Reshaping Incentivization: An Examination of California’s Gas Powered Vehicle Ban

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Introduction:

Equity or efficiency? Both are noble goals, but how do you choose between them? And should you have to choose? Advocating for efficiency means solving the most pressing problem as quickly as possible while reaching a large number of people; however, that is not an equitable solution as those hurt the most by the problem should receive greater attention and aid. In order to predict how regulators will handle this equity or efficiency dilemma in emerging green technology markets, this paper aims to study the decision of California regulators' to ban the sale of new gas-powered vehicles (GPVs), also referred to as internal combustion engine vehicles (ICEVs), by 2035. More specifically, this paper will study the use of existing market creation incentivization policies to understand how the ban and the likely connected policies will affect disadvantaged communities (DACs) to see if equity, efficiency, or both have been prioritized.

California is a unique case study within the United States because its stature and market power, as demonstrated in statistics such as population and gross domestic product (GDP), makes it difficult to perform a comparative analysis with other states. It is the most populous state in the nation with 39.5 million people and is ahead of second-place Texas by roughly ten million people (America Counts). In 2020, California had a Real GDP of $2.67 trillion, which again dwarfs the second-place state of Texas, with a Real GDP of $1.75 trillion, by nearly a trillion dollars (BEA: GDP Summary). Due to California's size, policies enacted by the state have the ability to impact and influence markets and policy decisions outside of California's borders and jurisdiction; David Vogel named this phenomenon as "The California Effect." As such, it is important to study the potential impacts of major policy decisions within California as they could have national and global effects.

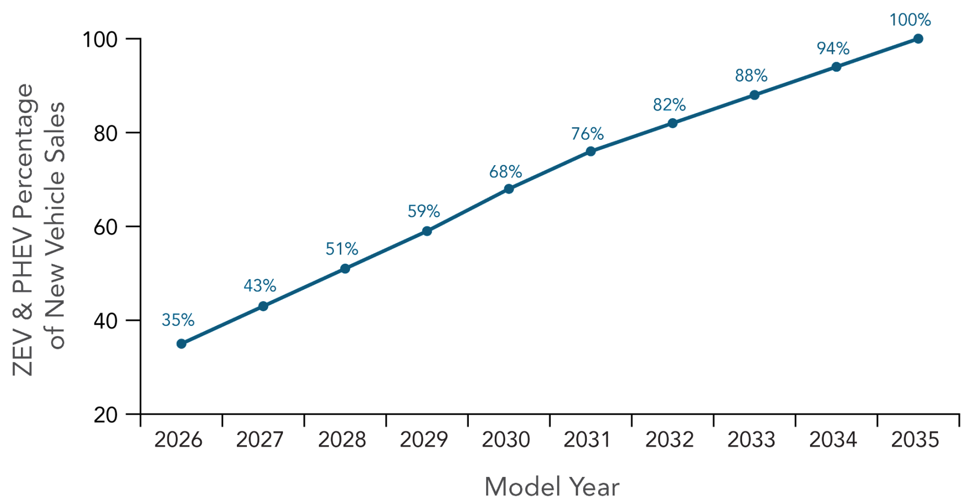
California’s decision to ban the sale of new GPVs, and the likely policies that will occur before 2035 supporting the new alternative markets, has the potential to change car manufacturing globally, so it is necessary to understand how this decision impacts Californians directly before it gets scaled beyond control. Since the markets for both hydrogen and electric vehicles are relatively new, it is also necessary to understand if historic and current policy initiatives regarding the early adoption of other green technology have been sufficient in solving externality problems efficiently and equitably. DACs–the communities suffering the most from the emission externality created by GPVs because they have higher exposure rates to pollutants and have lower socioeconomic status (Canepa)–should be at the center of any equity minded evaluation of how this policy will impact Californians. Ultimately, the goal of this study is to determine if there already is an effective solution to solving the problem of externalities created by GPVs that considers and addresses both efficiency and equity. If not, my goal is then to propose an alternative policy solution that is both efficient in solving the air pollution externality and equitable in redistributing the benefits created by policy incentives to the DACs to avoid perpetuating or deepening wealth inequalities and creating barriers to transportation.

Background:

While fully in place by 2035, the ban on the sale of new GPVs will start being phased in by 2026 (CARB: Vehicle Sales). A full timeline of the implementation of the ban can be seen below in Figure 1. In place of GPVs, consumers wanting to purchase a new car will have to purchase a vehicle powered by hydrogen or electricity; however, used GPVs will still be allowed to be bought and sold as they previously were. An exception can be found with new plug-in hybrids, which run on both gasoline and electricity, as they will be allowed under the ban, but cannot exceed 20% of a manufacturer's new car sales in the state (CARB: Vehicle Sales).

Additionally, although outside the range of this paper, the GPV ban is occurring alongside a shift to fully electric public transit by 2040, which was announced in 2018 (CARB: Bus Fleet).

Figure 1: Shift to Electric Vehicles Timeline



Source: CARB: Vehicle Sales

Since California's announcement, "Maryland, Massachusetts, New Jersey, New York, Oregon and Washington have made the commitment to stop allowing sales of new gas-powered vehicles after 2035" (Grieve). Additional states committing to ban the sale of GPVs will strengthen the production incentives created by California as more of the market will require electric vehicles; however, California's decision is still the most impactful as they have a far larger market share than any of the other states.

Since California's final decision to commit to the ban in August of 2022, few documents have emerged outlining a clear path forward from a policy perspective. There are references to three programs that existed prior to the decision–Clean Cars 4 All, The Clean Vehicle Rebate Project, and The Clear Vehicle Assistance Program–but funding for those programs is only guaranteed through the next three years and data is yet to be released on how this additional funding will impact the programs (CARB: Vehicle Sales). Instead, examining how California has previously incentivized early adoption of green technology, as the ban on new GPVs forces people to buy greener vehicles and will likely lead to the creation of various other policy incentives that promote the production and consumption of electric vehicles (EVs) prior to the 2035 deadline, provides greater insight on what policies are likely to come and the impacts that those policies will have. While the markets for electric vehicles and hydrogen vehicles are both relatively new and small and both types of cars are permissible to purchase under the ban, the focus for the later comparison with solar panels will be electric vehicles as it is the faster growing and larger market of the two. Both types of vehicles are considered by California as zero-emission vehicles (ZEVs).

