unused energy to the utility company-this prevents the electricity produced by the owner from going to waste. At the end of the month, net energy usage is calculated (energy consumed-energy produced=net usage). In doing so, policymakers enable clean energy, that would otherwise be wasted, to be distributed in the place of dirtier sources. This allows owners of photovoltaic cells to cover the up-front, fixed cost of the panel more quickly (Burkart and Arguea 2012). The structure and stipulations of net metering vary from state to state. In the case study section, the various approaches to net metering are examined.

While net metering is important, it still allows utility companies to buy unused solar energy at a price of their choosing. In response to this, some states have created feed-in tariffs. They mandate that utility companies purchase electricity from residential solar panels and at a minimum purchasing price that utility firms have to pay specifically for solar electricity. By setting the minimum-purchasing price at, or above, market rates, states are able to incentivize technologies that have a higher cost of production and greater social benefit.

Further, feed in tariffs typically do not impose restrictions on how much electricity homeowners can sell back to the grid-because feed in tariffs concern electricity purchase price rather than quantity produced. This removes a key barrier for homeowners considering purchasing a greater number of panels (EIA 2013). Feed in tariffs dramatically shift the financial cost benefit analysis for solar panel consumers. In doing so, they allow consumers to pay back the upfront cost of solar panels more quickly.

A final policy factor that has a sizeable impact on solar panel adoption is state level residential solar disincentives. Some states have enacted policies that penalize the purchase and usage of solar panels. These policies attach financial costs or regulatory restrictions to the adoption of residential solar energy. For example, the Oklahoma legislature recently enacted a policy that applied a fee to distributed energy sources, -including residential solar panels (Oklahoma S.B. 1456). Distributed electricity production is defined as electricity production from a number of separate sources rather than one centralized unit. In the following chapter, the reader will see the impact that this policy, and other like it, have in undermining local residential solar panel demand.

The influential factors enumerated above (panel cost, inverter cost, installation/permitting cost, prices of utility-based electricity, technical potential, population, political orientation, income, tax incentives, net metering program ,feed-in tariff, and solar disincentives) show the broad array of variables that result in a shift in solar panel demand. These independent variables influence the demand for rooftop solar panels in a variety of ways. They can all be incorporated into policy tools (to varying extents) as leverage points to increase the demand for solar panels. Chapter three provides case studies to examine the use of these variables-and to evaluate thee efficacy of policies that rely upon them.

Chapter Three:

Case Studies

Different states have employed a variety of policies to influence solar panel adoption. Four very different states have been selected as case studies. Their vastly different policy approaches make them valuable case studies and have resulted in a wide range of solar performance. Analyzing these states allow us to observe the impact of policy in a variety of different political and economic environments.

The selected states (Oklahoma, California, New Jersey, and Florida) have utilized a wide range of policy approaches. By examining these particular policies, and the ensuing performance of the stat's solar residential industry, insight can be gained into the full array of policy options. These diverse policies also allow us to compare and contrast the efficacy of starkly different approaches.

Due to the rapidly changing nature of this industry, and the wide array of new policies being implemented, only the most recent data can be relied upon to reflect the efficacy of these policies. In order to compare the efficacy of each state's policy, this thesis will utilize each state's technical potential (or ceiling) and the total rooftop capacity installed in 2014.

Oklahoma

Oklahoma is a valuable case study because of it policy decisions and its sizeable technical potential for solar. Despite this, the residential solar industry within the state faces a number of policy and non-policy challenges. The result has been a dramatic underperformance in the state residential solar industry. By examining what Oklahoma has done wrong, we can better understand how to create a policy environment that makes rooftop panels more financially feasible-and therefore, conducive to solar industry growth.

The National Renewable Energy Laboratory examined the technical potential for rooftop solar production in each state. It then projected the total potential rooftop capacity for each state based on exposure to sunlight and the amount of sunlight hours-the result is a wide range of values by state, from nearly zero to over 106,000 GWhs. Oklahoma's rooftop solar capacity was estimated to be roughly average for a state-12,000 GWhs (2012). This number is especially impressive given Oklahoma's relatively small population of 3.9 million (Census 2014).

Despite this potential, Oklahoma's solar installation progress towards this ceiling remains miniscule compared to the other states in this study. According to the most recent data from the Solar Energy Industries Association, Oklahoma installed less than one megawatt of rooftop solar in 2014 (SEIA 2015). The failure of residential solar to flourish, despite impressive technical potential, stems from a number of factors.

