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An Equitable Transformation of the Energy System: The Role of State-Level Incentives for Distributed Energy Resources

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An Equitable Transformation of the Energy System:

The Role of State-Level Incentives for Distributed Energy Resources

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EVST 495: Senior Essay Colloquium

Dr. Michael Fotos & Dr. Robert Klee

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Author's Note

As a member of the Yale College Class of 2021, I studied environmental studies and global affairs with particular interests in international cooperation on climate action and environmental justice. At Yale, I co-founded an action-based environmental group called GREEN and was involved in various other initiatives grounded in making the world a better place through the protection of both people and nature.

I conducted this study as part of the Senior Essay Colloquium within Yale College Environmental Studies (EVST). The purpose of the senior essay requirement is for students to engage meaningfully in a topic about which they are passionate while tackling a serious environmental problem. This process was a challenging and rewarding one. It has taught me how to pursue my curiosities by posing novel research questions that aim to study a potentially significant aspect of an issue. It has additionally strengthened my ability to persist in the face of obstacles, particularly the unavailability of information and the extensive (at times exhausting) data collection process, throughout an independent project. Finally, it has allowed me to practice my written communication skills through the production of this senior essay. Altogether, I am grateful for the opportunity and experience that the EVST Senior Essay Colloquium offers students in the department.

I hope that this final deliverable will be useful and inspiring to readers of all backgrounds. Lastly, I hope that it will contribute to a greater conversation about and practical application of environmental justice principles in the context of the transformation towards a decarbonized future.

Trinidad Kechkian

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To the rest of the Senior Essay Colloquium faculty—Dr. Kealoha Freidenburg and Dr. Jeffrey Park—and my wonderful classmates, thank you for the sense of community that you fostered, especially at a time when we may feel disconnected from one another due to the public health conditions. I hope we will be able to convene in person and stay connected beyond our time at Yale. I cannot wait to witness the incredible things you will accomplish; I know greatness awaits you—whatever that means for you.

To the birds that sing outside my window every day, thank you for reminding me that there is a whole world outside of myself. Thank you for reminding me to practice mindfulness throughout my day, that there is inherent value in simply existing, and that life goes on outside of the day-to-day concerns of a college student

Finally, to my family and loved ones, a very special thank you. Thank you for blessing me with your unconditional love and intentional care. You inspire me to approach each day with optimism, grace, confidence, and purpose. You mean the world to me, and it goes without saying that I love you, but it is a beautiful thing to say it anyway. I love you deeply.

My time at Yale College has been well worth it, and the Environmental Studies department will always have a special place in my heart. To everyone who has touched my life in some way, you have made me who I am today. You have my sincerest gratitude. I wish you all good health, safety, peace, bountiful love, and happiness.

Thank you.

Abstract

One of the great obstacles to the transition to clean energy is that not everyone has an equal opportunity to participate. While previous research has demonstrated that the distribution of solar photovoltaic and battery storage technologies is correlated with race and ethnicity, income, educational attainment, and other variables, it has failed to perform similar analyses on specific clean energy incentive programs. This study evaluates the equitability of past and current state-level incentive programs for solar photovoltaic and battery storage systems in California and Massachusetts using multiple linear regression models. Among the most notable results, for the California programs that are open to the general market, whiter and wealthier populations yielded a higher average incentive amount and a higher likelihood of being served by the programs. Overall, when states are intentional about involving communities and serving environmental justice populations, their programs are more equitable than broad programs for the general public. Ultimately, this study identifies injustices that may obstruct the shift towards a decarbonized society and explores more equitable transformation pathways towards a clean and renewable energy future through distributed energy resources.

Keywords: battery storage, clean energy, community, distributed energy resources, energy justice, equity, grassroots, renewable energy, resilience, solar photovoltaic

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I. Introduction

Climate change is the most important issue facing humanity today.[1] At its best, it provides a unique opportunity to revolutionize the energy system and uproot past inequities; at its worst, it poses a threat to almost every aspect of society. Climate scientists warn us with increasing urgency that greenhouse gas (GHG) emissions must decrease dramatically to limit average global warming to 1.5 degrees Celsius above pre-industrial levels and prevent irreversible changes to the Earth's climate systems, as established by the Intergovernmental Panel on Climate Change in its 2018 report on global warming and the Fourth National Climate Assessment by the US Global Change Research Program (IPCC, 2018; USGCRP, 2018). As droughts, storms, fires, and other natural disasters continue to increase in frequency, the toll on local populations will be devastating. If we do not take immediate and significant action to transform the energy sector from fossil fuels to clean energy sources, climate change will continue to bring about the destruction of infrastructure and precious natural habitats, the relocation of whole communities, the amplification of epidemics and other public health risks, and the destruction of ecosystems worldwide (IPCC, 2018; USGCRP, 2018).

Distributed energy technologies (DERs) are one avenue through which to address the looming problem of transitioning from dirty fossil energy to clean energy. DERs are small-scale units of local electricity generation or management that are connected to the grid at the distribution level. The term includes behind-the-meter generation technologies like rooftop solar systems, energy storage like home batteries, clean transportation technologies like electric

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[1] By no means is climate change the first existential threat (Heglar, 2020; Ray, 2021). I want to acknowledge past and current existential threats including but not limited to colonialism, physical and cultural genocide, slavery, capitalism, police brutality, and other forms of violence that are rooted in discrimination on the basis of race, ethnicity, religion, sexual orientation, and other identities. To say that climate change is the first time that humans have had to struggle for survival is ignorant and dangerous, as we must recognize and learn from history so that we can dismantle hateful systems of oppression and build new structures founded in justice, love, and community.

vehicles (EVs) and chargers, and demand response technologies like smart thermostats and meters (Horowitz et al., 2019). While there certainly is a need to decarbonize at the grid level and to revolutionize existing infrastructure specifically for the phasing out of fossil fuels, the integration of DERs at the residential level is also a necessary action through which to achieve these clean energy transformations (Horowitz et al., 2019).

Currently, however, the distribution and deployment of these critical global warming mitigation technologies have proven inequitable, obstructing their integration. A recent landmark study by Sunter et al. (2019) evaluates the effectiveness and equitability of current rooftop solar policies and programs, revealing that race and ethnicity are significant predictors of rooftop solar participation. By merging Project Sunroof[2] data with data from the United States Census Bureau American Community Survey (ACS),[3] the researchers found that Black-majority and Hispanic-majority neighborhoods had 61 and 45 percent less rooftop solar than no-majority neighborhoods, even when correcting for household income and homeownership, as reported in Table 1 below. Meanwhile, under the same conditions, White-majority neighborhoods had 37 percent more rooftop solar than no-majority neighborhoods (Sunter et al., 2019). Barbose et al. (2021)[4] found a similar trend in their more recent study on the demographics of solar-adopter households compared to those of all US households.

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[2] Project Sunroof is a calculator from Google that uses spatial data to map the solar savings potential on rooftops across the country (Google, n.d.). The tool provides personalized roof analyses to provide users with an optimized solar plan including a calculation of the annual sunlight that hits a home's roof, a recommended installation size to maximize the roof's potential and minimize electricity bills, and an estimate of the financial costs taking federal, state, and local incentives into account. For more information, visit google.com/get/sunroof.

[3] The American Community Survey is an ongoing survey administered by the US Census Bureau on an annual basis. It gathers current information about the social, economic, demographic, and housing characteristics that communities can use to make decisions. The five-year estimates represent data collected over 5-year ranges that can increase the statistical reliability of the data, especially for areas with smaller populations. For more information, visit census.gov/programs-surveys/acs.

[4] The essay explores the findings by Barbose et al. (2021) in greater detail in Section II.C, infra.

	racial demographics of neighborhoods		
	Black-majority	**Hispanic-majority**	**white-majority**
% difference in rooftop solar as compared to no-majority neighborhoods	-61	-45	+37

Table 1. The percentage difference in rooftop solar of Black-, Hispanic-, and white-majority neighborhoods, as compared to no-majority neighborhoods, based on the work of Sunter et al. (2019).

These inequalities exist not only when it comes to participation in climate mitigation, but also when it comes to the experience of the negative impacts of climate change. While climate change is a global problem affecting all people, not everyone bears an equal share of the burden. Climate change has differential impacts on peoples based on geography, race and ethnicity, gender and sexuality, able-bodiedness, economic class, and language barriers to communication among others. In the United States, environmental stresses disproportionately affect Black communities, Indigenous communities, and people of color (hereafter referred to as BIPOC), as well as low-income populations. It is precisely because BIPOC and low-income communities experience climate change differently that there is a dire need to include them in the problem-solving process.

Similar injustices exist in the energy sector, where different socioeconomic and demographic groups have differential access to resources. According to a model by Drehobl and Ross (2016), low-income, African-American, Latino, multifamily, and renting households have a disproportionately higher energy burden (i.e., they spend larger amounts of their income on energy) than their higher-income, white, and home-owning counterparts. Participation in clean energy programs typically saves participants money while often increasing costs for general ratepayers. The fixed costs of the utility companies, paired with decreased demand due to the implementation of DERs, inevitably increase the price of electricity sourced from fossil fuels

(Brown et al., 2020; Gearino, 2019; Johnson et al., 2017; Sirgin and Mooney, 2018). If there is not equal participation in these technologies and, instead, wealthier individuals are the ones who are implementing these technologies, then low- and middle-income households will suffer a disproportionate increase in their energy costs and, thus, in their energy burden.

Given these foundational racial and socioeconomic inequities—in participation in DER programs, household energy burden, climate change impacts, and access and participation in the policymaking process—this study analyzes the relative equitability of current DER incentive programs and offers recommendations on how to make them more inclusive. While previous research by Sunter et al. (2019) demonstrated that the distribution of rooftop solar technologies is correlated with race and ethnicity, even after controlling for homeownership, the researchers failed to closely analyze any specific solar incentive programs, which are the key catalyst for rooftop solar deployment. Sunter et al. did not evaluate other independent factors like level of education and language barriers. Additionally, past analyses focus mostly on rooftop solar systems and do not include the increasing array of DER options. Discussed in Section II.C, the study by Barbose et al. (2021) has similar shortcomings, failing to evaluate participation in state-level incentive programs, although it does include variables beyond race and income including home value, credit score, education, occupation, urban/rural status, and age.