This policy, branded as a climate change policy, is attempting to reduce the air pollution externality that is produced by GPVs. While solving the externality is the traditional policy focus, I want to see if this goal can be achieved alongside improving the welfare of disadvantaged communities and achieve both efficiency and equity. Aside from the larger externality of increasing the emissions put into the atmosphere and the implications that would have on climate change–which can be difficult to assign a direct cost for as the effects of climate change are the result of cumulative action and can be felt anywhere across the globe–air pollution from GPVs affects local health outcomes. This creates a direct cost in terms of medical bills related to increased rates of asthma, cancer, and cardiovascular and respiratory diseases. The severity of the health effects of air pollution can vary depending on the length of exposure and the type of air pollution (CARB: Inhalable). Air pollution resulting from GPVs is higher in densely populated areas, typically in city centers, so the people living in those densely populated areas are more at risk (Lukanov and Krieger pg 3). Questions of equity can be raised when analyzing who is statistically more likely to live in those densely populated communities. One common trend is that these neighborhoods are more likely to be the homeplace of low-income communities and communities of color**.** The California Environmental Protection Agency (CalEPA) has classified many of these areas as Disadvantaged Communities (DACs).

Literature Review:

In order to comprehend the potential impact that California's decision to ban the sale of new GPVs in 2035 will have, it is necessary to understand the new car market that currently exists within California. Californians purchase roughly two million new cars each year, which, according to a press release from the Governor of California's office, is 10% of the new car market in the United States (California ZEV Market). Of those two million cars, only 250,000 of those new cars were zero-emission vehicles (ZEVs) in 2021. Despite ZEVs only being a fraction of the overall 10% new car market share California has nationwide, California was responsible for 40% of zero-emission vehicle sales in the United States in the last year, which firmly establishes California as the leading state for ZEVs. According to state vehicle registration data from 2020, California's electric vehicle market was dominated by Tesla with 41.53% of all electric vehicles on the road in California being Teslas (ATLAS). Theoretically, Tesla's dominance in the market will decrease over time as more quality alternatives enter the market; however, as things currently stand Tesla's dominance adds a wrinkle in policy planning. Given that Tesla only produces electric vehicles, production side policy incentives will encourage them to make more vehicles but will not directly reduce the production of gas-powered vehicles as they are not shifting production from gas to electric vehicles, which is the larger goal as that will reduce emissions and air pollution externalities. Production side policies will still have some success with other manufacturers who begin shifting production from GPVs to EVs, but questions regarding how to tailor production policies around Tesla's market dominance still need to be evaluated further.

In economics, externalities are the consequences of production and consumption that affect uninvolved parties and thus are not captured in the original decision making process in the form of added or reduced costs (Helbling). Traditionally, externalities are looked at in their negative capacity; however, externalities can be positive. For example, vaccines benefit the individual by lowering their risk of illness and they also increase communal immunity, which lowers the rate of transmission. This duality of externalities increases the complexity of trying to address the existence of externalities. When factoring in demographics such as income levels and racial identity, the issue of externalities is further complicated by questions of equity because often certain communities experience negative externalities at higher rates than others.

There are two traditional approaches to getting rid of externalities: market based solutions and governmental intervention. The Coase Theorem supports leaving markets to solve the problem of externalities by "internalizing" the cost of the externalities (Parisi). In theory, with the absence of negotiating costs, this will lead to the most efficient outcome as the additional cost of the externality will be split between producers and consumers according to their elasticities. Whichever side is less elastic will pay a larger share of the increased cost. In reality, the Coase Theorem struggles to efficiently address externalities as negotiating costs exist and power imbalances create barriers to beginning negotiations. There is no free form of negotiation as it requires a commitment of time that not everyone can afford. In the case of GPVs, $PM_{2.5}$ is a form of air pollution that stands for fine particles of matter that are two and a half microns or less in width. "Emissions from the combustion of gasoline, oil, diesel fuel or wood produce much of the $PM_{2.5}$ pollution found in outdoor air" (CARB: Inhalable), and "communities of color, immigrant communities, and low-income communities are disproportionately exposed to higher $PM_{2.5}$ concentrations nationwide" because of cumulative discriminatory behavior and the zoning practices in neighborhoods that are less likely to have the ability to engage in a legal battle (Revesz, 211). Despite the fact that "scientific studies have linked increases in daily $PM_{2.5}$ exposure with increased respiratory and cardiovascular hospital admissions, emergency department visits and deaths" (NY Health), the market has not produced a solution that captures the cost these communities experience due to their prolonged exposure.

As indicated by the California Air Resources Board (CARB), the transportation industry is at least partially responsible for the externality of $PM_{2.5}$ through the burning of gasoline and diesel for fuel. The severity of the problem created by $PM_{2.5}$ emissions by the transportation industry varies by location as "the exposure to $PM_{2.5}$ pollution from cars, trucks, and buses… is highest in densely populated, urban areas and places downwind from those areas" (Reichmuth). Given that the cost of this externality is not felt evenly across different communities, internalizing the externality through private markets becomes more complex as each community would have to negotiate its own agreements to specifically address the level of harm experienced in that community.

One option for both the market and policymakers to address the unpriced effects of fossil fuels would be to raise the price of fossil fuels. "Higher costs for fossil fuels with significant externalities encourage substitution into other energy sources with fewer such externalities, such as renewable power sources or electric vehicles" (Deryugina et al. pg 2). Additionally, higher fuel prices and unchanging wages forces people to consume less fuel because they cannot afford more. In a fully efficient market, this price increase could happen without the intervention of any government; however, in our current imperfect market, this would likely require government intervention by adding additional taxation or setting a price floor.