While Oklahoma benefits from a great deal of sunlight, other non-policy factors are not so solar friendly. The price of electricity produced by utility-based competitors in Oklahoma is very low. The average price of electricity in the U.S. is 12.58 cents/KWh. In Oklahoma, the cost is 10.74 cents/KWh (EIA 2014). As a result of these low rates, there is a smaller incentive to abandon the utility firms and switch to producing one's own residential solar electricity.

Oklahoma's population is also not environmentally focused compared to many Americans. This is not surprising given the enormous role that fossil fuel production plays in Oklahoma. Although Oklahomans only make up 1.2% of the U.S. population, the state has over eight percent of the nation's natural gas producing wells (EIA 2014). Given the state's economic ties to the fossil fuel industry, it is not surprising that that Oklahomans systematically reject environmentally conscious political candidates in favor of those who are far less proactive (FEC 2012).

In fact, Oklahoma's senior senator, James Inhofe, is arguably the most aggressive climate change denier in the U.S. Senate. He has repeatedly refuted the existence of anthropogenic climate change on religious grounds saying "God's still up there. The arrogance of people to think that we, human beings, would be able to change what He is doing in the climate is to me outrageous (2012)." Given the popularity of climate change skeptics and the Republican Party in Oklahoma, it is clear that a majority of Oklahomans are less likely to pay for environmental goods out of pure environmental concern than the rest of the United States. As a result, compelling financial incentives are crucial.

The final non-policy factor is income. The inhabitants of Oklahoma have a lower than average median family income of approximately $47,000/year (Census Bureau 2014). As a result, Oklahomans, have less disposable resources through which they can purchase solar panels. As a result, the demand in this state is limited by its inhabitants' buying power.

The lack of substantial growth in residential solar can also be attributed to a number of policy factors. Unlike many states, Oklahoma does not offer a statewide feed in tariff encouraging solar panel demand (U.S. Department of Energy 2014), This is particularly problematic since, as mentioned in chapter two, solar produced electricity remains more expensive to produce per unit. This is especially relevant for Oklahoma because of its noticeably cheaper utility electricity rates. Without incentives to bridge this particularly wide divide, solar panel owners are left at a market disadvantage.

Oklahoma further differs from many other states because it offers neither a sales tax nor property tax break for purchasers of residential solar panels (U.S. Department of Energy 2014). The issue of property tax breaks is of special importance to residential solar. Attaching photovoltaic units to a house increases its value and, in so doing, increases the property taxes on the given home. This additional taxation creates a perverse disincentive by further taxing a product that creates positive externalities.

While the State of Oklahoma does offer net metering to residential solar panel owners, the benefits are relatively modest. The utility firms in the state are required to connect homeowners to the grid and to reduce a homeowner's energy bills by however much electricity his/her solar panels provide to the grid- with one key caveat. If a household's panel produces more electricity than the household uses, utility companies are not required by law to pay for this net excess electricity produced by solar panels. As a result, the benefits to homeowners are capped at simply covering their own electricity usage-even if the solar panel production greatly exceeds their electricity usage (U.S. Department of Energy 2014). This reduces the payback potential of solar panels and decreases the efficacy of the net metering incentive. The diminishing returns created by this cap also discourages homeowners from installing larger systems. Finally, this policy represents a huge gift to utility firms. When customers produce more than they consume, utility firms are able to sell the extra electricity at market cost without paying anything for the electricity. As a result, the current policy structure rewards and subsidizes utility firms at the expense of rooftop panel owners.

Furthermore, the Oklahoma State Government has added a major disincentive that undermines solar panel demand. Recently implemented State Senate Bill 1456 allows utility firms to levy a fee of their choosing on households that utilize net metering programs. (Oklahoma State Legislature 2014). This system overtly benefits utility companies at the expense of solar panel owners. Utility firms already gain free electricity when residential units produce more than the homeowner uses and now are able to levy a monthly fee as well. By charging homeowners to use net metering and keeping the benefits of net metering capped at simply matching usage, state policymakers are actively creating a hostile environmental for the development of solar energy. Namely, the state has managed to actively undermine most of the financial benefits associated with rooftop panels. By undermining the efficiencies associated with net metering, Oklahoma continues to be an excellent example of how to create a hostile policy environment and discourage residential solar growth.

