The Sociopolitical Influence on the Rise of Solar Technology in California

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Colin Patton

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Sean M. Ferguson, Department of Engineering and Society

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Introduction

As the threat of global warming has continued to rise over the past half century, countries are left searching for ways to transition to renewable energy sources. The burning of fossil fuels has consistently been considered the conventional method for energy production, but along with this process comes harmful byproducts, commonly known as greenhouse gasses, that are attributed to the causation and recent acceleration of climate change. These greenhouse gasses have depleted the Earth's ozone layer leading to an increase in global temperatures, rising sea levels and severe natural disasters (Rosen, 2019). A shift towards renewable energy technology is in the process in order to mitigate the effects of burning fossil fuels and production of greenhouse gasses. Solar, wind, hydroelectric, and geothermal energy are among the most promising alternative energy sources. In the United States, renewable energy generation currently accounts for 17% of total energy production, but only 0.5% of the renewable energy being from solar production (Aslani & Wong, 2014). In the United States, California is currently the leader in solar technology with 5% of the state's total energy production coming from solar, and the goal of zero-carbon electricity production by 2045 (U.S. Energy Information Administration, n.d.). This push for solar technology adoption has been led by early involvement in state renewable energy incentives along with public awareness and support.

With multiple factors and dimensions to consider, it can be difficult to trace the outcome of public policy. The relationship between the societal adoption of renewable energy sources, such as solar technology, with the government incentives that are put in place is not fully understood. Many states offer similar opportunities for green technology as California, but have contributed minimal amounts to the push for renewable energy in the United States (Sarzynski et

al., 2012). An analyzation into the factors around renewable energy and new technology is required to determine the effectivity of state initiatives and answer the question: what sociopolitical variables in California have contributed to its frontrunning position in solar technology implementation?

With the growing threat of climate change and global warming as a result of greenhouse gasses, it is important to track and identify the opportunities for renewable energy expansion. To do so, an analysis of how California's green initiatives were effective based the social and political views of the state over time. Without a plan to identify and correctly incentivize the public, renewable energy will struggle to combat the use and production of fossil fuels and greenhouse gasses. Using a multi-level perspective approach, this research paper will delve into California's green initiatives for solar technology adoption and how the sociopolitical factors together transformed solar technology in California from its niche formation to a cemented part of the state's sociotechnical landscape.

Background

A combination of public awareness for greenhouse gasses, concerns over energy supply, fossil fuel price fluctuations, and the rising threat of climate change demanded a response from policy makers as to how the country as a whole could diversify in favor of renewable energy. With only 4.5% of the world's population, the United States consumes 19.2% of the world's energy, with renewable energy responsible for a mere 5.8% of that as of 2009 (Aslani & Wong, 2014). Solar energy only accounts for a small fraction of renewable energy generated in the United States, but has the highest potential from growth through residential applications with an expected 11.7% year over year growth average through 2030 (Aslani & Wong, 2014). Solar technology has emerged at the center of public policy with regards to incentives for green

technology to encourage public involvement. These policy incentives come in different forms, most commonly: tax breaks, tax exemptions, loans, rebates, and funding (Sarzynski et al., 2012). With the initial startup costs of solar technology, these initiatives have been targeted at breaking down this barrier to entry. The specifics of the available renewable energy incentives are decided at the state level, which has created various combinations and rates for initiatives by each state. This variance in state public policy has added to the complexity of analyzing how effective each states policy is, as well as the other factors that may contribute to upticks in renewable technology deployment. California became one of the first states to utilize these incentives in attempt to crowdsource solar energy development from the public through tax breaks, tax exemptions, loans, rebates, and specific funding (Sarzynski et al., 2012). This is all in hopes of a decrease in reliance of energy imports, a creation of jobs, and the development of the renewable energy industry while achieving a clean and sustainable society.