Since the market has not produced an adequate solution for these communities, I shifted to looking at what governmental initiatives and policies were in place to help address the air pollution externality for these communities. In California, communities that are at a higher risk from this air pollution can be classified as disadvantaged communities (DACs) by the California Environmental Protection Agency (CalEPA) after considering the four following characteristics: exposure to different types of pollutants, environmental indicators, sensitive populations, and socioeconomic factors (Canepa). These characteristics are scored by a program called CalEnviroScreen 3.0 and DACs are "the census tracts that score in the top 25% statewide on the CalEnviroScreen 3.0 metric" (Lukanov and Krieger pg 2). Those living in DACs are more likely to suffer from additional factors that are negatively correlated with solar panel adoption such as housing burdens, linguistic isolation, and low education levels (Lukanov and Krieger pg 9).

By having DAC status, communities are allocated funding from "proceeds from the state's Cap-and-Trade Program" for investments "aimed at improving public health, quality of life and economic opportunity… and at the same time, reducing pollution that causes climate change" (OEHHA: SB 535). Having access to this funding, while important, is only part of the issue. The second, and perhaps more important, factor is if the money from the Cap-and-Trade program, as well as other state funding, is being used effectively as the state has limited resources. In the context of this study, effectively will mean questioning if the funding allocated is able to equitably and efficiently promote the adoption of electric vehicles to help address the air pollution externality. Since the electric vehicle market is still new, although it has grown rapidly compared to 2011 when only 7,000 ZEVs were able to be sold in California (California

ZEV Market), California's incentivization of solar panels will be used as a case study to see if the state's existing policies incentivizing the early adoption of green technology are adequate. Additionally, a study that compares Mexico's current electricity rate subsidies and their impact on solar panel adoption rates to the outcomes of a theoretical policy solution will be considered for the possibility of policy scaling.

While governmental policies are better suited than the free market to address the air pollution externality problem, they are also not a perfect solution as they interact with the market. The government will suffer from asymmetric information problems as it does not have complete information on the inner workings of car manufacturers and consumer behavior. Without complete information, the government runs the risk of creating perverse incentives within the electric vehicle market.

Efficiency & Equity:

Efficiency as a policy goal is traditionally viewed in regard to how quickly and cost-effectively a problem can be solved. For dealing with the emissions and pollution problems, "economists generally agree that pricing the externality is the most efficient way to address social damages from fossil fuel use" (Deryugina et al. pg 1); however, policymakers tend to avoid directly altering the price of fossil fuels. Instead, they often pursue policies that promote alternative energy sources or products that are more energy efficient. The California Solar Initiative is a perfect example of policymakers focusing on indirect methods to address fossil fuels. Indirect methods, while not as efficient, allow for some flexibility to manage how consumers are impacted. The decision to ban the sale of new GPVs is a more extreme policy, but falls along similar lines of indirectly solving the fossil fuel problem even before the ban fully comes into effect because it will likely result in additional policies to support and grow the EV market prior to 2035.

Despite the fact that policymakers do not pursue the most efficient policy of directly pricing the externality, they often are still pursuing efficiency with their alternative policies. In the case of fossil fuel externalities, the focus has been on targeting groups that historically have produced the most emissions. The World Inequality Report of 2022 states that according to income, the bottom 50% of the population in North America produces only 9.7 tonnes of CO2 per person whereas the top 10% of the population is responsible for producing 73 tonnes of CO2 per person. The mindset behind targeting wealthy emitters has been labeled “trickle-down environmentalism” (Lynch) and has had a mixed review amongst climate activists in the media. Trickle-down environmentalism is the mentality that all climate change policies are beneficial to the poor because the poor are the ones who suffer the most from climate change. If you provide monetary benefits to the rich to promote cleaner behavior, then yes the poor also benefit from having a cleaner environment; however, the poor still suffer from an income inequality problem as the rich get richer. It also highlights the framing of the efficiency versus equity debate. For those focused on efficiency, resources should not be spent on equity issues because that does not solve the larger problem.

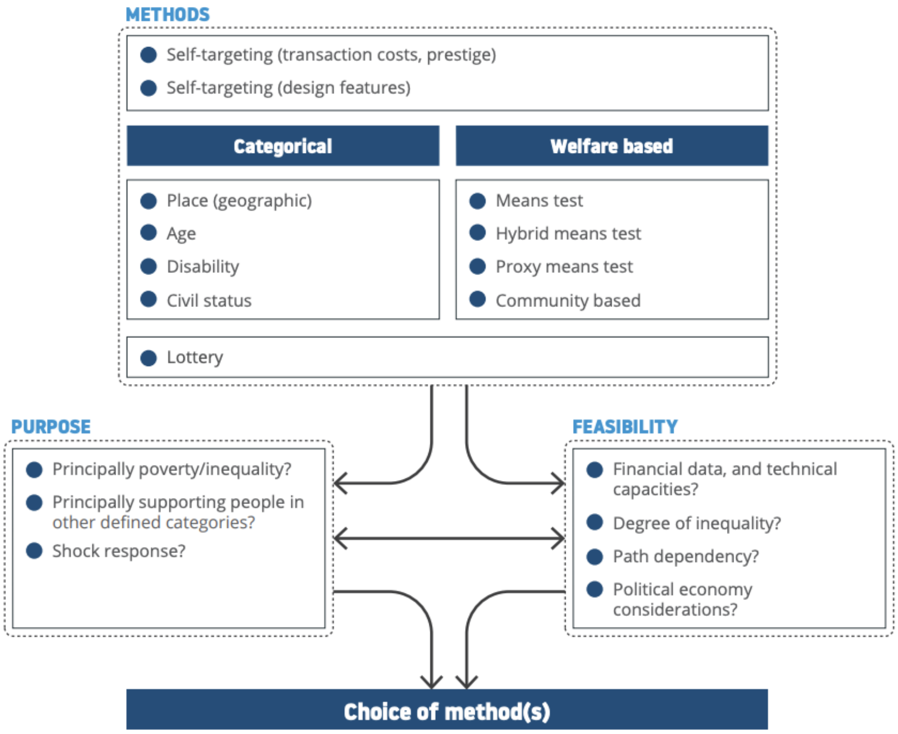
On the opposite side of the efficiency versus equity debate, equity minded advocates argue that trickle-down environmentalism does not work as the benefits of these policies stay concentrated in the high-income class. A study found that for clean energy tax credits related to the purchase of electric vehicles, “the top income quintile has received about 90% of all credits” (Borenstein & Davis). One factor that this study highlights as partially responsible for the disproportionate distribution of the tax credits is how they were administered. The tax credits were nonrefundable, meaning that if the credit exceeded your tax liability, you would get nothing in return. This creates an additional barrier as the tax credit incentive will not be available for many low-income filers who already had no tax liability. The gap in benefits received from policies among income levels is not unique to EV tax subsidies and can be seen across all clean energy tax credits as the same study found that “the top quintile has received about 60%” of all clean energy tax credits while “the bottom three income quintiles have received about 10% of all credits” (Borenstein & Davis).