California

California, on the other hand, is an important case study because of the impressive residential solar growth that the state has helped to engender. In 2014, the state installed approximately 700 megawatts of rooftop solar capacity-more than every other state combined. As a result, it comfortably maintains its position as the state with the largest installed rooftop capacity (SEIA 2015). California experienced this success due to both policy and non-policy factors.

Like Oklahoma, California benefits from substantial sunlight and solar power potential. According the National Renewable Energy Laboratory, California's rooftop solar capacity was listed at an impressive 106,000 GWhs-more than any other state in the U.S. (2012). California also benefits from a number of other factors.

Electricity consumers in California pay a great deal more for grid electricity than their counterparts in Oklahoma, 13.32 cents/kwh vs 10.74 cents/kwh (Energy Information Agency 2014). While this is seen by many citizens to be an overall detractor, it is enormously beneficial to residential solar retailers. Higher electricity costs create an incentive for residents to forego utility companies and purchase solar panels.

The population in California is much more environmentally oriented compared to Oklahoma, as indicated by electoral preferences (FEC 2012). This makes Californians far more likely to buy goods with positive environmental externalities. As discussed earlier, an environmental focus can cause consumers to look at factors beyond sticker price. This changes the consumer's willingness to pay. Finally, the population in California also has substantially higher income than its counterpart in Oklahoma, with a median family income of approximately $56,000 per year (Census Bureau 2014). This elevated average income enables a greater percentage of Californians to purchase rooftop photovoltaic panels compared to states with lower average incomes.

While California benefits from a number of non-policy factors, policymakers in the state have contributed to the growth of residential solar through a number of generous policies. The State of California mandates that all utility firms offer net metering and grid connectivity for solar panel users. Furthermore, unlike their counterparts in Oklahoma, the State of California does not allow utility companies to charge consumers to connect to the grid (California Energy Commission 2014).

The State of California also offers a feed in tariff to stimulate residential solar panel demand as well. Utility firms are required to form contracts with users regarding the size of the tariff (U.S. Department of Energy 2014). For a solar panel owner starting a 10 year contract in 2015, the producer would receive 8.8 cents for each KWh produced by his/her panels and sold back to the grid (State of California Public Utilities Commission 2015).

Adopted 2011 Market Price Referents (Nominal - dollars/kWh)				
Contract Start Date	**10-Year**	**15-Year**	**20-Year**	**25-Year**
2012	0.07688	0.08353	0.08956	0.09274
2013	0.08103	0.08775	0.09375	0.09695
2014	0.08454	0.09151	0.09756	0.10081
2015	0.08804	0.09520	0.10132	0.10464
2016	0.09156	0.09883	0.10509	0.10848
2017	0.09488	0.10223	0.10859	0.11206
2018	0.09831	0.10570	0.11218	0.11572
2019	0.10186	0.10928	0.11587	0.11946
2020	0.10550	0.11296	0.11965	0.12326

California Public Utilities Commission

Policymakers in California also implemented a series of tax rebates. The General Market Program of the California Solar Initiative offers consumers a rebate based on panel capacity (U.S. Department of Energy 2014). Consumers are able to choose between two options. The Expected Performance-Based Buydown (EPBB) allows consumers to take a lump sum rebate up front that is based upon expected performance. The other option available to consumers, the Performance Based Incentive (PBI), allows consumers to receive compensation based upon performance over a period of five years. A Californian who installs a 1,000-watt panel can expect an incentive of $2.00 per watt ($2,000 total) up front. Meanwhile, if the person chose the PBI route, he/she would be compensated at 30 cents/KWh for five years (State of California 2015). The consumer is ultimately able to select which program is more financially appealing to his/her specific needs and resources.

The state government has also implemented the incentive program SASH, Single Family Affordable Housing. This program provides free or very low cost solar panels to low income families in single family homes. The state is able to provide this service by enlisting volunteers for the installation and utilizing a total budget of over $92 million dollars to fund generous incentives of approximately $6.00 per watt-six thousand dollars for a ten MW panel (State of California Public Utilities Commission). The SASH incentives make solar panels affordable for communities that would previously be unable to purchase a rooftop photovoltaic cell. In doing so, it dramatically increases demand for panels.

On a similar note, the state of California has also implemented MASH (Multifamily Affordable Solar Housing). This unique program offers elevated rebates for government assisted housing sites with multiple families. The MASH program offers two tracks that citizens can apply for. Track one provides a payment of $1.90 per watt if the solar panel provides electricity for a common load, in which the electricity is dispersed through the entire building's common areas, or a payment of $2.80 per watt if the solar panel provides electricity that goes straight to tenants. Track two provides rebates to cover up to the entire cost of the solar panels. Projects that bureaucrats consider to have the greatest upside and community impacts are selected through the more generous track two (State of California Public Utilities Commission 2015).