This study attempts to quantify the equitability of state-level incentive programs for rooftop solar systems and battery storage with a focus on two leading clean energy states: California and Massachusetts. In the sections to come, I provide background on topics of environmental justice, energy justice, the three DER technologies of interest, and existing incentive programs in the two states of interest (Section II). Next, I describe the data used in the statistical model, state the unit of measurement for equitability, and explain the structure and variables of the statistical model (Section III). The results of the linear regressions performed using Stata reveal the extent to which race and ethnicity, median income, level of education, English proficiency, tenure, and household size impact the distribution of rebates across the two states (Section IV). These results establish the equitability of the incentive programs and rank their relative values. The following section will identify the elements that explain the programs' relative equitability (Section V). Finally, I synthesize key findings and offer policy recommendations for making DER incentive programs more equitable so that all individuals have equal opportunity to participate in the transition to clean energy (Section VI).

II. Background

A. Energy Justice

Between the late 1970s and 1980s, issues of environmental justice in the United States began to gain momentum.[5] During this time, environmentalists and civil rights activists started collaborating in pursuit of social justice and environmental protection, igniting a quickly growing movement that now includes issues of pollution, public health, access to clean and renewable energy, and so many other issues. Inspired by these collaborations, the First National People of Color Environmental Leadership Summit produced the "Principles of Environmental Justice" in 1991. The manifesto outlines a vision for environmental justice and includes 17 demands such as ethical and responsible land use, compensation rights for victims of environmental injustice, safe work environments for all, cessation of hazardous material production, and protection from damaging nuclear activities (First National People of Color Environmental Leadership Summit, 1991).[6] Its creation reflected the growing awareness of environmental justice issues, establishing a foundation upon which activists continue to build the movement today.

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[5] In 1978, Ward Transformer Company began dumping transformer oil containing a variety of toxic chemicals—particularly polychlorinated biphenyls (PCBs)—along the roadways across North Carolina (Reimann, 2017). With 31,000 gallons of oil dumped, the Environmental Protection Agency (EPA) sought to contain the problem. The Toxic Substance Control Act of 1976 called for the disposal of PCB-contaminated materials (Yen, 2015, p. 2), and the state of North Carolina chose Warren County—a 65 percent Black county and one of the poorest in the state—as the host for the landfill that would hold this waste (Reimann, 2017). In 1982, the EPA-funded landfill opened, ready to receive the 60,000 tons of contaminated soil. The community resisted, holding nonviolent marches and sit-ins in an attempt to block the trucks from unloading, concerned about the potential contamination of groundwater sources and other consequences (NYT, 1982). Six weeks and 500 arrests later, the protest was reported as "the largest civil disobedience in the South since Dr. Martin Luther King, Jr. marched through Alabama" in a *Duke University Chronicle* article (Johansen, 2020, p. 176). Although it was unsuccessful in stopping the landfill's creation, it is said to have sparked the modern environmental justice movement.

[6] While they each provide specific guidelines across a variety of topics, they all generally encompass three prongs of environmental justice: recognition, procedural, and distributive (Carley & Konisky, 2020; Jenkins et al., 2016, pp. 176-179). Although these three prongs are each immensely important and arguably inseparable from the others, it is important to note that practically every issue of environmental justice is one of distributive justice that typically stems from a lack of procedural and recognition justice (Raymond, 2003).

An emerging branch of environmental justice, energy justice is the application of justice principles to energy systems and every step in the full lifecycle of energy resources—from extraction to waste (Jenkins et al., 2016, p. 179).

An example of an energy injustice at the extraction level is the impact that oil drilling by large fossil fuel companies has had on surrounding communities. These impacts can include but are not limited to human rights violations; displacement and use of slow violence; loss of ecosystem services and increase of public health issues through pollution of life-sustaining water sources and key natural habitats (Healy et al., 2019, p. 221).[7]

At the production level, the air pollution that originates from processing plants has significant negative effects on the health of typically BIPOC and low-income communities with limited procedural power. For example, in Louisiana, pollution from oil refineries and petrochemical plants has led to such a dramatic increase in cancer cases that the 85-mile stretch of land along the Mississippi River between Baton Rouge and New Orleans -- a primarily Black community -- is colloquially known as "Cancer Alley" (Singer, 2011, p. 142).[8]

The distribution of energy can have disproportionate effects on the communities through which energy is transported, either through pipelines, railway, or other methods (e.g., water contamination; displacement and livelihood disruption) (Healy et al., 2019, p. 221). The construction of the 1,172-mile-long underground Dakota Access Pipeline from North Dakota to Illinois threatens the access to clean water and cultural heritage associated with the land of the

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[7] Around the world, fossil fuel extraction has displaced and poisoned Indigenous communities around the world, two of the most prominent examples being Chevron-Texaco's polluting of native Amazonians' ecosystems in Ecuador (Patel, 2012) and Shell's exploitation of the Ogoni people in Nigeria (Boele et al., 2001).

[8] Formed in 2000, the justice group Louisiana Bucket Brigade (LABB) uses EPA-approved air sampling devices to document the pollution (Rolfes, 2013). Although no citizen should have to demand a healthier environment to protect their unalienable rights to life, liberty, and the pursuit of happiness, LABB has worked to empower communities negatively impacted by the petrochemical industry. For more information, visit labucketbrigade.org/.

Dakota and Lakota peoples of the Standing Rock Sioux Tribe, violating and devastating sacred lands and waters (Whyte, 2019, p. 121).

Regarding disposal, dumping of toxic chemicals and the concentration of GHG emissions from combustion can contaminate the air, water, and soil in typically BIPOC and low-income communities with limited procedural power to resist (Healy et al., 2019, p. 221; King & Murphy, 2012, p. 9). One example of injustice at this stage of the lifecycle of energy resources is the dumping of high-level nuclear waste in native lands deemed "wastelands" by the US military, which jeopardizes the health and wellbeing of the surrounding environment and Indigenous communities (Endres, 2009; Kyne & Bolin, 2016).

However, this essay focuses on energy justice at the consumption level, as it relates to DERs.[9] Residential adoption of DER technologies has the opportunity to increase resilience by providing an alternative method of electricity generation during climate-related power outages (Federal Energy Management Program, 2019; Zitelman, 2020). Disproportionate adoption of these technologies, however, can mean that some communities will be more prepared than others to deal with the negative impacts of climate change.

Inequitable deployment of DERs can also cause energy justice issues. For example, EVs are charged with electricity from the grid and do not produce tailpipe carbon emissions, which may cause an overall reduction in emissions. However, the increase in EV adoption may shift air pollution to neighborhoods where power plants are located, typically in BIPOC and low-income communities with limited procedural power, which can lead to increased health risks for these populations (Holland et al., 2016; Mejía-Duwan, 2020).[10]

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[9] The essay explores DERs in greater detail in Section II.B, infra.

[10] As such, this example is an issue of distributive justice, given that BIPOC and low-income communities affected do not receive any of the benefits while EV adopters reap the benefits without bearing any of the burden.

The lack of access to affordable energy and energy resources additionally results in disproportionately high and increasing utility bills for low-income communities (Brown et al., 2020; Johnson et al., 2017; Sirgin and Mooney, 2018). Here is where the concept of "energy burden" comes into play. The term refers to the percentage of gross household income spent on energy costs. While the energy justice movement sees access to affordable energy sources as a human right, one in three households in the United States reported experiencing energy insecurity in 2015, whether forgoing a meal to pay for the utility bill or suffering through unsafe temperatures (Berry et al., 2018).

A study by the firm of Fisher, Sheehan, and Colton (FSC, 2003) finds that the difference between the observed home energy bills and affordable home energy bills (i.e., the "home energy affordability gap") is significant and differs greatly across regions. The FSC model calculates the affordability gap on a county-by-county basis across the country, resulting in two key findings. First, the total annual affordability gap reached $18.2 billion for 2002. Second, the federal fuel assistance programs only cover a fraction of that gap with the Low-Income Home Energy Assistance Program (LIHEAP) covering 9.2 percent in the same year (FSC, 2003). Updated each year, the affordability gap doubled since 2002, reaching $36.4 billion in 2020, and the gross LIHEAP allocation was $3.2 billion, covering only a little over 8.9 percent in the same year (FSC, 2021, p. 1).

	Year	
	2002	**2020**
Total Annual Affordability Gap	$18.2	$36.4
Percentage of Affordability Gap Covered by LIHEAP	9.2	8.9

Table 2. Total annual affordability gap and percentage of affordability gap covered by LIHEAP, as calculated by the FSC model for 2002 and 2020 (FSC, 2003; FSC, 2021).

The FSC study is a piece of historically important literature for framing the rest of the conversation on energy burden, and the FSC model has become a crucial tool for research, policymaking, and policy analysis. That said, its findings are limited because the study only analyzes the affordability gap based on geography. It fails to address income, race, ethnicity, and many other factors that may impact energy affordability. Finally, this report only considers federal assistance programs as an avenue for closing the affordability gap, overlooking energy efficiency as a possible tool.

Drehobl and Ross (2016) build upon the FSC model and past energy affordability literature, providing an up-to-date analysis of energy burden across 48 major metropolitan areas in the United States, taking into account variables previous papers have failed to consider. Drehobl and Ross find that income, race, household type, homeownership, and geography all contribute to household energy burden. According to their model, low-income, African-American, low-income multifamily, Latino, and renting households spend much larger shares of their income on energy costs compared to the median United States energy burden, as Table 3 below reports (Drehobl & Ross, 2016; pp. 3-4). Further, 67 percent of low-income households face a high energy burden (defined as spending over 6 percent of household income is spent on energy costs), a larger share than other demographics (Drehobl & Ross, 2016; FSC, 2003; Pyzyk, 2020).

	Household Demographics					
	low-income	**African-American**	**low-income multifamily**	**Latino**	**renting**	**median**
median percentage of income spent on energy costs	7.2	5.4	5.0	4.1	4.0	3.5
percentage of energy costs that could be eliminated with energy efficiency	35	42	---	68	97	---

Table 3. The median household energy burden and percentage of energy costs that could be eliminated with increased energy efficiency by demographics, based on the work of Drehobl & Ross (2016).

Drehobl and Ross (2016) introduce a novel analysis of the role of energy efficiency in closing the energy affordability gap, a crucial potential solution that the aforementioned FSC report overlooks. They find that more energy efficiency measures could help eliminate between 35 and 97 percent of excess energy costs for low-income, African-American, Latino, and renting households, as Table 3 above reports (Drehobl & Ross, 2016). This study introduces the barriers to and importance of building equity into current and future programs designed to incentivize household participation in weatherization and energy efficiency programs—concepts which apply to DER incentive programs, as well (Drehobl & Ross, 2016).

Although Drehobl and Ross mainly focus on energy efficiency as an effective solution to eliminating excess energy burden for BIPOC and low-income households, there is a dire need for multiple policies and programs to be working simultaneously. Improving energy efficiency standards alone accounts for a fraction—although not an insignificant one—of excess energy burden. However, the equitable deployment of new DERs will be another piece of the puzzle for closing the equity gap and broadening participation in the clean energy transition.