Aside from the concerns regarding disproportionate access to the benefits created by policy incentives, the other concern for proponents of equity centered policies is addressing who is responsible for the problem and who is impacted the most by the problem. In the case of air pollution, “non-Hispanic whites experience a ‘pollution advantage’: They experience ~17% less air pollution exposure than is caused by their consumption” whereas “Blacks and Hispanics on average bear a “pollution burden” of 56% and 63% excess exposure, respectively, relative to the exposure caused by their consumption” (Tessum et al.).

While the focus has seemingly been on efficiency, there is reason to believe that policymakers do consider equity when making climate policies that focus on efficiency. For example, one potential explanation for why the most efficient route of pricing the fossil fuel externalities does not occur is because “policymakers forgo efficient policies because energy taxes create large burdens for particular households—either low-income households generally or households with less energy-efficient capital or lifestyles” (Deryugina et al. pg 1). This opens the possibility for considering policies that are both equitable and efficient. This could take the form of more radical, and in turn, more equity focused, policies such as mass investment low-income targeted subsidies as “low-income EV buyers are more responsive to incentives” and “are likely to benefit most from an EV yet are typically less likely to adopt one" (Bauer et al). On the more traditional side, this could look like re-examining existing policies to make them more equity focused while maintaining efficiency targets. This has already been proposed by Borenstein and Davis who, when examining the nonrefundable nature of clean energy tax credits, were not "able to come up with any coherent economic argument for making these credits nonrefundable." They argued this point from both an efficiency perspective, "there is nothing fundamentally different between filers with positive and negative tax liability," and an equity perspective, "from a distributional perspective, restricting the credits to exclude taxpayers without tax liability decreases both horizontal and vertical equity."

While both the literature and historic climate change related policies have been traditionally focused on efficiency over equity, new conversations are emerging about how policies can be both efficient and equitable. In early 2022, The World Bank published a collection of essays on a similar topic, looking at targeting and universalism, in the form of a book entitled *Revisiting Targeting in Social Assistance: A New Look at Old Dilemmas*. They make it clear that targeting is happening, "it is a fact of life that hundreds of social programs around the world differentiate eligibility and/or benefits in various ways" and that there are many different ways "to differentiate eligibility and benefits to fit programs to purpose and reduce their costs" (Gross et al. pgs 1-2). To Gross et al., the debate is "whether current practice is acceptable, can be improved, or should be abandoned" (Gross et al. pg 2). Despite the "should be abandoned" rhetoric in the debate, their end goal in this book is to "inspire more success where the choice is made to target" (Gross et al. pg 3). Rather simply, they want more efficiency in the targeted programs that are designed to promote equity. Figure 2 showcases their provided framework for how to design a targeted policy, which will be used in this paper to craft the final policy recommendation.

Figure 2: Choosing the Correct Targeted Policy



Source: Gross et al.

Research Design and Rationale:

This project is an exercise in questioning if our existing methods and policies are sufficient at addressing the distributional equity concerns that surround the creation of markets and the adoption of new green technology. If not, which I will argue that our current methods are not sufficient in addressing both efficiency and equity, then this paper becomes normative in nature as it will seek to propose alternatives to current methods that allow for the redistribution of wealth to disadvantaged communities through green technology adoption policies. While there will be real world political limitations that may interfere with my proposal, this paper will nevertheless theorize an ideal and just outcome according to environmental economics and public finance theories.

Before moving into theoretical ideals, it is first necessary to analyze whether or not historic policy plans have been statistically successful or not. Since Texas was an inadequate state for comparison for green technology policies, I shifted focus to researching previous policies done by California to incentivize the early adoption of green technology for my primary case study. While there were potential country comparisons to analyze, sticking with a California based case study also provided the added benefit of being potentially predictive of the behavior and supporting policies that California might enact alongside the transition of banning the sale of new GPVs. The most recent comparison was California's campaign to promote private ownership of solar panels in the mid-2000s. Specifically, the Go Solar California campaign and its California Solar Initiative program. Assuming that California will follow a similar set of policy programs to incentivize ownership of electric vehicles, I will evaluate the policies that were used to promote the adoption of solar panels as a case study to see how they fared in terms of equity and efficiency.

For the secondary and supporting case study, I felt it necessary to expand beyond California as there were limitations in the scale at which the targeted policies had been applied. By looking into hypothetical alterations of Mexico's electricity usage tariff pricing and the connected subsidies, which impacts almost all of Mexico's electricity using population, the potential of targeted policies could be seen at a much larger scale. This increased scale can showcase the possibility of expansive equity based policies while demonstrating how they relate to efficiency when done at increased scale.

To measure if the historic policies were successful in terms of efficiency, I will use national adoption data from Barbose et al.'s *Residential Solar-Adopter Income and Demographic Trends: 2021 Update* to study if the demographics of those purchasing solar panels indicate whether or not they would have been able to afford these solar panels without government intervention. This national data will be looked at in conjunction with the *California Solar Initiative Annual Program Assessment of 2018*. While more recent data is available, the 2018 report has the final data from the initial ten year campaign. The newer reports have data from re-imagined versions of SASH and MASH, which while important, are outside the direct comparison to the General Market Solar Program and outside the scope of this paper.