These tracks make residential solar production accessible to low income communities and those who live in multifamily sites like apartment buildings. As a result more Californians have access to solar electricity and the positive externalities that it provides (U.S. Department of Energy 2014). This allows the state to increase its pool of potential consumers by granting support to lower income communities. By enabling lower income communities to afford solar panels, the State of California has managed to increase its demand pool and quantity demanded.

Finally, unlike their counterparts in Oklahoma, the state government offers crucial real estate tax breaks when consumers purchase a rooftop unit. As a result, even though rooftop panels increase the value of a property, panel owners do not have to pay more in property taxes (U.S. Department of Energy 2014). Given these numerous and generous programs, in conjunction with non-policy factors, it is not surprising that residential solar in California has thrived in recent years.

California's aggressive and accommodating policies stand in stark contrast to Oklahoma. While Oklahoma's policy decisions have squandered its solar potential thus far, California has capitalized on its potential through aggressive policymaking- particularly net metering, feed in tariffs, and property tax breaks. Furthermore, California has managed to increase its demand pool beyond that of traditional solar incentives by reaching out to lower income communities. As a result, it will continue to demonstrate impressive rooftop solar growth. The success of these policies allow for the formation of a number of potential recommendations

New Jersey

New Jersey stands out because of its relatively aggressive policies and rapid growth in residential solar. The policies of New Jersey have engendered impressive solar panel adoption. In 2014, 60 MW of solar rooftop electricity capacity was installed in New Jersey (SEIA 2015).

The majority of non-policy factors favor residential solar in New Jersey, with one glaring exception. Due to its relatively low amount of sunlight, the rooftop solar capacity for New Jersey was calculated by the National Renewable Energy Laboratory to be approximately 16,000 GWhs –versus 106,000 in California and 12,000 in Oklahoma (2012). The state's modest sunlight exposure must be taken into account when weighing the efficacy of its policy incentives.

The State of New Jersey has a number of factors that support residential solar energy. They include New Jersey’s a relatively large population. Further, the citizens of New Jersey make a much higher median income than most states. The median household income in New Jersey is approximately $ 65,000 per year-even higher than that of California (Census Bureau 2014). As a result, the New Jersey’s inhabitants have a greater income with which to purchase rooftop panels.

While New Jersey gets less sun than some states, the population of nearly 9 million (Census Bureau 2014) means that there is no shortage of rooftops for photovoltaic units. The inhabitants of New Jersey are also notably environmentally aware and concerned. This is reflected by voting patterns and preferences (FEC 2012). This focus on environmental issues indicates that New Jersey’s consumers are environmentally aware and, as consumers, more likely to be motivated by environmental concerns than their counterparts in Oklahoma.

New Jersey also features a very high cost of utility-based electricity, at over 15.50 cents/kwh-compared to 10.74 cents/kwh in Oklahoma and 13.32 cents/kwh in California. (Energy Information Agency 2014). These elevated electricity prices create an incentive for electricity customers in New Jersey to switch to rooftop solar.

The state of New Jersey has managed to overcome its middling solar capacity to be one of the leaders in part due to its aggressive policies. New Jersey has an impressive array of policy tools designed to encourage solar adoption. This state employs a net metering program that connects users to the grid. This program analyzes consumers’ net solar production on a monthly basis, like Oklahoma, but allows net excess production to carry over from month to month (as long as it is within the same calendar year). This incentive is especially beneficial considering the rooftop production differentials between winter and summer. By allowing customers to carry over summer excess production to slower winter months, the negative financial impact of fewer sunlight hours during the winter is diminished (State of New Jersey 2015).

In addition, New Jersey uses an SREC Solar Renewable Energy Certificates program that operates like a feed in tariff. Utility companies are required to have 4% of their portfolio from in state solar installations by 2028. The state audits utility companies and determines their progress for this requirement based upon the number of Renewable Energy Certificates that the utility firms possess. Utility firms are only able to gain these certificates by purchasing solar electricity from grid-connected providers. As a result of this government-mandated demand for clean energy, utility companies are compelled to pay a premium (determined by market competition) for solar electricity (U.S. Department of Energy 2014). This market based approach allows consumers to recoup the up front cost of the panel more quickly and increases the financial incentive for consumers to purchase panels.