B. Distributed Energy Resources

DERs are small-scale units of local electricity generation or management that are connected to the grid at the distribution level. The term includes behind-the-meter generation technologies like rooftop solar systems, energy storage like home batteries, clean transportation technologies like EVs and chargers, and demand response technologies like smart thermostats and meters (Horowitz et al., 2019). More and more, the DER mix is moving towards residential technologies with the total capacity from residential load management, distributed solar, distributed storage, and EV charging expected to reach 387 gigawatts by 2025 (Kellison & Wang, 2020). The integration of DERs at the residential level is a necessary step in the transformation and decarbonization of the energy system.[11]

The deployment of DERs is, additionally, one step towards the integration of smart grid technologies. Smart grid technologies are those with two-way communication between the utility (and non-utility actors like Google Nest)[12] and its customers (Bayindir et al., 2016; Ekanayake et al., 2012). These technologies include intelligent appliances, net metering, smart thermostats, and even EVs (when not used for transportation or when not charging, using them as a battery storage device for the entire grid) among others, which all work to increase energy efficiency. Instead of transitioning to different sources of energy, a smart grid calls for a shift in behavior to both decrease overall energy demand and decrease peak demand—particularly at times of grid

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[11] By no means does that mean that the impetus for addressing climate change falls solely on individuals. Governments and corporations often try to guilt individuals for the climate crisis to distract from the greater responsibility that they hold (Byskov, 2019; Hyman, 2020). There certainly is a need to decarbonize electricity generation at the higher grid level and revolutionize existing infrastructure (the transmission grid and vehicle fueling supply chain) for the phasing out of fossil fuels and integration of renewable energy sources into the electrical grid (Gagnon et al., 2016, p. 2; Porter et al., 2020; Tai, 2019).

[12] Google Nest is a brand of smart home technologies including Internet-connected thermostats that can facilitate communication between utilities and customers to achieve a more resilient electrical grid through energy messaging and demand response (John, 2019a). For more information, visit store.google.com/us/category/google_nest.

stress (e.g., peak load times)—or increase beneficial demand at times of peak renewable power generation (Bayindir et al., 2016; Ekanayake et al., 2012).

1. Solar PV Systems

In 2020, solar PV accounted for 43 percent of “all new electricity-generating capacity additions,” the largest increase in the industry’s history and the second consecutive year that ranked as the fastest-growing among all generation technologies, as shown in Figure 1 below (Davis et al., 2021, p. 6). Specifically, residential solar has dramatically increased over time and is currently the dominant form of DER at the moment. Growing 11 percent in 2020 despite the initial shock of the coronavirus outbreak, residential solar is expected to see similar record-setting trends in growth through 2021 (Davis et al., 2021, p. 6).

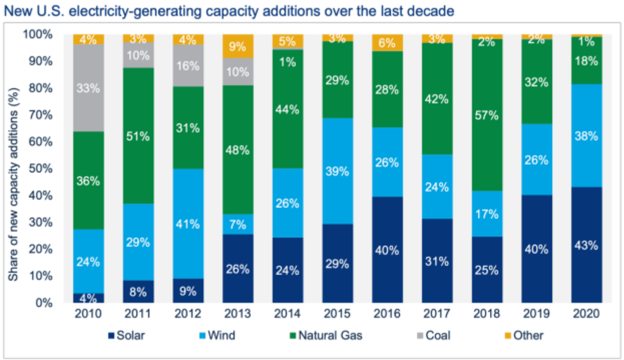

Figure 1. New electricity-generating capacity additions in the United States from 2010 to 2020 (Davis et al., 2021).

The National Renewable Energy Laboratory estimates that the total potential for solar energy production through rooftop PV systems across the United States is 1,432 terawatt-hours of annual energy generation, which is roughly 39 percent of total national electric-sector sales (Gagnon et al., 2016). California and Massachusetts, the two states analyzed in this study, can each theoretically use solar to cover an above-average percentage of their total energy sales, estimated to be 45-55 and over 55 percent of their sales in 2013, respectively (Gagnon et al., 2016). These numbers are not insignificant.

Previous research on the disparities of rooftop solar deployment has identified several barriers, including income and credit scores, tenure and owner/tenant split incentives, and single-or multi-family housing among others (Barbose et al., 2021). Incentivizing rooftop solar generation through state-level rebate programs can help overcome these barriers and additionally encourage the integration of smart grid technologies. Especially when paired with battery storage systems, smart meters and time-of-use rates can provide many benefits to both residents and the rest of the electrical grid, including reduced electricity bills, increased energy security, and increased climate resilience.

2. Battery Storage Systems

In 2015, Vermont electric utility Green Mountain Power (GMP) launched a Grid Transformation Pilot that offered Tesla Powerwall batteries to homeowners for $37.50 per month (John, 2015). Having great success, the pilot became a permanent program in 2020. It now offers two ways for homeowners to get batteries, either through a 10-year lease of two batteries for $55 a month or through a "bring your own device" option where GMP pays a one-time amount up to $10,500 based on the capacity (Spector, 2020). Although battery systems are not nearly as widely adopted as solar PV, they offer savings in energy costs and increased resilience in the face of power outages (Spector, 2020). The growing demand for batteries, especially in California communities that experience fire-season safety shutoffs, presents an opportunity to design the deployment of storage in a more equitable fashion from the beginning, compared to solar PV systems (John, 2019b; Spector, 2020).

In addition to reducing energy bills and increasing climate resilience, batteries aid in the transition towards renewables. Referred to as the "duck curve,"[13] Figure 2 below shows discrepancies between peak supply from renewable energy sources and peak demand throughout

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[13] For more information on the duck curve, read Jim Lazar's "Teaching the Duck to Fly" available at https://www.raponline.org/knowledge-center/teaching-the-duck-to-fly-second-edition/.

the day, which make it difficult to rely on clean and renewable sources like solar and wind energy without storage technologies (Burger, 2018). However, increasing battery storage nationwide can lead to decreased reliance on fossil fuels and a strengthened electrical grid by capturing the excess electricity generated from solar in the middle of the day for later use or to sell to the grid during peak hours. Especially because one of the major barriers to mass deployment of battery storage is its cost, incentivizing this DER technology can therefore have a large impact on the energy sector, carrying forward the transition to clean and renewable energy sources.

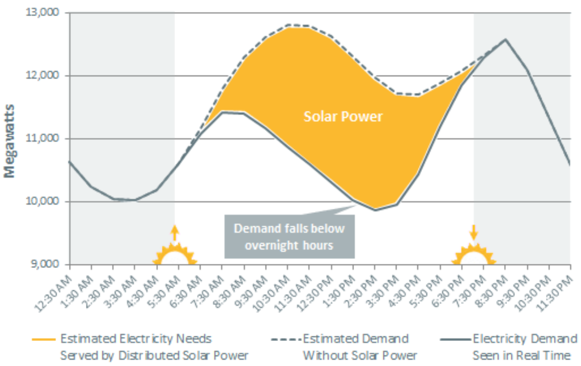


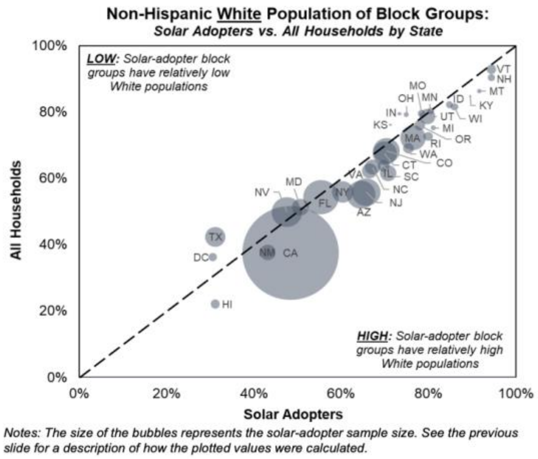
Figure 2. This infamous "duck curve" of energy demand throughout the day. Overlaid is the curve that tracks solar energy production throughout the same period of time. The area between the two curves represents the amount of excess renewable energy that results from these two trends (Burger, 2018).

C. Observed Injustices in the Deployment of DERs

As discussed in Section I, Sunter et al. (2019) have revealed that inequities based on race exist as they relate to the deployment of solar systems across the country, where white-majority neighborhoods had higher adoption rates and BIPOC-majority neighborhoods had lower adoption rates, using no-majority neighborhoods as a baseline. A more recent report by Barbose et al. (2021) at the Lawrence Berkeley National Laboratory (Berkeley Lab) further supports these findings and identifies other trends by comparing the demographic of solar-adopter households with those of general US households.

In their study of solar adoption trends with race and ethnicity, Barbose et al. (2021) found a similar trend to Sunter et al. (2019). Figure 3 below shows the percentage of the population that is white non-Hispanic (at the Census Block level) for solar adopters vs. all households by state.

With most states falling below the diagonal line (indicating a 1:1 ratio), the graph reveals a trend that solar adopters skew towards areas with relatively high white non-Hispanic populations, compared to all households in the state. In California, for example, solar adopters live in Blocks where the population is 48 percent white non-Hispanic on average, while the average Block in the state for all households is 38 percent white non-Hispanic (Barbose et al., 2021, p. 32).



Notes: The size of the bubbles represents the solar-adopter sample size. See the previous slide for a description of how the plotted values were calculated.

Figure 3. Percentage of the population that is white non-Hispanic (at the census block level) for solar adopters vs. all households by state (Barbose et al., 2021, p. 32).

Evaluating solar-adopter trends according to income, Barbose et al. (2021) found that the solar-adopter income tends to skew higher than that of the rest of the population. Figure 4 to the right shows the percentage of households by household income, overlaying the 2019 data for all households, all owner-occupied households, and households with solar (Barbose et al., 2021, p. 11). Even when comparing only to owner-occupied households, wealthier households adopt solar at a higher rate than households with lower incomes (i.e., the column representing solar-adopters extends beyond the other two at higher incomes while the columns for all households and all owner-occupied households extend beyond the solar adopter column at lower incomes). The report by Barbose et al. (2021) additionally

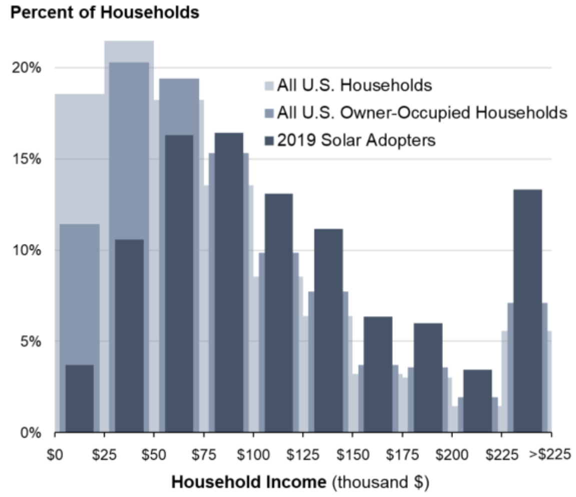
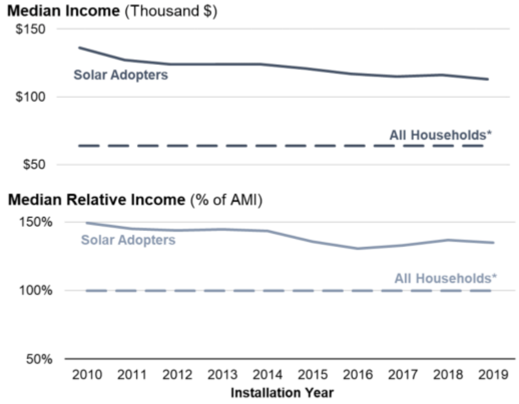


Figure 4. Percentage of households by household income for all households, all owner-occupied households, and solar-adopters in the United States (Barbose et al., 2021, p. 11).