In terms of equity, I will be using the same Barbose et al. report in conjunction with additional data from a Lukanov and Krieger paper entitled *Distributed Solar and Environmental Justice: Exploring the Demographic and Socio-economic Trends of Residential PV Adoption in California* to see if DACs were able to access solar panels. Additionally, to help craft a policy recommendation, I will be using the framework for choosing a targeted policy from the World Bank's *Revisiting Targeting in Social Assistance: A New Look at Old Dilemmas* book in conjunction with a paper from Eric O'Shaughnessy entitled *Rooftop Solar Incentives Remain Effective for Low-and Moderate-Income Adoption* that analyzes what existing policies have been effective at reaching DACs.

I have focused on evaluating the policies according to efficiency and equity because the common debate for these types of policies is efficiency or equity. On one side of the equation, those advocating for efficiency want to solve the most pressing problem as quickly as possible while reaching a large number of people. Stimulus checks are a prime example of focusing on efficiency. While stimulus checks did promote equality, as everyone under a set income threshold received identically sized checks, it was not equitable as it did not consider who had been most impacted by Covid-19 and therefore needed more aid than those who were able to avoid economic problems. For climate change policies, the focus often is how can we address negative externalities as fast as possible to prevent further damage; however, this speed is often at the expense of addressing equity. The opposing argument is that these policies should be focused on equity. For climate change policies, this would mean focusing on providing benefits to communities most impacted by climate change and scaling aid according to how specific communities were impacted; however, focusing on equity can be slower and reach fewer people as there is more background research necessary compared to blanket efficiency policies. I plan on addressing both sides of this argument as well as taking the less common path of attempting to navigate a solution that is both efficient and equitable.

California Solar Initiative:

The California Solar Initiative (CSI) was part of the larger “Go Solar California” campaign. CSI was a ten year project running from 2006-2016 and had a total budget of $3.3 billion (CPUC: CSI). The CSI program was the largest subsection of the Go Solar California campaign and it largely focused on rebates and subsidies for the purchase and installation of solar panels. The goal was to subsidize the market for solar panels until the market had grown large enough to lower costs naturally, which California felt it had done by 2016 and thus decided not to extend the program beyond the initially planned end date. While CSI did include $250 million in funding to gas related programs, the focus was overwhelmingly on solar electricity generation as $2.367 billion was allocated to solar programs (see Figure 3). It included a multitude of programs with the largest programs being the General Market Solar Program, Single-Family Affordable Solar Homes (SASH), and Multifamily Affordable Solar Homes (MASH). Both SASH and MASH were programs specifically targeting low to moderate-income (LMI) households. These two programs each were budgeted $108.3 million. In contrast, the General Market Solar Program, which was open to the rest of the population, was budgeted just under $2.1 billion (Loewen pg 5). In justification of this higher level of funding, the General Market Solar Program was expected to generate 1,750 megawatts of energy whereas the MASH and SASH programs were expected to generate 30 and 15 megawatts of energy respectively.

Figure 3: Allocated Budget for California Solar Initiative

	Budget ($ Millions)	Goal
CSI Electric Budget (2007-2016)	**$2,367**	1,940 MW
General Market Solar Program (includes PV and electric displacing CSI-Thermal program)	$2,097	1,750 MW
Single-family Affordable Solar Homes (SASH)	$108	~15 MW
Multifamily Affordable Solar Housing (MASH)	$108	~30 MW
Research, Development, Demonstration, and Deployment (RD&D)	$50	~
Solar Water Heating Pilot Program (SWHPP)	$2.6	750 SWH systems
CSI Gas Budget (2010-2017)		
CSI-Thermal Program (Gas-Displacing solar thermal/hot water)	***$250***	*585 million therms*
Total CSI Budget	**$2,617**	

Source: Loewen

According to the *California Solar Initiative Annual Program Assessment of 2012*, the SASH program was designed to provide incentives for solar panel ownership as well as to "promote or provide energy efficiency services, workforce development and green jobs training opportunities, and broad community engagement with low-income communities." Incentives came in two forms: an initial payment to reduce the up-front cost of installation and then a rebate program that paid a set rate per wattage generated. An important note is that the rates for this program did not decline over time, unlike the rebate program in the General Market Solar Program which decreased annually. The rate varied depending on Federal Income Tax Liabilities and whether or not the owner of the house was eligible for the California Alternatives Rates for Energy (CARE) program. In order to be eligible for these incentives, you had to have a "total household income that was below 80% of the area median income" and own your own home (Loewen et al. pg 40). Outreach coordinators were hired to help build relationships and guide people through the application process (Navigant). Low-income renters were excluded from participating in this program, although they were able to benefit from the MASH program instead.

The MASH program was similar in nature to the SASH program except that it was designed for multi-tenant buildings in which “at least 20 percent of the tenants are low-income” (Loewen et al. pg 44). This eliminated the homeownership barrier of the SASH program but did so at the cost of less overall benefits for low-income families who lost out on the gains of capital accumulation as solar provided additional value to properties. MASH participants would receive credits toward their electricity bills. This credit was again the rebate program that featured in SASH; however, MASH paid out lower rates per wattage generated. The rate was determined by two different tracts that depended on whether or not the energy generated was offsetting common area energy usage or resident area energy usage. As the program was benefitting more than one individual tenant, the rebates were divided amongst tenants and the property owner according to a pre-arranged allocation agreement. The initial application for benefits happened at the property ownership level, so tenants could receive these benefits without doing much work themselves.

The General Market Solar Program is by far the largest of the three main programs within the CSI. This program provided incentives for both residential solar panel adoption as well as non-residential solar panel adoption. The incentive structure behind the General Market Solar Program was unique from the MASH and SASH programs for two reasons: initially, it offered choices in incentives and featured diminishing returns. In terms of incentive choices, applicants could apply for either a one time lump sum that was based on the expected energy generation or receive monthly payments for five years based on the actual generation of energy. Eventually, the program shifted to requiring projects greater than 30kWh to take the performance based payments. The monthly payments were paid according to rates per kWh, but these rates would decrease over time as more people participated in the program. This incentivized early adoption but also reflected the real market for solar energy according to basic supply and demand models. As more solar energy was produced, with demand relatively constant, the cost of solar energy would decrease.