Furthermore, the State of New Jersey offers loan subsidies to consumers in order to facilitate the purchasing of solar panels (U.S. Department of Energy 2014). In doing so, more citizens are able to pay the often-intimidating upfront cost of residential solar panels. New Jersey also offers both property and sales tax exemptions to lower panel costs. As a result, homeowners in New Jersey are not be taxed extra for purchasing a panel (U.S. Department of Energy 2014). While these policies may seem minor, they effectively remove two of the largest obstacles to solar panel purchases-up front costs and increased taxes.

By implementing these policies, New Jersey has created a number of changes that make the state very friendly to rooftop solar. Citizens have access to financing, net metering to shorten the payback period, and smart tax policy to prevent an accompanying rise in taxation. As a result, New Jersey's inhabitants have affordable access to residential solar energy and the positive externalities that come with it.

Florida

Florida's policies produced a much more complex and mixed result than Oklahoma, California, or New Jersey. In, residential solar in the state installed approximately 10 MW of electrical capacity (SEIA 2015). In order to understand the implications, various factors that influence solar panel demand must be considered-particularly solar technical potential. The following factors explain why this state has neither triumphed nor explicitly failed to stimulate residential solar energy adoption.

Florida has a high average solar potential. The National Renewable Energy Laboratory gave the state a rooftop capacity of over 63,000 GWhs (2012). As a result, it benefits from an innate advantage over states like New Jersey when it comes to producing residential solar electricity. Florida's failure to match New Jersey, despite having greater potential, stems from a number of demand factors.

While boasting a much larger population than New Jersey with nearly 20 million inhabitants (U.S. Census Bureau 2014), Florida lacks New Jersey's decisively pro environmental policies. Candidates who run for office with pro environmental ideology underperform compared to those who remain skeptical of the need for environmental action (FEC 2012). Residential solar in the state is also undermined by its citizens' relatively low income. The median income for a Floridian family is approximately $47,000 per year (U.S. Census Bureau 2014). As a result, families in Florida have fewer financial resources through which to purchase solar panels than their counterparts in New Jersey. Finally, there is less of an incentive to purchase solar panels in Florida because electricity prices are substantially lower (at 11.99 cents/kwh) than in many states. This low cost of electricity (compared to California and New Jersey) makes residents hesitant to switch from their utility providers.

The State of Florida has attempted to overcome these non-policy obstacles by implementing several impressive incentives. The first of which is a statewide net metering program to encourage residential solar panel adoption. This policy has been designed very generously. Floridian utility companies are compelled to carry over net excess solar production from month to month for up to 12 months (like the policy in New Jersey). Unlike New Jersey, however, the Floridian plan requires that, at the end of the year, utility companies pay providers of residential solar electricity the balance if they produced more than they consumed. Thanks to this very generous plan, owners of rooftop panels did not have a ceiling on their potential earning from solar and could repay the upfront cost much more quickly. However, this policy limits the amount of citizens who can utilize it by only applying it to units with a capacity of less than 2 MWs (U.S. Department of Energy 2014). As a result, the amount of electricity that utilities have to buy is capped and this narrow incentive is unable to encourage significant demand.

The state once offered a rebate of two dollars per kilowatt of output (up to $20,000) for consumers who purchase solar photovoltaic panels. But, this generous policy has run out of funds (Florida Department of Power and Lighting 2015). When operating, however, this rebate dramatically shifted the cost-benefit equation for solar panels in favor of consumers and, in doing so, stimulates demand.

Furthermore, the State of Florida provides property and sales tax exemptions to incentivize solar panel purchases (U.S. Department of Energy 2014). As a result, customers are not taxed extra when they purchase solar panels. This removes a major disincentive from the decision to purchase solar panels and further increases demand for rooftop panels. This makes Florida's policy environment more hospitable to solar panel consumers than states like Oklahoma.

Finally, the state has provided subsidized loans for would-be consumers unable to pay the up front cost for solar panels. In doing so, the state provides more citizens with the opportunity to purchase solar panels. At this point, however, they are not uniform in every community and are provided by utilities and counties, rather than a statewide policy. As a result, their availability, and usage, varies significantly across the state (U.S. Department of Energy 2015). Given the separation of municipal and state governments, discrepancies like this are unavoidable. The implementation of policy, even at the sub-state level, proves useful in analyzing case. The utilization of loan subsidies here is very interesting and will be discussed in greater detail in the following chapters.