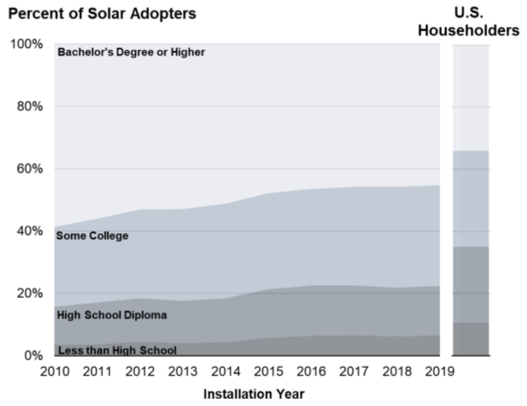
reveals that the median household income of solar-adopters dropped from around 150 to 140 percent of the area median income between 2010 and 2019, as shown in Figure 5 to the right (Barbose et al., 2021). Although these differences in the demographics between those households with and those without solar are diminishing over time, they are doing so rather slowly.



*The flat lines for "All Households" reflect incomes in Q1 2020 and simply serve as a reference level for the solar-adopter incomes, which are based on the same timeframe.

Figure 5. Median income and median relative income of solar-adopter households, as compared to all households, from 2010 to 2019 (Barbose et al., 2021, p. 13).

Regarding educational attainment, Barbose et al. (2021) found that the level of education of solar adopters is generally higher than that of the rest of the population. 45 percent of solar-adopter households in 2019 had at least one person with a bachelor's degree or higher and 22 percent had a high school diploma or less, as compared to 34 and 35 percent population-wide (p. 28). Figure 6 below shows the percentage of solar-adopter households in each category of educational attainment compared to all households from 2010 to 2019, demonstrating that solar adoption tends to skew towards higher levels of education (Barbose et al., 2021, p. 28). The difference in solar-adopter education level and that of the general population is shrinking over time, as the graph shows, which may be due to increased public awareness of and familiarity with these kinds of technologies and



Notes: Education level for each solar adopter is based on the highest known education level among adult household members, and for the U.S. population is based on the education level of householders.

Figure 6. Percentage of solar-adopter households by educational attainment, as compared to all households, from 2010 to 2019 (Barbose et al., 2021, p. 28).

related programs. However, this trend is happening at a rather slow pace—nearly over a decade—and seems to have flattened in recent years.

D. State-Level Incentive Programs

State-level financial incentive programs (in the form of rebates, performance incentives, etc.) are a key strategy for shifting away from fossil fuel infrastructure and moving towards a clean and renewable energy future; they can also be a tool for addressing energy injustices like the ones observed by Sunter et al. (2019) and Barbose et al. (2021). Incentivizing the adoption of DERs at the residential level can increase the pace of deployment—which is especially important due to the urgency of the climate crisis—and reduce the cost of these technologies over time via economies of scale (Lantz & Doris, 2009, pp. 13-17). Additional benefits that may come with these kinds of programs include reduced household energy bills, increased consumer awareness of DERs, and social mobilization for climate action (EPA, 2015).

In addition to facilitating the transformation of the energy system, rebate programs that incentivize these technologies may further encourage people to shift towards other climate-friendly behaviors, having felt the rewards (i.e., the one-time rebates and long-term decrease in energy bills) of their actions (Cossman, 2013, pp. 895-900; Salamon & Gage, 2020). Increasing opportunities for consumer-level action creates a culture of responsibility and even reduces levels of climate anxiety, as it offers people more agency and teaches them that individual action is important even in what can sometimes feel like a hopeless fight against climate change (Mark, 2019; Nugent, 2019).

Not only can these kinds of programs encourage further engagement in the climate movement, but they also can inspire a positive ripple or snowball effect (Rowlatt, 2019). Often referred to as "seeding," the first-mover users of state-level incentive programs can lead the way in growing the adoption of DER technologies in their neighborhoods (Bollinger & Gillingham, 2012; Graziano & Gillingham, 2015; The Solar Foundation & SEIA, 2019, p. 15). This phenomenon typically occurs with rooftop solar systems, as they are always visible to neighbors, but other technologies like solar-plus-storage systems and EVs have the potential to spread in similar ways.

However, Sunter et al. (2019) find that, in addition to having fewer solar PV installations overall, Black-majority neighborhoods have a disproportionately lower initial deployment of solar than other demographics. Figure 7 to the right shows the percentage of Black-, Hispanic-, Asian-, and white-majority census tracts with at least one existing solar installation. Through this categorical analysis, the researchers found that 47 percent of Black-majority census tracts do not have existing rooftop PV installations, which is about twice as high as other demographics. However, Sunter et al. find that when seeding does happen in communities of color, adoption of solar increases more significantly across low-income households.

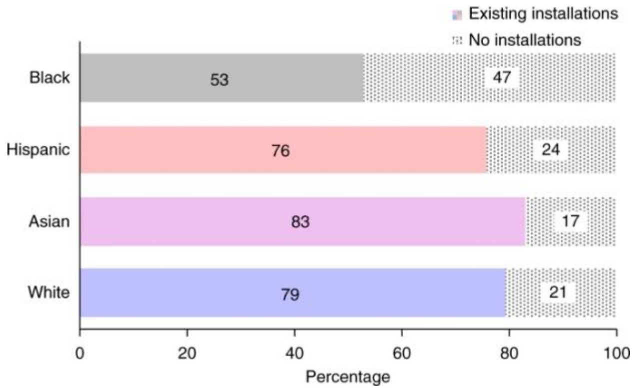


Figure 7. Percentages of each census tract with and without existing rooftop PV installations 2019 (Sunter et al., 2019).

Given these results and the potential that state-level incentive programs have for transforming the energy system—particularly rapidly within BIPOC and low-income communities—state-level incentive programs must equitably serve people. This study directly addresses this critical question of the equitability of DER incentive programs and builds upon the work of Barbose et al. (2021), Drehobl and Ross (2016), and Sunter et al. (2019) by analyzing the equitability of past and current state-level incentive programs for solar PV and battery storage systems in California and Massachusetts. In the subsections below, I present each state's position as a national leader in environmental policy, accompanied by background information on each of the incentive programs they offer (see Table 4 below).

State	**Technology**	**Period**	**Incentive Program**
California	Battery Storage	2001-Present	Self-Generation Incentive Program
	Solar PV	2007-2016	General Market Program
		2008-2021	Multifamily Affordable Solar Housing
		2009-2021	Single-family Affordable Solar Housing
		2019-Present	Disadvantaged Communities - Single-family Affordable Solar Housing
		2019-Present	Solar on Multifamily Affordable Housing
Massachusetts	Solar PV	2010-2014	Commonwealth Solar
		2011-Present	Solarize Massachusetts
	Solar PV + Battery Storage	2018-Present	Solar Massachusetts Renewable Target

Table 4. In chronological order for each state, all California and Massachusetts incentive programs for solar PV and battery storage systems included in this study.

1. California

California is a pioneer of environmental policies and solutions in the United States. Its progressive political leaning and susceptibility to poor air quality, droughts, and wildfires mean that the state is typically one of the first to react to the climate crisis through political action. The deployment of DERs has been crucial for mitigating precautionary power outages during wildfire seasons across the state, and demand for these technologies continues to increase (John, 2019b). Incentive programs have been a powerful tool for the deployment of DER technologies in California.

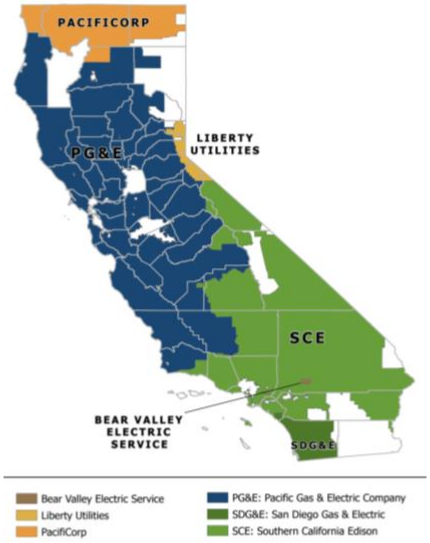


Figure 8. Map of the six electric IOU areas in California: Bear Valley Electric Service, Liberty Utilities, PacifiCorp PG&E, SDG&E, and SCE (California Energy Commission, 2020).

Most of California's DER incentive programs are offered through the state's three major electric IOU companies: Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E), together serving about 12 million electric customers throughout the state in 2017 (California Department of Technology, 2020). Figure 8 shows the service territory map for the six electric IOU areas in the state (California Energy Commission, 2020).

In the subsections below, I describe each of the solar and battery storage incentive programs in California included in this study: the General Market Program, Single-family Affordable Solar Housing (SASH), Multifamily Affordable Solar Housing (MASH), Disadvantaged Communities - Single-family Affordable Solar Housing (DAC-SASH), Solar on Multifamily Affordable Housing (SOMAH), and Self-Generation Incentive Program (SGIP).

a) California Solar Initiative

California has had several residential solar incentive programs over the years through the California Solar Initiative (CSI), including the General Market Program and two subprograms specifically designed for low-income communities—SASH and MASH.

Designed with a declining block incentive structure, CSI is meant to support the growth of the solar industry while reducing its reliance on subsidies. The General Market Program supported businesses and existing homes in the adoption of rooftop solar. With an incentive budget of $1.95 billion and a goal of installing 1750 MW throughout its course, the program ran from January 2007 to December 2016 (State of California, 2021b). After that point, California did not see a need for a direct incentive on solar for the general market, as the cost of solar panels significantly decreased as a result of previous incentive efforts.