Literature Review

Early Development of State Initiatives and Climate Change Awareness

In 1978, Congress passed the Public Utility Regulatory Policy Act that "established the right for independent power producers to interconnect with the local utility distribution system" (Go Solar California, n.d.). This law made it possible to begin to pursue larger applications of photovoltaic and other solar energy production systems. As part of the contingencies for these systems, federal legislation required a cost rate to be paid to the avoided cost of traditional grid power. This hindered any attempts to create solar energy systems for small scale residential areas, but proved to open up doors for larger scale investigations into the power of solar technology. As a response to an emerging oil crisis from tensions with Iran, Congress passed the Energy Tax Act of 1978 (Go Solar California, n.d.). This was aim specifically towards

homeowner's involvement in renewable energy, offering tax credits for solar and wind technology. This tax credit of up to $2,000 on solar installations for homeowners was in place for only nine years, as it was eventually appealed by the Regan administration that claimed it was in the best interest of the government to "leave energy conservation and renewable energy decisions up to market conditions" (Go Solar California, n.d.). This halted the federal incentives for solar technology, but lasted long enough to jump-start the development of the renewable energy sector and transition the technology from a niche to a regime, particularly in California.

Compelled by the federal incentives for large scale applications of renewable technology, construction of two of the world's largest solar facilities began, both in California. The ARCO Solar manufacturing facility development began in 1979 in Camarillo, California, with the goal of producing more than 1 megawatt of photovoltaic modules per year. By year four, ARCO Solar had created a 6-megawatt photovoltaic facility that was capable of powering 2,500 homes (Go Solar California, n.d.). With this success, three other major solar facilities emerged in California over the next decade: Solar One, the first large scale thermal solar power plant; Sacramento Municipal Utility District, a 1-megawatt photovoltaic power plant; LUZ Solar Energy Generating Stations, the world's largest solar thermal facility (Go Solar California, n.d.). By the end of the 1980's, California had taken advantage of the federal incentives, planting itself as the leader in the then niche market of solar energy production and advancement.

Beginning in the 1980's, the public perception of global warming moved from a nonexistent threat, to a serious issue for political debate. United States public awareness of greenhouse gasses as a 'very serious' threat to our ecosystem jumped from 12% to 39% by the end of the 1980s. This came as a result of a string of severe weather in 1988, and James Hansen's public testimony before Congress that global warming had begun. Over the years, this

public perception of global warming has increased to approximately 50%, but has constantly wavered at the expense of cooler summers (Bord et al., 1998). Through a series of survey's and analysis by Richard Bord, the research concluded that the United States public displayed environmental awareness and concern, had a somewhat flawed understanding of what global warming entails, all while expressing a willingness to pay and sacrifice for environmental goals (1998). This aligns with what is seen through the development and expansion into residential involvement with solar technology within California.

As the nation became aware of the growing threat of climate change, California citizens received a warning from the California Energy Commission in a report on greenhouse gasses in 1989. Residents were made aware of the droughts, floods, fires, and heatwaves that would appear as a result of the continued use of fossil fuels for energy production (Rosen, 2019). This report, well ahead of its time, outlined specifics about carbon dioxide in the atmosphere and how it would impact ecosystems, farmers, power production, sea levels, air quality, and more. This report brought public awareness to the issue within the state and led to the first greenhouse gas emissions and climate policy recommendations in 1991 (Rosen, 2019). As if these climate change models were not enough to convince the public, a series of alarming signs through earthquakes and wildfires made it a reality for California residents. Kari Smith, resident and division manager at the San Jose Clean Energy department, states that the majority of what the report outlined came to life, "Now, 30 years later, we're recognizing that it all happened a lot more quickly than we anticipated" (Rosen, 2019). This early on mentality of social awareness and concern for climate change in California allowed for these publicly backed green initiatives to develop through elected officials over the coming years.