Despite Florida's incentives, the state has failed to implement a feed in tariff to further incentivize solar panel adoption (U.S. Department of Energy 2014). As pointed out earlier in the thesis, solar power requires a substantial up front cost and provides a clear public good. Given the positive impact that solar panel usage has on the economy and the environment, states should shorten the payback period by using a feed in tariff (preferably one with a higher than market rate). Florida's failure to utilize a feed in tariff robs its consumers of an appealing incentive that rewards clean energy production and allows buyers to repay the upfront cost much more quickly

In summation, Florida has failed to come close to meeting its vast solar potential. Despite having a flexible net metering program, the state is weakened by a number of policy caveats, such as the capacity cap on net metering and the funding problems for rebates. Furthermore, the solar in the state is undermined by Florida's lower income and the lack of environmental consensus on the part of its inhabitants. Despite these obstacles, Florida's solar potential isn't going anywhere. If the net metering and funding issues were resolved, and the state implemented a feed in tariff, the residential solar industry in the state can make drastic strides towards its lofty potential.

The various policy approaches of the four case studies are included in the preceding graphic. In addition, the chart lists the total electricity generation and total rooftop solar electricity production. This particular metric can be utilized to determine how much of each state's electricity is produced by solar-a useful metric when evaluating the efficacy of different policy approaches. Finally, the states' populations and electricity rates are given so that they can be accounted for in the analysis.

Having evaluated these four very different states, and their policy approach to rooftop solar panels, this paper will next make a number of policy recommendations.

These recommendations will be based upon the successes and failures of each state-as well as the relevant variables identified in chapter two. While New Jersey and California implemented innovative ways to make solar panels cheaper, Oklahoma and Florida implemented half measured net metering and saw their rooftop solar capacity fall behind. Oklahoma further contributed to its stagnated solar industry by imposing increased property taxes on solar panel owners. These varying policy approaches represent excellent lessons on how to encourage panel growth and, in some cases, how to prevent rooftop solar from taking off.

Chapter Four:

Policy Recommendations

The severity of climate change necessitates drastic and immediate change in electricity sourcing. Fortunately, this thesis provides a blueprint for states to engender substantial growth in rooftop solar panel capacity and (in doing so) reduce their reliance on fossil fuels. The exploration of underlying economic theory, identification of shift factors, and examination of relevant case studies has yielded key insight into policy tools. The purpose of this final chapter is to provide specific policy recommendations based upon case studies and the variables outlined in chapter two. These policy recommendations will be presented in order of their importance.

Unsurprisingly, the most basic policy change to stimulate rooftop panel growth is the elimination of active rooftop solar disincentives. It is crucial that goods with positive externalities not be discouraged by additional taxes. One unintentional example of this concerns property taxes. As pointed out in chapter 2, the addition of solar panels to a home increases its valuation. Unfortunately, this results in higher annual property taxes for consumers of solar panels, which increases the real cost of the panel and discourages potential buyers. The same can be said of the failure to create sales tax exemptions. Given the high up front cost of panels, the sales tax implications can be significant. By implementing an exemption, policymakers can remove yet another obstacle for potential buyers.

The importance of property and sales tax breaks can be clearly seen based upon the results in the four states. Of these four states, New Jersey, California and Florida have all seen notable growth in solar. Meanwhile, Oklahoma has failed to capitalize on its substantial annual sunlight. While a number of factors surely contribute to this, it is easy to identify the perverse disincentive created by imposing taxes on solar panel owners. States wishing to encourage solar panels should grant property and sales tax exemptions and avoid charging consumers extra for purchasing a positive good. States that fail to do so, like Oklahoma, will continue to see their residential solar development stagnate.

In addition to addressing taxes on solar, policymakers must eliminate subsidies offered to fossil fuel competitors in order to provide new technologies with a fighting chance. As pointed out in chapter one, these subsidies encourage the use of fossil fuels by lowering prices (which, due to externality costs imposed on communities instead of users, are already artificially low). Fossil fuel based utility companies function as competitors for rooftop panels. As a result, low utility prices, particularly those made artificially low through subsidies, represent an impediment to the growth of solar-they discourage the purchase of solar panels and the adoption of other clean energy investments. Furthermore, they use up resources that could be used to fund the solar incentives outlined in this chapter. These outdated and unsustainable subsidies must be eliminated.