Meanwhile, SASH and MASH are in a transition period, soon to be replaced by new versions of each program. Originally available in the three major IOU service territories, SASH is only accepting applications for customers in SCE's service territory for the remainder of 2021 and MASH has completely closed to applications (State of California, 2021c; State of California, 2021d). With common goals of reducing household energy bills and increasing solar adoption in the affordable housing sector, a key difference between the two programs is that SASH offered one incentive rebate rate while MASH offered two different rates: one for installations where the tenant received less than 50 percent of the economic benefit of allocated generation and the other for installations where the tenant received at least 50 percent of the benefit.

b) DAC-SASH and SOMAH

Launched in 2019, California's two most recent incentive programs—DAC-SASH and SOMAH—are successors to the state's earlier SASH and MASH programs, respectively. Both programs are specifically designed to encourage solar adoption in the affordable housing sector, accepting applications from low- to moderate-income customers in disadvantaged communities within the PG&E, SDG&E, and SCE service territories (State of California, 2021e; State of California, 2021f). SOMAH is additionally available in the Liberty Utilities Company and PacifiCorp territories.

Funded by GHG allowance auctions per the state's Cap-and-Trade Program,[14] DAC-SASH and SOMAH are set to provide \$8.5 million and \$100 million in incentives annually through 2030, respectively (CESA, 2021a; CESA, 2021b).

c) Self-Generation Incentive Program

Established in 2001, SGIP originally supported the deployment of solar PV technologies but has since transitioned to other distributed energy resources (State of California, 2021a). In particular, the long-running state-level program provides financial incentives for the deployment of technologies including wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells, and advanced energy storage systems. Available throughout PG&E, SCE, SDG&E, and SoCalGas service territories, the program aims to reduce GHG emissions, reduce energy demand, and transform the market for distributed energy resource technologies (State of California, 2021a).

Utilizing a declining block incentive structure, the program's rebate rate decreases \$0.05-0.10 per watt-hour over five blocks ("steps," as they are called within the program) from the initial \$0.50 per watt-hour rate for residential storage systems, allocating a total of approximately \$40 million for energy storage systems at each block (State of California, 2017, p. 24; State of California, 2021a). SGIP additionally offers higher rebate amounts for low-income, medically vulnerable, and at-risk for fire communities through its "equity" and "equity resilience" categories—which constitute the program's "Equity Budget." However, the program creates this Equity Budget by reducing the program budget by 25 percent in Steps 3-5, and by delaying the

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[14] California's Cap-and-Trade Program is a market-based approach to regulating and gradually reducing GHG emissions. Administered by the California Air Resources Board, it establishes a declining limit (or "cap") on the amount of permissible GHG emissions throughout the state. Allowances equal to the cap can then be bought and sold (or "traded") among businesses and other emitters to comply with the established limit. For more information on the state's Cap-and-Trade Program, visit arb.ca.gov/our-work/programs/cap-and-trade-program.

timeline for when qualifying projects would be able to apply the increased "equity" and "equity resilience" (State of California, 2017, p. 11). Given the urgency of the environmental and climate crisis in California, where wildfire seasons already cause great devastation, equity and resilience concerns must be at the core of incentive programs, rather than treated as an addition to them.

2. Massachusetts

Another leader in the environmental policy sphere, Massachusetts has recently passed a bill that encourages a move towards clean and renewable energy sources (Cronin, 2012). On March 26, 2021, Governor Charlie Baker[15] signed "An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy" that aims to reduce GHG emissions and protect EJ communities (192nd General Court of the Commonwealth of Massachusetts, 2021).

An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy, Section 11F3/4
(a) Each municipal lighting plant shall establish a greenhouse gas emissions standard, which shall be known as the "Municipal Lighting Plant GGES."
(b) A Municipal Lighting Plant GGES shall set the minimum percentage of non-carbon emitting energy sold by each municipal lighting plant to all retail end-user customers purchasing electricity pursuant to rates established pursuant to section 58 of chapter 164 as follows: (i) 50 per cent non-carbon emitting energy by 2030; (ii) 75 non-carbon emitting energy per cent by 2040; and (iii) energy sales achieving net-zero greenhouse gas emissions by 2050.

Table 5. Section 11F3/4 of Massachusetts's Bill 9, increasing the standards for municipal lighting plants (192nd General Court of the Commonwealth of Massachusetts, 2021).

The deployment of DERs across the state is essential to reach the objectives outlined in Table 5 above. Similar to California, Massachusetts has run several incentive programs to stimulate the adoption of DER technologies at the residential level throughout the past decade and a half. These include Commonwealth Solar, Solarize Massachusetts (Solarize Mass), and

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[15] Action on climate and clean energy does not need to be a politically partisan issue. Notably, Governor Baker is a Republican while Governor Newsome in California is a Democrat. Both understand that a transformation of the energy system is necessary and inevitable, and that it is imperative to think about equity as it takes place.

Solar Massachusetts Renewable Target (SMART), in addition to Solar Renewable Energy Certificate (SREC) I and II, which are not included in this study because incentive amounts for these programs are variable and not clearly defined due to the nature of the program. In the subsections below, I describe each of the solar and battery storage incentive programs in Massachusetts that are included in this study.

a) Commonwealth Solar

Commonwealth Solar is one of Massachusetts's early solar PV incentive programs. Launched in 2010, it aimed to increase solar adoption in the residential, commercial, industrial, institutional, and public sectors and to create jobs across the state (MassCEC, 2015). The program utilized a declining block incentive structure with two adders[16] that provided an increased rebate rate for low and moderate home value and low- and moderate-income households (Massachusetts Technology Collaborative, 2008, p. 12; OpenEI, 2014). Closing in 2014, the program succeeded at fulfilling both objectives, supporting a local solar industry that employs over 12,000 people and facilitating a $407 million investment in solar energy by providing $36 million in rebates (MassCEC, 2015).

b) Solarize Massachusetts

The Massachusetts Clean Energy Center (MassCEC), in partnership with the state's Department of Energy Resources, piloted Solarize Mass in 2011 as part of a state-wide initiative to install 250 megawatts of solar by 2017 (MassCEC, 2012).

The program aims to increase solar through a two-pronged approach: (i) grassroots education campaigns driven by community leaders and volunteers, and (ii) a tiered pricing

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[16] Adders are additional incentives incorporated into the program structure that can increase the rebate amount for applications that meet certain predetermined criteria, as per the program guidelines.

structure by which the rebate rate increases as more households in the community participate (MassCEC, 2012). Together, these two components utilize the power of community organizing to reduce the cost of installations through reduced marketing and acquisition costs and bulk purchasing.

c) Solar Massachusetts Renewable Target

Launched in November 2018, SMART is a long-term sustainable incentive program that supports the deployment of solar PV and battery storage systems in Massachusetts. Created as a successor to Commonwealth Solar and SREC, the current SMART program is a performance-based program with a 3,200-megawatt declining block incentive structure. Its base compensation rate depends on the distribution company, size of the solar system being installed, low-income status, and capacity block. The program offers multiple adders, including ones based on location (e.g., agriculture, brownfield, building mounted, canopy, and landfill); offtaker (e.g., community shared, low-income community shared, low-income property, and public entity); solar tracking; being pollinator-friendly; and incorporating energy storage.

E. Purpose of Study

A growing number of recent studies have analyzed the distribution of DER technologies and show that the distribution of DERs is not equitable (Barbose et al., 2021; Drehobl & Ross, 2016; Schunder et al., 2020; Sunter et al., 2019). As described above, Sunter et al. (2019) used remote sensing and demographic data to show that the deployment of rooftop solar panels predominantly occurs in white neighborhoods, even after controlling for homeownership. A more recent report by Barbose et al. (2021) at the Berkeley Lab supports the Sunter et al. findings, revealing inequalities in DER deployment and adoption based on race and ethnicity, income, level of education, and other demographics. Barbose et al. explore how the inequitable deployment of DERs has cascading effects that can increase the intensity of the unequal distribution of benefits and burdens of the new clean energy economy—a classic example of distributive injustice. Furthermore, as explored in Section I above, the inequitable deployment of DERs exacerbates the vulnerability of those already burdened communities by denying them energy resilience in the face of climate change-related power outages (Federal Energy Management Program, 2019; Zitelman, 2020).

States must thus strive towards equitable access to these technologies, paying particular attention to the aspects of DER incentive programs that may contribute to or take away from equal participation. With that in mind, my research builds on previous findings, assessing rebate programs for solar PV and battery storage systems in California and Massachusetts in Sections III and IV. By analyzing the distribution of these rebates against race and ethnicity, median income, level of education, English proficiency, tenure, and household size, Section V of my study quantifies the relative equitability of these programs and identifies elements of each that might explain their ranking. Finally, in Sections VI, I explore recommendations to increase the equitability of existing programs and suggest structures for the establishment of new and equitable solar rebate programs where they do not yet exist.

F. Statistical Model

This study requires that I set a unit of measurement for the DER incentive programs to determine whether the DER incentives are equitably distributed. I created two statistical models for each program based on two measures of DER incentive equitability at the zip code level: (i) the average incentive amount per household by year and (ii) the percentage of households that the program served by year. The first measure explores whether households in specific zip codes, differentiated by the demographic data, receive more or less DER incentive money. Meanwhile, the second measure evaluates whether the DER programs are more or less popular in specific zip codes, providing the likelihood that a household is served based on demographics.

As for the independent variables in my study, I included race and ethnicity, median income, level of education, English proficiency, tenure, and household size. I decided to include this group of independent variables based on data availability, statutory definitions of an "environmental justice population," and literature that drew connections between the deployment of DER technologies at the residential level and these demographics.

While California defines a "disadvantaged community" as the highest scoring 25 percent of census tracts from California Communities Environmental Health Screening Tool Version 3.0,[17] Massachusetts defines "environmental justice population" in the recently signed Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy, as follows:

An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy, Section 56
"Environmental justice population," a neighborhood that meets 1 or more of the following criteria: (i) the annual median household income is not more than 65 per cent of the statewide annual median household income; (ii) minorities comprise 40 per cent or more of the population; (iii) 25 per cent or more of households lack English language proficiency; or (iv) minorities comprise 25 per cent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 per cent of the statewide annual median household income

Table 6. Massachusetts's statutory definition of "environmental justice population," as it appears in Bill 9 (192nd General Court of the Commonwealth of Massachusetts, 2021).

Considering that the definition includes race and ethnicity, median income, and proficiency in English, I include the following independent variables: race and ethnicity, median income, level of education, English proficiency, tenure, and household size.