This program was theoretically available to anyone and did feature low and moderate-income applicants, but the *California Solar Initiative Annual Program Assessment of 2012* believes this was likely due to the acceptance of funding towards third-party ownership of the solar energy generating system. In third-party ownership agreements, the systems "are owned, maintained and operated by a company or developer but they are installed on the roof of a utility customer's home or business" (Loewen et al. pg 29). This allowed for low and moderate-income residents to participate in the program and receive some benefits, namely in credits on their electricity bills, but they were essentially leasing the equipment and gained no capital through ownership. By 2012, the halfway point of the program, 72% of all residential projects were done through third-party agreements (Loewen et al. pg 30). Additionally, it is important to note that non-residential projects were receiving more benefits than residential projects and a rate of more than 2:1 in funding. In contrast to residential projects where there is a prevalence of third-party owners, these non-residential projects were largely owned by the business and institutions participating in the program.

The success of these three programs is ultimately relative to the factors that are being used to critique them. As demonstrated by Borenstein and Davis, there is a divide regarding whether it is more important to be efficient in addressing the externality or if it is more important to be equitable in addressing the externality. This is not a unique conversation for addressing externalities and this debate has been held recently in response to major policy decisions such as the distribution of stimulus checks. The decision to choose between efficiency or equity is often decided on a case-by-case basis and in the CSI program there was a clear preference towards efficiency as the General Market Program received substantially more funding than the equity focused programs in SASH and MASH.

Mexico Electricity Tariffs:

Mexico's electricity is controlled by a state owned utility company: Comisión Federal de Electricidad (CFE). Under CFE's control, "residential electricity users in Mexico afford an intricate increasing block tariff (IBT) that is based on the geographical location of households;" however, under this tariff system there is "a consumption subsidy that is received by approximately 98% of residential users across the country" (Hancevic et al. pg 70). This subsidy and the subsequent pricing errors from the IBT system created a significant amount of deadweight loss that dissuaded investment in electricity related infrastructure and other long term projects. As a result of the lack of investment, "only 0.6% of households have rooftop solar panels according to the National Survey on Energy Consumption in Private Homes (ENCEVI) 2018 conducted by INEGI" (Hancevic et al. pg 86).

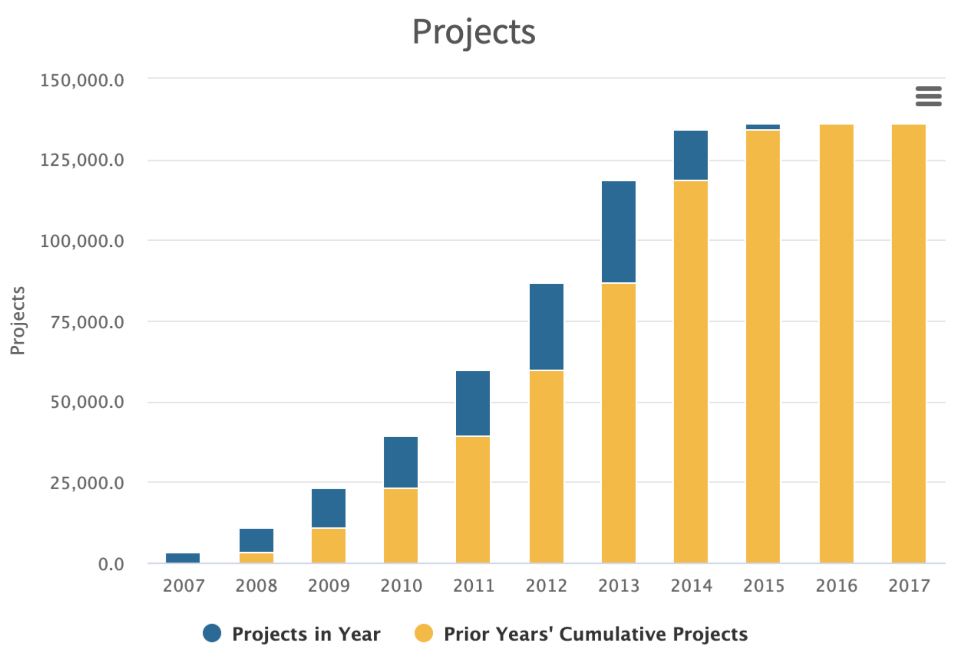
While the subsidy's reach is essentially equal to all residents, it is neither efficient nor equitable. "From an equity perspective, the use of consumption-based subsidies embedded in the IBT scheme is quite inefficient as an income redistribution device" because it "is received by virtually all households, independently of their wealth, income, or any other objective measure of living conditions." (Hancevic et al. pg 70). Additionally, while inefficient as a way to redistribute income, it is also inefficient in recovering costs. On average, resident users pay only "46% of the total cost of the service" and "the residential subsidy amounts to more than 0.4% of GDP" (Hancevic et al. pg 70). The large cost of the subsidy is important when considering that Mexico has limited resources and 52.4 million people, or 41.9% of its population, living below the national poverty line (Poverty & Equity Brief).

The hypothetical solutions that Hancevic et al. provides to solving Mexico's residential electricity pricing and subsidy failures while constrained to Mexico's limited resources has the potential to be both an efficient and equitable usage of state funds. While not enacted as an official policy with concrete results, their solution aims to move towards the rule that "the marginal price paid for one extra unit of energy must be equal to the marginal cost of supplying it," while not fully committing to the rule because of it is negative impacts on the poor (Hancevic et al. pg 76). Instead, they want to implement "a well-designed and well-targeted social tariff scheme to alleviate the impact on low-income families" (Hancevic et al. pg 83).