Ensuring that the policies do not discourage or disadvantage rooftop panels is vital to this industry's success. Having said this, policymakers must not rest on their laurels after simply eliminating obstacles. The implementation of a net metering program unlocks crucial economic efficiencies and financial gains for panel owners-particularly given the lack of storage technology for solar referenced in chapter two. Consequently, the state must ensure that homeowners have <u>free</u> access to grid connectivity. Any attempts by the state to tax or undermine net metering substantially reduces consumer demand and delays the growth of residential solar energy.

There are a number of nuances concerning net metering that are key to developing rooftop solar electricity. By taking the best of each plan, states can implement a much more effective measure. This thesis has identified the most effective incentives based on various policy approaches by different states. For example, Florida's policy of paying the balance to consumers if they produce more than they use is very appealing to consumers. Meanwhile, states with low caps on capacity for net metering, like Florida, can increase demand by raising the caps to include larger residential installations. By eliminating these caps on earnings (based on panel size or electricity production), states can drastically increase the number of installations as well as the size of future installations. The recommendation of this thesis is to combine these two adjustments into one generous and fair net metering program. States should allow all residential units to utilize net metering (regardless of installation size) and utilize Florida's approach of paying households the balance when they produce more than they consume.

Grid connectivity is very useful for homeowners, but the price of the exchange of electricity between panel owners and the grid can be used to create even stronger incentives for panel growth. This powerful financial incentive was first identified in chapter two as a potential shift factor. Based upon the distributed solar growth in California and New Jersey, the implementation of solar feed in tariffs is a common denominator for success. This useful policy instrument insures that providers of solar electricity are compensated for their higher cost and positive environmental externalities.

In fact, the implementation of a statewide feed in tariff is the only policy factor that separates New Jersey's success from Florida's mixed performance. This is unsurprising given that implementing the feed in tariff increases the marginal private benefit of rooftop panels-which then increases quantity demanded (This precise effect is illustrated in the final chart of chapter one). As a result of these considerations, this thesis strongly recommends implementing a feed in tariff system and that the tariff be set significantly above market electricity rates. In doing so, policymakers will increase the financial feasibility of rooftop panels, decrease the payback period, and spur demand.

It is also important to note that feed in tariffs can be accomplished in one of two ways. They can be imposed at a given price statewide (like in California) or set using market factors when the state mandates that utility firms demand a certain percentage. Both approaches have their benefits and detractors. The California model is more certain, but this also makes it more rigid. While the New Jersey market based approach is more flexible, it also harder to predict the ensuing premium that it will create. This thesis suggests no particular preference given the success that both states have experienced. The important thing is that a feed in tariff is implemented-not what structure the policy utilizes.

While solar panel installation is on the rise, it remains a good that only the financially secure can afford. As a result, a large percentage of potential consumers are unable to install panels. Innovative states like California have managed to address this issue by making panels affordable for low-income residents. California's (Single Family Affordable Housing) and MASH (Multiple Family Affordable Housing) programs provide excellent examples of successful initiatives that expand demand for residential solar panels. These programs provide financial incentives to low income families wishing to purchase rooftop solar units. In doing so, the State of California has effectively enlarged the group of potential consumers to include individuals who would otherwise be unable to afford panels. By adopting this approach, other states can dramatically increase the number of residents who can afford panels and, in doing so, increase the total installation of residential solar panel units.

Another policy that should be available in every state is a simple rebate. Despite being much more appealing to consumers than loan subsidies (Zhao et al. 2012), this program is only offered in a few select states, including Florida. By enacting direct rebates, states aggressively lower the substantial up front cost for consumers in a way that is clear and easy to understand. However, the efficacy of these programs diminish significantly when they run out of funding-as Floridians have not doubt discovered. While it is extremely important to implement incentive programs, they fail to stimulate growth if they are not appropriately funded.

Carbon taxes can also be used as a policy tool to address this issue-and as a source of funding for many of the aforementioned initiatives. Carbon taxes increase the cost of fossil fuel based utility competitors and provide revenue that states can use to fund rebates, feed in tariffs, and other incentives. In doing so, they function as a Pigovian tax to discourage negative externalities. Cap and trade programs function in a similar capacity by attaching a cost to carbon pollution in the form of mandatory tradable permits (Goodstein 2010). Thus far, cap and trade programs have been implemented at the state level (California) and the regional level-Northeast United States (EIA 2015). Like eliminating fossil fuel subsidies, following this recommendation would provide states with resources to fund the aforementioned solar incentives.