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[17] California Communities Environmental Health Screening Tool Version 3.0 (CalEnviroScreen 3.0) is the most recent version of California's place-based screening tool that depicts the distribution of negative environmental impacts across communities by census tract. For more information on CalEnviroScreen 3.0, visit oehha.ca.gov/calenviroscreen/report/calenviroscreen-30.

1. Race and Ethnicity

My analysis of energy justice will necessarily explore the intersection of energy systems and social justice, therefore contributing to our understanding of the long history of systematic racism in the United States that continues to exist. In addition to Massachusetts's definition of an environmental justice population, various studies in the literature have revealed a connection between the deployment of solar energy resources at the residential level and an area's racial and ethnic composition.

Using the findings by Sunter et al. (2019) and Barbose et al. (2021) discussed in Sections I and II.C as a foundation, I included race and ethnicity in my study, represented by the "white non-Hispanic" variable and measured as the percentage of the population within a zip code that identifies as white non-Hispanic.

2. Median Income

In addition to being part of Massachusetts's definition of an environmental justice population, economic status is a key dimension of social justice. The findings by Barbose et al. (2021) discussed in Section II.C combined with the fact that low-income households experience the highest energy burden, spending 7.2 percent of their income on energy costs, it is important for state-level DER incentive programs to financially support households with the greatest needs (Drehobl & Ross, 2016). To evaluate the equitability of these programs based on income, I included an income variable, measured as the median household income by zip code.

3. Level of Education

Given the trend observed by Barbose et al. (2021) and discussed in Section II.C, I included a variable that represents a population's level of education to evaluate whether the same skew towards more highly educated households occurs with state-level incentive programs for DERR technologies as it does with solar adoption. The education variable is measured as the percentage of the population within a zip code that has earned a bachelor's degree or higher. Including this variable in the statistical models allows me to measure the accessibility of incentive program materials based on educational attainment.

4. English Proficiency

Along with the average level of education, the percentage of non-English speaking households is another variable that may measure the equitability of incentive programs. If programs fail to provide materials in different languages representative of the state population, then people with low proficiency in English may be systematically excluded from participating. Additionally, given that a population's level of English language proficiency enters into the definition of an environmental justice community, I included a variable that represents English proficiency measured as the percentage of households that are not limited English-speaking households, as per the ACS (192nd General Court of the Commonwealth of Massachusetts, 2021).

5. Tenure

Whether a household is owner- or renter-occupied plays an important role in the tenants' ability to control their energy usage and sourcing. As previously discussed, Drehobl et al. (2020) find that renters face a higher energy burden than the median US household at 4.0 percent and that 97 percent of those energy costs could be eliminated with increased energy efficiency. However, because landlords would bear the cost of upgrading appliances and improving weatherization while tenants receive the immediate benefits (often referred to as "split incentives"), landlords typically under-invest in these opportunities for energy savings (Bird & Hernández, 2012; Melvin, 2018).

The same is true for electricity sourcing. In their report, Barbose et al. (2021) discuss that solar-adopter households included in their analysis are almost entirely owner-occupied due to the increased control that owners have over their rooftops and the shortcomings of the owner/tenant split incentive. Consequently, the limited agency and ability that tenants have to install solar PV and battery storage systems decrease their likelihood to apply for and use state-level incentive programs for these technologies. Given these findings, I included a variable representing tenure, measured as the percentage of households within a zip code that are owner-occupied.

6. Household Size

Although there is no set maximum size of a solar array that households are allowed to install, states and local utilities typically cap the amount of electricity that residents can generate on their rooftops based on their average annual household electric usage, as a measure to prevent residences from over-producing solar energy and competing with utilities. Although California does not set a maximum size for solar installations, residents who install arrays larger than 15 kilowatts must pay higher permitting fees; SDG&E additionally sets a service area-specific limit of 125 percent of the average household energy usage (Freedom Forever, 2019). Meanwhile, Massachusetts takes a different approach. Although there is no state-wide limit on the size of solar arrays permitted, there is a cap on the amount of solar that is eligible for net metering at 10 kilowatts (EnergySage, 2020).

Given that the size of solar and, consequently, battery systems are typically determined by the average household energy usage, a household with more people will typically use more energy and thus be eligible for a larger solar array installation. However, other factors like decreased leisure time to learn about DERs and related incentive programs may lead larger households to be less likely to discover and use these opportunities. For these reasons, it is important to evaluate the effect that household size can have on rebate amounts and the likelihood of being served by these programs. In this study, household size is measured as the average number of people per household within a zip code.

III. Methods

A. Selection Process

California and Massachusetts were chosen for this study because of their robust programming that incentivizes DER technologies. Both states are leaders when it comes to offering rebate programs for the three technologies chosen for this study. The programs of interest—General Market Program, SASH, MASH, DAC-SASH, SOMAH, SGIP, Solarize Mass, and SMART—were chosen because they cover the programs previously and currently offered in each state for solar PV and battery storage systems.

B. Data Collection & Formatting

Sourcing from Social Explorer,[18] I used the ACS five-year estimates as the source of foundational demographic data for California and Massachusetts at the zip code level. I downloaded two data sets for the years 2010-2014 and 2015-2019, including the variables listed in Table 7 below (US Census Bureau, 2015; 2020). Because data for the years before 2010 and after 2019 were not available at the zip code level, I stretched the data two to three years in each direction to include all of the years during which the programs covered in this study operate, covering a total year range from 2007 to 2021.

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[18] Social Explorer is a web-based tool that provides easy access to current and historical data about the United States population. It can be used to create maps and other visualizations. For more information on Social Explorer, visit socialexplorer.com/.

Name	**Description**
B01003	Total Population
B03002	Hispanic or Latino Origin by Race
B11016	Household Type by Household Size
B15003	Educational Attainment for the Population 25 Years and Over
C16002	Household Language by Household Limited English Speaking Status
B19013	Median Household Income in the Past 12 Months (in 2019 Inflation-Adjusted Dollars)
B25003	Tenure

Table 7. List of variables used from the ACS five-year estimates for the years 2010-2014 and 2015-2019 (US Census Bureau, 2015; 2020).

For the race and ethnicity variable in my study, I transformed the white non-Hispanic variable under "Hispanic or Latino Origin by Race" into a percentage by dividing it by the total population. For the household size variable in my study, I divided the total population by the total number of households under "Household Type by Household Size." For the education variable in my study, I added the number of people with a bachelor's or higher degree and divided it by the total population to obtain the percentage of the population with a bachelor's or higher degree. For the language barrier variable in my study, I added the "English Only" and all of the "Not a Limited English Speaking Household" under "Household Language by Household Limited English Speaking Status," later dividing it by the total number of households to obtain the percentage of households in which at least one person has an adequate proficiency in English. For the income variable in my study, I did not modify the median income variable from the ACS data sets. Finally, for the tenure variable in my study, I divided the number of "Owner-Occupied" households by the total number of households to obtain the percentage of owner-occupied households, as opposed to renter-occupied.

As for the incentive programs, the California General Market Program data were taken from the CSI data set provided by the California Distributed Generation Statistics (CaliforniaDGStats), assuming that the “Small Commercial and All Residential” category represents the General Market Program. As reported on the website, I used the “completed” and “in payment” incentive applications for my study, ensuring to use only the projects at the residential level (CaliforniaDGStats, 2021).

California’s SASH, MASH, and DAC-SASH data were all taken from the Low-Income data set provided by CaliforniaDGStats. As reported on the website, I used the “completed” and “confirmed reservation” incentive applications for my study, ensuring to use only the projects at the residential level (CaliforniaDGStats, 2021). MASH specifically supports solar PV projects on multifamily housing, but some of the values for the number of units in the participating multifamily housing developments were missing. Where the number of units was missing, I multiplied each data point by 36, representing the average number of units per multifamily housing development, calculated across the entire data set.

California’s SOMAH data were provided by the California Distributed Generation Statistics. As reported on the website, I used the “completed” and “in progress” incentive applications for my study, ensuring to use only the projects at the residential level (CaliforniaDGStats, 2021). Given that SOMAH specifically supports solar PV projects on multifamily housing, I used the “Total Number of Units” column as the number of households served.

Data for the final California program, SGIP, were provided by the program website (Center for Sustainable Energy, 2021). As reported on the website, I used the “completed” and "reserved incentive" applications for my study, ensuring to use only the projects for battery storage at the residential level.

Massachusetts's Commonwealth Solar and Solarize Mass data were provided by MassCEC. This data sheet provided the "in service" incentive applications, and I ensured to use only the projects at the residential level (MassCEC, 2021). Unfortunately, data for Solarize Mass were not available after the year 2016, although the program continues to run today. This lack of available data is a limitation of my study.

With support from Marx Science and Social Science Library at Yale University, SMART program data were extensively reformatted because the original data did not report the amount of money given to each household. I used the "approved" incentive applications for my study, ensuring to use only the projects at the residential level. Using the data and key provided by the Commonwealth of Massachusetts (2021), I calculated the amount of money awarded to each application, ensuring to account for adders and other special cases that impact the rebate rate. Because the SMART incentive amount is based on the actual amount of solar energy generated by the solar array, I had to use some reasonable assumptions to calculate the incentives. Specifically, I used the same generation rate of 1,250 kilowatt-hours per year for all households with an annual degradation rate of 0.5 percent. Additionally, to calculate the storage adder rate, I estimated that 1 kilowatt AC is equal to 1.5 kilowatts DC. Using the resulting values for the storage adder rate, I created two different rebate rates for each SMART application: (i) the full rebate rate and (ii) the storage adder rate. I used the first one to evaluate the equitability of SMART as a complete solar incentive program and the second to evaluate the equitability of SMART as a battery storage incentive program.

For all of the California and Massachusetts solar programs, I downloaded the data in March and April 2021 to ensure I used the most recent versions available, as current programs provide weekly or monthly updates. I used the pivot table function in Microsoft Excel to export the data, creating rows for each zip code by year and columns for the incentive amount awarded and the number of households served under each program. After merging the demographic data with the program data, I divided both the incentive amount and the number of households served by the number of households within that zip code to get the incentive amount per household and the percentage of households served for each program.

C. Assumptions & Limitations

Assumptions are a necessary part of any study to simplify the issue at hand into one that can be modeled and analyzed, and this study is no exception. In addition to the generalizations made throughout the data processing and formatting process, I assumed that each application represents a unique project for a unique household, except for multifamily-specific applications, as mentioned in Section III.B above.

Additionally, to perform the multiple linear regressions, I assume that there is a linear relationship between the dependent and independent variables in each model; independent variables are not highly correlated with each other (i.e., little to no multicollinearity); residuals are normally distributed (i.e., multivariate normality) and the variance of residuals is constant (i.e., homoscedasticity); and that observations are independent of one another.