Results:

As a whole, the California Solar Initiative provided funding to 136,297 residential (CDGS: CSI Statistics) projects from 2007 to 2017, showcased below in Figure 4, of which only "a total of 5,262 projects" were from SASH (Esfahani et al. pg 29) and MASH "completed 379 projects" (Esfahani et al. pg 34). This results in SASH being responsible for roughly 3.86% of all residential projects, MASH being responsible for roughly 0.28% of all residential projects, and the General Market Solar Program covering the rest. While SASH and MASH created a relatively small amount of projects compared to the General Market Solar Program, which can be attributed to the significantly less funding that SASH and MASH received, the sample size is important for understanding whether or not DACs were reached at all.

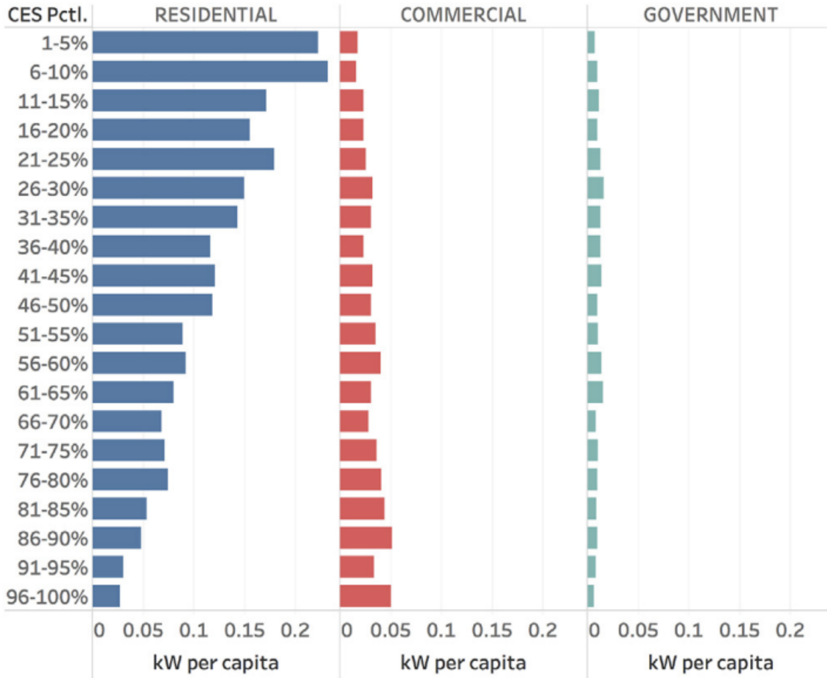
Figure 4: Projects Completed by CSI



Source: CDGS: CSI Statistics

While using a different metric, the amount of energy generated as opposed to the number of projects completed, Lukanov and Kreiger's work provided a data breakdown of rooftop solar installation and energy generation by CES scores. Figure 5, below, has a full breakdown of adoption data broken down by 5% ranges. The bottom five brackets, percentages 76-100, are the communities considered to be DACs. In the lowest bracket, which represents the communities that statistically are the most disadvantaged, residents adopted solar at a rate "8.2 times lower" than the least disadvantaged bracket in the top five percent (Lukanov and Krieger pg 5). Expanding further, the bottom decile was only responsible for "2.6% of the total residential solar capacity has been installed" (Lukanov and Krieger pg 5).

Figure 5: Energy Generation By CES Percentiles



Source: Lukanov and Kreiger

Although DACs were poorly reached, thus failing the equity through redistribution piece of the equation, the efficiency side was relatively successful. The California Solar Initiative program surpassed its target goal of generating 1,750 MW (Esfahani et al. pgs 22-23). Additionally, it technically succeeded in its long term goal of establishing a market for solar panels as a 2014 study found that the "customer-side solar PV market has shown significant progress toward market transformation since the initiation of the CSI program" (Esfahani et al. pg 25). Despite lowered costs, the market is still relatively exclusive as the median income for solar adopters as of 2019 was $113 thousand (Barbose et al. pg 11). This high median income is occurring years after the conclusion of the General Market Program and thus in the absence of major policy incentives, strengthening the exclusionary nature of the market. Relatedly, the SASH and MASH programs were inefficient depending on how success is determined. The programs were designed to be accessible to low and moderate-income households in California and applicants were determined qualifiers by regional based median income. In wealthy regions, where the median income is well beyond that of DACs, families with incomes at 80% of the median area income were still eligible despite earning more than people living in DACs. They were likely to receive lower benefits from the programs, as those were "calculated on a sliding-scale that is based on the homeowner's tax liability and the customer's eligibility in the CARE program;" (Loewen et al. pg 40) however, they had fewer barriers to entry when considering the additional factors DACs suffer from and thus were able to participate in the program at a higher rate. This meant that technically low to moderate-income households were reached, but those suffering the most, DACs, were not as well reached. Even though DACs were not explicitly stated as the target group to reach, it reflects poorly on the CSI programs that their equity tailored programs failed to reach those who needed assistance the most.

While the targeted policies in the CSI program failed to efficiently solve problems of equity, the Mexican electricity tariff case study provides an alternative narrative. SASH and MASH had the potential to be successful, both on the scale they were funded and on a much larger scale, but suffered from inefficient targeting practices. Hancevic et al.'s study highlights that while removing the universal subsidy and correcting the electricity usage pricing by tying it to the social marginal cost would allow for "full cost recovery of the value chain," it would be "unacceptable from most political perspectives that have fairness and social equity among their main goals" because the poor would "suffer the largest bill increments in percentage terms" (Hancevic et al. pgs 82,90). Instead of prioritizing efficiency, applying a correctly targeted subsidy through means testing, as opposed to the current subsidy that is received by 98% of the population, "it seems possible for the government to start a consistent path of subsidy reduction and efficient pricing and, at the same time, do not affect the poor significantly" (Hancevic et al.

pg 84). While this is all hypothetical as the study models potential policy outcomes, it illustrates the possibility to have equity benefits while achieving a more efficient outcome if there are correctly targeted policies. Figure 6 showcases the cost to consumers with various simulated scenarios, including full cost recovery in Case A, and the most efficient subsidy simulation in Case C. While means tested subsidies incur administrative costs related to validating subsidy applicants, some of these costs can be recovered from the savings generated by not issuing the subsidy to 98% of the population.