The final influential factor appears in the form of income. States with higher median incomes, like California and New Jersey, showed a much higher rate of panel installation than their less wealthy counterparts in Oklahoma and Florida. As a result, it is clear that income has a clear impact on the purchasing of solar panels. The recommendation of this thesis is for states to push up median income through progressive tax cuts for the middle class and higher minimum wage policies. Both of these initiatives will increase disposable income and ensure that more consumers have the financial means to purchase rooftop solar panels.

The absence of government loan subsidies from these policy recommendations may initially appear surprising. When making policy, it is important to take behavioral economics into account. Some policies that are deemed appealing by policymakers will not have the same appeal for most consumers. The success of residential solar in California, despite the absence of loan subsidies (U.S. Department of Energy 2014), and residential solar's mixed showing in Florida, where loan subsidy programs are utilized aggressively at the local level (U.S. Department of Energy 2014), lends support to the growing notion that loan subsidies do not widely appeal to would-be buyers.

Economists polled consumers in Florida in order to determine the impact that subsidized loans have on compelling demand for green products (including solar panels). In doing so, they found that less than one in five potential consumers were interested in this benefit (Zhao et al. 2012). Based upon the survey responses and the results from state programs, it can be concluded that, while not deleterious, subsidized loans do not attract most consumers to a product or notably increase its demand. In short, subsidized loans do not attract a broad base of potential customers for solar energy. Based upon the case studies, consumers would prefer lower prices from rebates or policies that shorten payback periods (like net metering and feed in tariffs). While loan subsidies do not necessarily harm the solar industry, it should not receive funding over programs that better entice consumers. As a result, the policy recommendation of this thesis is for states to allocate resources into alternative incentives that better stimulate demand.

These policy recommendations come at an urgent time given our changing climate and growing health concerns regarding pollution. As a result, they require immediate implementation. While some will have a more direct impact on rooftop solar demand than others, they all allow policymakers to utilize relevant variables as mechanisms to engender much needed energy policy overhaul. By implementing these incentives, states will create a much more hospitable environment for rooftop solar panel consumers and create an ideal environment for distributed solar growth. Furthermore, the successful implementation of these policies at the state level provides federal policymakers with a blueprint that can be adopted for national implementation with relative ease.

Chapter 5

Conclusion

The threat imposed by anthropogenic climate change necessitates immediate and significant changes to our way of life. While the requisite changes are broad and must encompass a wide array of necessary changes, this thesis addresses on one specific, but crucial, aspect-the source of our electricity. Our current electricity needs are largely fulfilled by the combustion of fossil fuels. This method's sizeable negative externalities, including its contribution to anthropogenic climate change, make it untenable in the long run. As a result, the growth of clean alternatives must be expedited.

Unfortunately, there remains a significant pricing gap between solar energy and its fossil fuel competitors. The judicious and aggressive use of incentives, however, can stimulate significant growth in this industry. This thesis identifies the shift variables that can be used to stimulate solar demand in chapter two. In chapter three, the reader was presented with case studies of state policies that utilized these variables to stimulate rooftop panel demand. The varying approaches employed in Oklahoma, California, New Jersey and Florida allow for the formation of key recommendations regarding how to best stimulate solar panel growth.

Based upon the aforementioned shift factors and case studies, a series of recommendations have been identified. In order to incentivize solar, states must firstly ensure that panel owners are not penalized with taxes or fees. Furthermore, panel owners should have free access to the electricity grid to sell unused electricity-without caps on compensation form production. Feed in tariffs and rebates both improve the cost effectiveness of solar panels and encourage panel ownership.

In addition to these well-publicized policy approaches, more unique approaches can be used to stimulate consumption. For instance, particularly generous versions of the aforementioned incentives should be offered to low income communities in order to broaden the demand pool. Policymakers should also eliminate subsidies for fossil fuels and impose costs on these polluting firms (in the form of carbon taxes or cap and trade programs). This will force them to internalize their negative externalities and make solar more competitive. This thesis also recommends implementing more progressive tax systems and a higher minimum wage. This would enable a greater proportion of the population to afford to purchase panels.

Given the polarized political climate, it may be difficult for many states to implement this "solar wish list." The current national gridlock, however, necessitates aggressive action at the state level. States that are able to rise to this challenge will be able to replicate California and New Jersey's success and capitalize on their own energy production potential. In doing so, they will be able to utilize the shift factors and policy recommendations that this thesis provides to build a strong residential solar industry, diversify their energy portfolios, reduce their contribution to anthropogenic climate change, and improve the overall health of their citizens.

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