Other limitations to my study include that program data was only available at the zip code level. This macro-level analysis means that, although rebate dollars may be allocated towards zip codes with a relatively low white non-Hispanic population (for example), there is no way to know from the data whether they specifically went to a white non-Hispanic household or a household of color. Further, because the data was not available through the ACS, I did not include the average household size in terms of square footage. This data would be relevant, given that the size of solar and battery systems is typically determined by the average household energy usage, and that a larger house that requires a greater amount of energy to maintain may impact the amount of money it receives from incentive programs for the adoption of DERs (Freedom Forever, 2019).

D. Statistical Analysis

For each incentive program, I constructed two multiple linear regression models that look for significant independent variables that explain the following two dependent variables: (i) the incentive amount per household within each zip code by year and (ii) the percentage of households within each zip code that the program served by year. The first measure explores whether households in specific zip codes, differentiated by the demographic data, receive more or less DER incentive money. Meanwhile, the second measure evaluates whether the DER programs are more or less popular in specific zip codes, providing the likelihood that a household is served based on demographics.

As for the independent variables in my study, I included the percentage of the population that is white non-Hispanic, median income, the percentage of the population with a bachelor's degree or higher, the percentage of the population that is proficient in English, the percentage of owner-occupied households, and the average household size in number of people. I additionally created indicator variables for each year to control for factors that may have changed across all observations for a given year.

Table 8 below shows the command that I used to reach the results in Section IV. For each program, I ran the regression twice, replacing "[program variable]" with each of the two dependent variables.

Stata Command
regress [program variable] race income education language tenure household_size i.year, robust

Table 8. Stata command used to reach the results in Section IV.

IV. Results & Analysis

The results tables are included in Appendix 1, where Tables 9 and 10 correspond to incentive programs for solar PV deployment, and Tables 11 and 12 correspond to incentive programs for battery storage systems. Tables 9 and 11 both show the regression output when the dependent variable was the percentage of households served in a zip code. Tables 10 and 12 show the regression output when the dependent variable was the percentage of households served in a zip code.

A. Race and Ethnicity

The coefficient for the variable representing the percentage of the population that is white non-Hispanic is positive and statistically significant for California's General Market Program in both regressions, as reported in Tables 9 and 10. The direction and statistical significance of the coefficient indicate that, as the white non-Hispanic population within a zip code grows, so too do the incentive amount per household given to that zip code and the likelihood that a household is served by an incentive program. The same is true for California's SGIP, as reported in Tables 11 and 12.

Additionally, for the California programs specifically designed to serve disadvantaged communities—MASH and DAC-SASH—this coefficient is negative and statistically significant. The direction and statistical significance of the coefficient indicate that, as the white non-Hispanic population within a zip code grows, the incentive amount per household given to that zip code and likelihood that a household is served by an incentive program both decrease.

The rest of the programs do not have statistically significant results with respect to race and ethnicity, which suggests that the percentage of the population that is white non-Hispanic does not impact the average amount of money that these other programs award to a zip code or the likelihood of being served.

B. Median Income

The coefficient for median income is positive and significant for California's General Market Program in both regression models, as reported in Tables 9 and 10. The direction and statistical significance of the coefficient indicate that, as the median income in a zip code increases, so too does the incentive amount awarded and the likelihood of being served by this program. I expected to see this result, as California's General Market Program is one of the earliest of its kind nationwide and was not specifically designed to serve lower-income populations.

Meanwhile, the coefficient is negative and significant for California's SASH program and Massachusetts's Commonwealth Solar and SMART programs. The direction and statistical significance of the coefficient indicate that, as the median income in a zip code increases, the incentive amount awarded and the likelihood of being served by these programs decreases. The results suggest that the programs are succeeding in reaching lower-income communities, which may be because they became active years after California's General Market Program and may have learned from its mistakes. As opposed to California's program, these programs were specifically designed either to serve low-income residents (SASH) or have special incentives for low-income participants (Commonwealth Solar and SMART).

The rest of the programs in California and Massachusetts do not have statistically significant results, which suggests that median income does not impact the average amount of money that a program awards to a zip code or the likelihood of being served.

C. Level of Education

The regression results for the education variable are mixed. The coefficient for education was negative and statistically significant for California's General Market Program, SASH, and DAC-SASH. This variable indicates that the average rebate amount awarded and the likelihood of being served by these programs in California both decrease as the percentage of the population with a bachelor's or higher degree increases. However, for both Massachusetts programs, Commonwealth Solar and SMART, the opposite is true: the coefficient is positive and significant.

One explanation for these results might be that the concepts and language surrounding DERs can often be jargony and difficult to understand without higher education or prior knowledge on these technologies and the available state-level incentive programs. Therefore, it makes sense that, at least in Massachusetts, zip codes with a higher percentage of the population with a bachelor's or higher degree are more likely to utilize these kinds of programs and, as such, receive higher incentive amounts on average. What may account for the difference between the two states is that California may succeed in making program materials accessible to the general public by using plain language and embarking on more thorough education campaigns; further research on California's communication and marketing strategies is necessary.

A noteworthy result is that the one program in Massachusetts that does not have a significant coefficient for this variable is Solarize Mass, a program specifically designed around a grassroots approach to education. The statistical analysis thus shows that educational attainment is not a driver of participation in the program in either direction. The data suggest that a program like Solarize Mass, which utilizes a grassroots education approach, may do a good job of making program materials available to all. For this and the rest of the programs that do not have a significant coefficient, the data suggest that educational attainment does not impact the average amount of money that a program awards to a zip code or the likelihood of being served.

D. English Proficiency

The coefficient representing the percentage of the population that is proficient in English was only statistically significant for two of the programs but in different directions: positive for California's General Market Program and negative for California's SASH. The direction and statistical significance of the coefficient for the General Market Program indicates that, as the percentage of households with English proficiency in a zip code increases, so too does the likelihood of being served by this program. Meanwhile, for the SASH program, the opposite is true for both dependent variables; as the percentage of households with English proficiency in a zip code increases, both the average amount of money awarded and the likelihood of being served by the program decrease. This result could be explained by further research into whether SASH employs a publicity campaign that specifically targets the non-English speaking population.

The rest of the programs do not have statistically significant results, the data suggest that English proficiency does not impact the average amount of money that a program awards to a zip code or the likelihood of being served.

E. Tenure

Across most of the programs, the variable representing tenure is positive and statistically significant. What this means is that zip codes with a higher percentage of owner-occupied households receive a higher rebate amount and are more likely to be served by the incentive programs. It makes sense that the more households within a zip code are owner-occupied, the higher the rebate amount, because homeowners have greater agency over the property upon which they live, as compared to renters. Conversely, when a household is not owner-occupied, the tenants have little agency and ability to make these kinds of decisions themselves.

Additionally, as described in Section II.F.5 above, owner/tenant split incentives reduce uptake of DER in rental property, because landlords do not have a financial reason to invest in energy resources that would only benefit the tenant. Because these solar and battery DER programs are often publicized as a way for households to reduce their energy bills and generate their own electricity, it is not surprising that homeownership was a significant variable across many of the programs assessed in this study.

F. Household Size

The results for the variable representing average household size (in number of people) are mixed, and too few of the programs have significant results to make any sort of comparisons among programs. There are a few and not mutually exclusive options for what may be occurring. One is that households with more people in them typically use more energy than those with fewer people. Because there are barriers to installing large solar arrays based on the household's electricity consumption patterns, households with fewer people may be limited to smaller solar arrays—even though they might have enough space for a larger array on their roofs—thus limiting in the average amount of money they receive through these programs. Because of the added complexity of the limits on solar size, and how these rules vary by state, as explained in Section II.F.6 above, it is not surprising that regression output for household size may not yield statistically significant results.

Simultaneously, the unavailability of data on average household size in terms of square footage may create confusion in these results, as square footage also impacts the average household energy consumption. To make any conclusion for how household size may impact the average amount of money awarded and the likelihood of being served, the study would likely have to include a variable that represents the average physical size of households within a zip code.

V. Discussion

A. Policy Implications & Importance of Equity

Looking at the race and income variables across the programs, the coefficients that are positive and significant correspond to the solar and battery programs in California that are open to all. Meanwhile, the rest of the programs that either has negative and significant coefficients or have non-significant coefficients correspond to programs that specifically support disadvantaged communities or are otherwise community-centered. The results in Section IV reveal that, when programs are intentional about involving communities and serving environmental justice populations, they are more equitable than the programs that are meant for the general public.

Specifically, the coefficients for race and income for California's General Market Program are both positive and significant, meaning that the whiter and richer that a population grows, the larger the incentive amount they receive and the more likely they are to be served by the program. After its termination in December 2016, however, the state no longer saw a need to subsidize solar for the general public. Instead, it continued to fund programs dedicated to single- and multifamily low-income households.

Despite the state's current and relatively successful focus on solar deployment in low-income communities, California's more recent program for battery storage systems—SGIP—seems to show some of the same shortcomings as the General Market Program did. On the one hand, the higher rebate amounts that SGIP offers low-income, medically vulnerable, and at-risk for fire communities through its "equity" and "equity resilience" categories seem to prevent a positive relationship between the dependent variables and income. On the other, the negative and significant coefficient for the race variable follows a similar trend as the General Market Program did. There may not be a need for California to offer battery subsidies for the general public, and it can instead dedicate the full program budget to supporting the most vulnerable communities.

Another noteworthy observation is that SOMAH and Solarize Mass are the only two programs with no significant coefficients, suggesting that race and income are not drivers of participation in these programs in either direction. Particularly interesting are the strategies that SOMAH and Solarize Mass employ.

SOMAH has incorporated as part of its structure a community advisory council that continuously informs program development and strategizes how to increase the program's effectiveness in supporting communities (California Public Utilities Commission, 2021). The program has formed partnerships with community-based organizations including the California Environmental Justice Alliance and Asian Pacific Environmental Network among others that provide support in maximizing participation and the program's benefits to residents (California Public Utilities Commission, 2021).

Solarize Mass's two-pronged community-driven approach has also proven successful in terms of supporting the equitable deployment of DERs. Its grassroots education campaign and increasing tiered pricing structure encourage participants to engage with their neighbors and other community members, share experiences with the program and knowledge about rooftop solar systems, and maximizes seeding potential (MassCEC, 2012).

It is important to note that the strategies that SOMAH and Solarize Mass use to involve community members are not accidents or after-the-fact additions; they are at the core of these programs. As such, it is imperative that decision-makers consider issues of equity during a program's initial stages and not as an afterthought, as tends to be the case. Especially considering the leading roles that California and Massachusetts have in environmental policy, identifying injustices and effective strategies to mitigate them allows for other states to implement more equitable programs from the start.