California's Public Support for Renewable Energy

In 1996, the shift from large scale solar facilities to residential scale grid-tied solar systems began. Under the California Energy Commission's Renewable Energy Program, the first incentives were established for grid-tied solar systems to be used as rooftop systems for homeowners' electrical usage. With the public awareness of the growing reputation for solar technology in California but previously no way to get involved, the new program aimed at utilizing public support to develop a self-sustaining market for solar technology by cutting down the initial cost of the system through rebates. In the following decade, this program was responsible for installing over 150 megawatts of electricity (Go Solar California, n.d.). However, with the attractive program incentives and extraordinary public support for green energy, the cash rebate incentives were compiling onto the state's budget crisis, thus bringing an end to the program. With the downfall in rebate incentives in California, the state legislature restructured the solar technology incentives as less attractive tax credits and loan guarantees through the Renewable Energy Program (Go Solar California, n.d.).

During this decade, researchers Sarzynski, Larrieu, and Shrimali attempted to provide an empirical framework for analyzing the efficiency of state financial incentives within the solar technology industry in order to determine the public policy that drives renewable technology growth. The framework centered around four different state incentive types: income tax incentives, cash incentives, sales tax incentives, and property tax incentives. On the surface, the regression results showed that states offering cash incentives such as rebates and grants experienced more extensive and stronger deployment of solar technology than states without. Along with this, states offering tax incentives did not experience systematically stronger solar technology deployment (Sarzynski et al., 2012). While the analytical framework yielded results that aligned with the expected trends of incentives and solar technology implementation, there

were still gaps in the predicted and actual values especially with where California fell in regards to the switch to tax credits at the beginning of the decade. This extreme outlier presented a flaw in the analysis of strictly quantitative variables when assessing the impact of public policy incentives. Sarzynski concludes with:

> "What is less understood is how the entire suite of financial incentives may encourage solar energy usage… The complexities of these new policy tools are not reflected in the present analysis but highlight the need for continued evaluation and analysis of state-level policy innovation moving forward" (Sarzynski et al., 2012, p. 556).

This reflection forced policy makers to look outward for the reasons and explanations as to why California, with its existent yet diminishing incentives, had become the frontrunner in solar technology. With similar incentives and opportunities for solar technology deployment across the United States, the social factors, coinciding with the political movements, were realized to be attributed to what was helping place California ahead in the public adoption of solar technology and its integration as a sociotechnical regime.

Solar Technology's Self Dependence from State Initiatives

Since 2011, California has been a predominantly democratic state. The executive offices, board of equalization, state legislature, United States Congress, and electoral college votes all leaned blue for the state. In recent years the partisanships have begun to divide over policies on climate change, and has not shown signs of stopping. Blue states have set laws to eliminate greenhouse gasses by certain deadlines to place a state emphasis around clean and renewable energy. At the same time, the current presidential administration has loosened restrictions on fossil fuel and greenhouse gas emissions, further dividing red and blue states (Plumer, 2019). In

the midst of this political divide, California became the first state to pass a Clean Energy Standards policy, setting the goal of achieving 100% zero-carbon electricity by 2045 (U.S. Energy Information Administration, n.d.). The focus of the Clean Energy Standards policy is to bring clean energy resources to market. With California's established solar technology, the enacted bill has ensured their intent to hold the position in the future, despite weakening green incentive programs.

During this time period, California did not concede from its position as the state leader in solar technology deployment, but rather further implanted solar technology and renewable energy into the sociotechnical landscape of the state. The continued support for renewable energy was backed by a new wave of renewable technology and zero-carbon goals set for the state. With the emergence of California based electric car manufacturer Tesla, the state saw an increase in unsubsidized solar technology for electrical usage (Partain & Frass, 2015). California has led the electric vehicle deployment with nearly half of all United States electric vehicle sales occurring within the state (Partain & Frass, 2015). This rise of electric vehicles and emerging renewable energy alternatives followed a similar trend as solar technology, again backed by the public interest and a new understanding of renewable technology's integration into the sociotechnical landscape of the state. As solar electrical technology installation costs have exponentially decreased, it has developed into a complementary good for many electric vehicle owners (Partain & Frass, 2015). This relationship displays the clear public backing for renewable technological development in California and how solar technology continued to thrive, supported within the sociotechnical landscape, independent from the attractive government incentives.