Figure 6: Cost to Consumers by Income Decile

	CASE 0 Status quo		CASE A Full rebalacing (No subsidy)		CASE B Means tested program w/o cross subsidies (30% subsidy reduction)		CASE C Means tested program w/ cross subsidies (30% subsidy reduction)	
Electricity bill (USD/month)								
Decile	mean	sd	mean	sd	mean	sd	mean	sd
1	5.24	(4.67)	13.74	(7.64)	7.30	(6.73)	5.58	(6.90)
2	6.87	(6.68)	15.88	(10.24)	10.05	(9.57)	8.78	(9.75)
3	7.85	(7.58)	16.91	(10.82)	11.68	(10.14)	10.72	(10.32)
4	8.87	(9.42)	18.08	(12.79)	13.42	(12.28)	12.70	(12.50)
5	9.87	(10.27)	19.21	(14.10)	15.01	(13.61)	14.45	(13.80)
6	10.37	(11.31)	19.53	(14.29)	16.06	(13.88)	15.76	(14.09)
7	12.36	(13.35)	21.63	(16.55)	18.65	(16.09)	18.59	(16.31)
8	14.12	(16.77)	22.89	(17.86)	20.57	(17.57)	20.78	(17.85)
9	17.32	(25.03)	24.80	(20.35)	23.26	(20.18)	23.88	(20.49)
10	27.88	(35.42)	29.05	(24.59)	28.35	(24.46)	29.59	(24.80)
All users	12.08	(17.84)	20.17	(16.27)	16.44	(16.47)	16.09	(17.01)

Source: Hancevic et al.

Policy Recommendation:

While I support California's decision to ban the sale of new GPVs by 2035, I am concerned about the supporting policies that will likely be administered to help speed up the creation of an electric car market, if California follows the path established by the California Go Solar campaign. CSI suffered from inefficient targeting programs, which left DACs behind and failed as a means of redistribution. Since the end of the California Go Solar campaign's initial ten year project with CSI, there have been improvements; notably, the updated version of SASH called DAC SASH. While following a similar incentive structure as SASH, this program specifically requires applicants to live in DACs (Solar in Disadvantaged). This cleans up the targeting issue from the previous iteration of SASH, but it still is not funded on a large scale.

Referring back to Figure 2, I would propose that the market supporting policies are targeted through both means testing and geography, specifically focusing on households in DACs and households earning 80% or lower of the state's median income rather than regional median income. This data is already accessible and very similar to SASH's income requirements, so it should not impose additional administrative costs. Additionally, I would encourage community based targeting by providing funding to community programs that can perform outreach. Unlike the home-ownership burden that DAC SASH still had, the subsidies for electric cars could be applied to both leases and purchases, decreasing the financial burden and credit requirements. There still would likely need to be a subsidy program similar to the General Market Solar Program that helps fund purchases outside of DACs, but I would recommend imposing a stricter maximum income cap to lower the number of unnecessary subsidizations, as "early adopters tend to be wealthy consumers" (Canepa et al. pg 19). Lowering the income cap makes additional funding available to the DAC targeted subsidy.

Limitations:

This paper would have benefited from increased demographic adoption data from the electric car market as well as manufacturing data highlighting the trend of production in the absence of mass subsidization. Additionally, this study was unable to determine the effects on the prices of the used car market, which will impact DACs and low-income households' ability to purchase vehicles. The change in prices will also likely lead to a shift in usage of public transit, which an increased strain on public transit could impact access to transportation, and in turn, mobility to access jobs and food, if not met with a related increase in investment and size of public transit infrastructure. Public transit policies could play a large role in addressing some of the equity concerns; however, it is important that it does not become a market in which poor people are unable to afford a car and are forced to take public transit.

The Biden administration recently announced their own plan to try to shift the country to electric vehicles with a target of having “electric cars represent between 54 and 60 percent of all new cars sold in the United States by 2030” (Davenport). While a federal policy would supersede California’s plans and have a far larger market impact, concerns regarding equity would still be in play and therefore the results and conclusions of this study would still be relevant to this significantly larger policy.

Conclusion:

I don’t believe that previous policies under the CSI are adequate at being both equitable and efficient, but, given the 2035 target date, there is still sufficient time to craft policies to ensure that concerns regarding efficiency and equity can both be addressed. Through looking at policies surrounding the incentivization of solar panels, I found that most of California’s policies surrounding the early adoption of green technology have been focused on efficiency instead of equity, which has exacerbated wealth gaps between the upper and lower classes as well as between racial demographics. While there were a few demographically targeted policies that attempted to get solar panels into low to moderate-income households, these programs struggled to reach DACs because of how the targeted policies were designed. I believe it may be possible to increase the scale and application of these targeted policies by placing them at the center of policy decisions and updating targeting criteria. Targeted policies will certainly meet the equity criteria and I believe still can achieve the efficiency criteria by addressing the most problematic locations, densely populated areas that are home to many DACs, and thus effectively spending the government's limited resources. This also has the potential to lower waste generated from unnecessary incentives. Unnecessary incentives on the production side occur when manufacturers receive policy incentives when they would make the shift to producing electric vehicles with or without policy incentives due to market incentives. On the demand side, incentives can be unnecessary if the consumer would have the ability to purchase an electric vehicle regardless of assistance.

Even if previous rollouts of green technology adoption incentivization policies have not been perfect, they are important for speeding up the creation of new green technology amidst a growing climate crisis. More specifically, it is important that California continues to push for the creation and adoption of green technology as their market size gives them the ability to indirectly incentivize global markets. Additionally, while they could be superseded by a federal program, California's policies will be more stable given the polarized nature of national politics. Any major program done by the Biden administration could be rolled back by the next Republican president, while California's policies will be unlikely to be changed given their relatively stable political climate.

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