Discussion

Summary of Findings

Through the analysis of these three different time periods in California, the sociopolitical factors that placed California as the frontrunning in solar technology deployment have surfaced. This study of California's state initiatives policy and public perception of climate change explains the contributing factors to the rapid advancement of the technology from its niche formation to its vast implementation within the state. At the start, California public awareness and acknowledgement for climate change and renewable energy alternatives led to a niche formation of solar technology development within the state. As time progressed, the state became the first to offer initiatives for renewable energy technology at the residential level, combatting the barrier of high startup costs through tax breaks, tax exemptions, loans, rebates, and specific funding. Homeowners concerned with climate change, as well as those simply looking to save money through renewable energy sources, were now able to deploy their own solar technology systems for personal use. Due to the large public involvement in the movement during this era, the state's funding for renewable energy incentives dried up and were cut to less attractive levels. Against expectations, the solar technology market in California did not relinquish in part to the rapid technological development of renewable energy companies, such as Tesla, that introduced new uses and more affordable systems for solar technology to the public that created a cultivating sociotechnical landscape for solar technology to thrive.

Takeaways and Insight for Policymakers

The breakdown of the political standing of California's legislature coinciding with the social movements over this time period brings to light the relationship between the sociopolitical factors influence on technology. California's early involvement with solar technology through the use of policy and public awareness can provide insight for future policymakers. This case study shows how early involvement and public support for a technological agenda can maximize

the effectivity of political movements and initiatives, especially in regards to emerging renewable energy sources that will continue to arise with the movement against climate change. With this, the public backing can turn a technological niche into a self-sustaining technological regime built upon the foundation from the work accomplished as a result of the political push. This result seen here should be considered by policymakers in the future when thinking about policies to support emerging technological developments, in terms of both when and where they should take action, especially with the push for renewable energy to combat greenhouse gasses.

Preceding and Future Work

Ornetzeder and Rohracher's (2013) previous study into similar examples of grassroots innovations resulting in sociotechnical regimes helps validate the takeaways presented, as they conclude their own findings with:

> "The aim is a better understanding of the preconditions, patterns of growth and change and factors of success of grassroots innovations for more sustainable sociotechnical regimes such as energy and transport. In the analysis we focus on dimensions such as the structural conditions and resources of origin, motivations of social actors involved, learning processes and outcomes, competences and activities of those actors, processes of institution-building, and the relationships to mainstream market actors" (p. 856).

This discussion on technology rising from a niche to a technological landscape provides a structure similar to that which California's rise in solar technology has shown. With their basis on the social and cultural actants influence on technology and compiling it with California's political involvement, the multitude of dimensions and relationships in the system of new technology reliance is indisputable. As new technological innovations surface in the future, the

stakeholders and policymakers involved must use these dependent relationships to their advantage in the acceleration of the deployment process as well as the self-sustainability down the road.

As each scenario regarding new technology in the future will be different in one way or another, there is still work to be done in understanding the direct impact and magnitude of different sociopolitical factors. For California, the direct sociopolitical influences were identifiable after the technological regime was established, but were often overlooked at the time of occurrence. A future analysis and framework creation for early stage identification of beneficial sociopolitical environments for niche technology would allow for more prosperous implementations. In coordination with this, further quantitative studies could be done to evaluate the strength of these relationships between political, social, and technological factors to determine where focus and emphasis should be placed by policymakers.

As discussed, this analysis and any future scholarly studies can help us understand how to support the deployment of new technology through social and political influence. This knowledge will be especially crucial to the strides that are currently being made, and that will be made, to combat climate change. As the threat of global warming from greenhouse gasses continues to rise, an accelerated transition to renewable green energy will be required in order to maximize the sustainability of the planet. Through the use of the previously described sociopolitical factor analysis, this movement can be most effectively supported and achieved.

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