B. Approaches to Equity

As explained by leading energy justice scholar Shalanda Baker,[19] many approaches to clean energy deployment in the energy sector tend to support the "resilience" of the energy sector -- and not in the positive sense of the word "resilience," which is commonly used to describe the energy system's ability to withstand severe weather. Rather, resilience-focused problem-solving methods in the energy sector act to reinforce existing structural inequalities that have accrued over time throughout the entire energy system, as outlined in Sections I and II above (Baker, 2019, p. 6). Solutions that aim for a *transition* to a clean energy system fail to consider the need for a complete *transformation* of the existing energy infrastructure and for the alleviation of social, economic, and environmental injustices that are baked into our existing energy system, are resistant to change and typically fall upon BIPOC and low-income communities. In response to this negative resilience of the energy system, Baker (2019, p. 26) urges decision-makers to include these communities in the shift towards a clean and renewable energy system instead of merely hoping that they "bounce back" from traumatic experiences after the fact. The key lesson from Baker's work is that DER incentive programs must include all people in the transformation of the current energy model to a clean energy future.

This call for procedural justice follows the seventh Principle of Environmental Justice that "demands the right to participate as equal partners at every level of decision-making,

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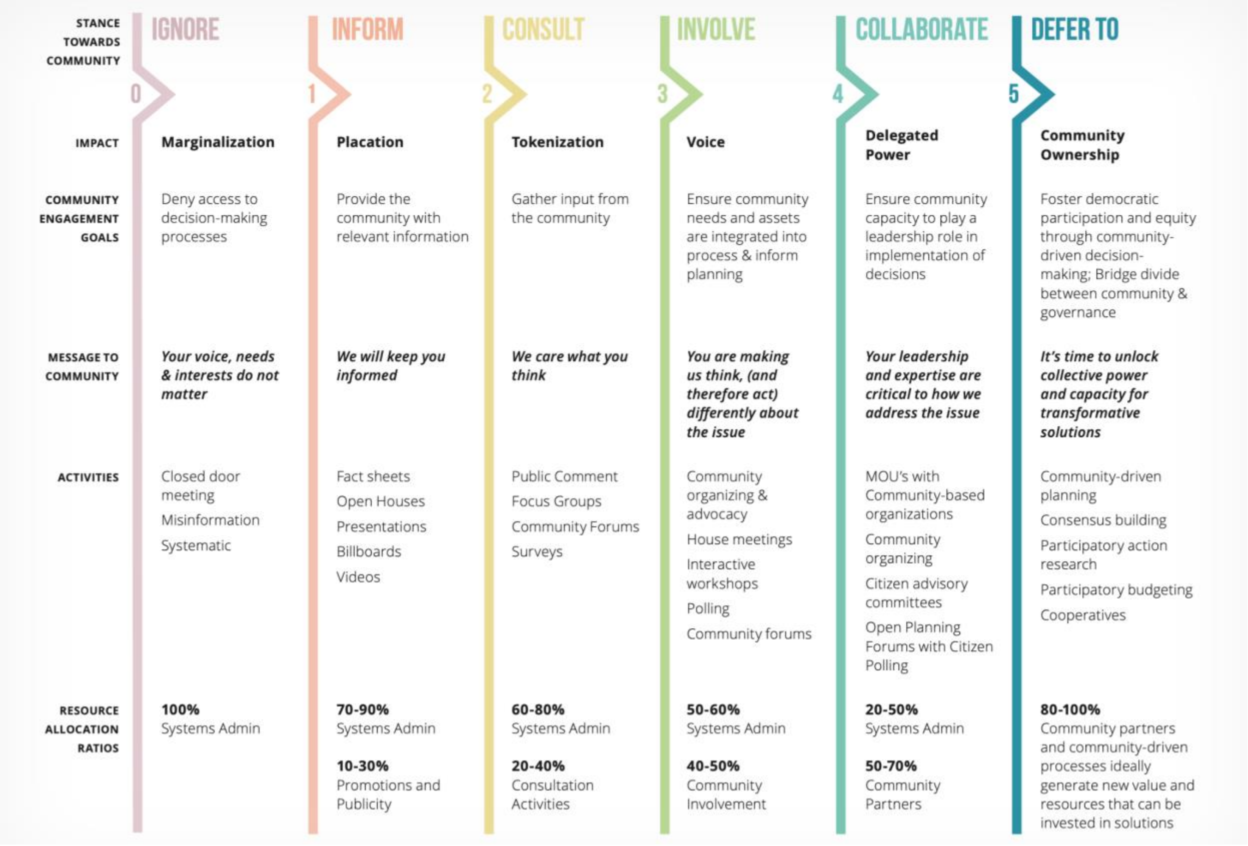
including needs assessment, planning, implementation, enforcement and evaluation" (First National People of Color Environmental Leadership Summit, 1991). Currently, state-level incentive programs for DERs fail to incorporate community members' experiences and instead leaves the immense potential and power that they hold untapped. To ensure that programs are effective, states must focus on involving communities more meaningfully. The "Spectrum of Community Engagement to Ownership" in Figure 9 below can guide state governments in this process (González, 2019).



STANCE TOWARDS COMMUNITY	IGNORE 0	INFORM 1	CONSULT 2	INVOLVE 3	COLLABORATE 4	DEFER TO 5
IMPACT	**Marginalization**	**Placation**	**Tokenization**	**Voice**	**Delegated Power**	**Community Ownership**
COMMUNITY ENGAGEMENT GOALS	Deny access to decision-making processes	Provide the community with relevant information	Gather input from the community	Ensure community needs and assets are integrated into process & inform planning	Ensure community capacity to play a leadership role in implementation of decisions	Foster democratic participation and equity through community-driven decision-making; Bridge divide between community & governance
MESSAGE TO COMMUNITY	***Your voice, needs & interests do not matter***	***We will keep you informed***	***We care what you think***	***You are making us think, (and therefore act) differently about the issue***	***Your leadership and expertise are critical to how we address the issue***	***It's time to unlock collective power and capacity for transformative solutions***
ACTIVITIES	Closed door meeting Misinformation Systematic	Fact sheets Open Houses Presentations Billboards Videos	Public Comment Focus Groups Community Forums Surveys	Community organizing & advocacy House meetings Interactive workshops Polling Community forums	MOU's with Community-based organizations Community organizing Citizen advisory committees Open Planning Forums with Citizen Polling	Community-driven planning Consensus building Participatory action research Participatory budgeting Cooperatives
RESOURCE ALLOCATION RATIOS	**100%** Systems Admin	**70-90%** Systems Admin **10-30%** Promotions and Publicity	**60-80%** Systems Admin **20-40%** Consultation Activities	**50-60%** Systems Admin **40-50%** Community Involvement	**20-50%** Systems Admin **50-70%** Community Partners	**80-100%** Community partners and community-driven processes ideally generate new value and resources that can be invested in solutions

Figure 9. *Steps along the "Spectrum of Community Engagement to Ownership" from ignoring communities (a zero on the spectrum) to deferring to communities (a five) (González, 2019, p. 2).*

Except for marginalization, each element of the Spectrum of Community Engagement in Figure 9 is a necessary part of "building capacity for community collaboration and governance" (González, 2019, p. 5). That said, in the few instances that governments attempt to increase community engagement, informing and consulting communities is the most common form. This level of participation is often viewed by policymakers as sufficient for understanding the problems that communities face and identifying solutions for them. However, because these "solutions" are not developed and implemented by community members for community members, the solutions often fail to fully address the issue at hand and, even worse, can lead to the creation of new problems.

The problem that energy-focused programs are facing is that decision-makers are failing to foster meaningful connections with community members. A study by Catalano et al. (2019) analyzed conservation projects that have failed, categorizing their causes for failure by five primary themes: people, action, information, funding, and economic and political.[20] Having reviewed a final selection of 59 articles, the researchers found that the "people" category was the most common reason for failure with "relationships between stakeholders" being the top secondary theme, as shown in Figure 10 below (Catalano et al., 2019).

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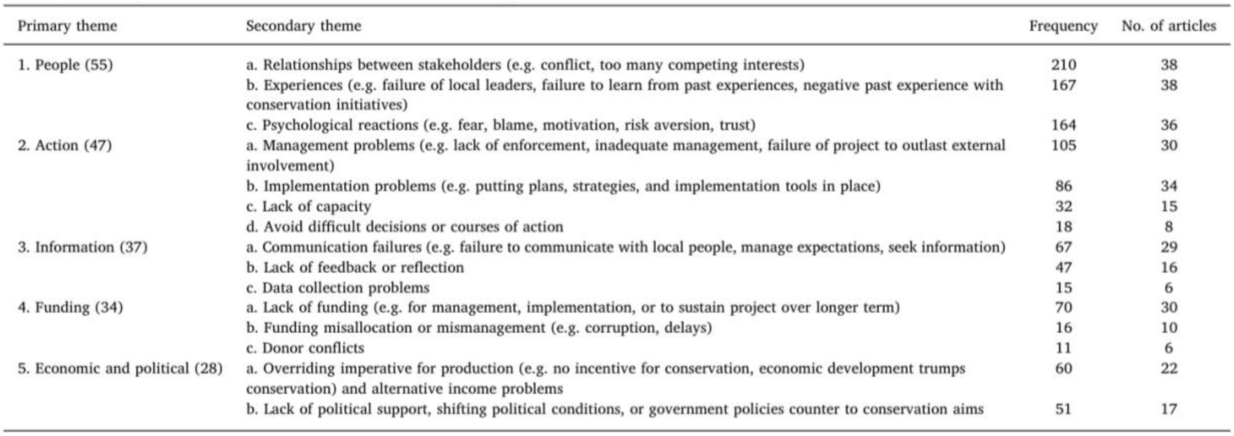
[20] Catalano et al. (2019) additionally recognized two limitations to their study. The first is that it is often difficult to tell whether a project has "succeeded" and "failed" based on reporting because the language used is unclear and there are no fully defined criteria for success. The second is that institutions and project managers rarely report failed projects either because they do not think it would be useful to do so or because they want to preserve their reputation. The researchers thus urge planners both to indicate how they are measuring the project's success or failure and to report failures, as they are oftentimes just as useful as success stories (Shiffman, 2019).



Primary theme	Secondary theme	Frequency	No. of articles
1. People (55)	a. Relationships between stakeholders (e.g. conflict, too many competing interests)	210	38
	b. Experiences (e.g. failure of local leaders, failure to learn from past experiences, negative past experience with conservation initiatives)	167	38
	c. Psychological reactions (e.g. fear, blame, motivation, risk aversion, trust)	164	36
2. Action (47)	a. Management problems (e.g. lack of enforcement, inadequate management, failure of project to outlast external involvement)	105	30
	b. Implementation problems (e.g. putting plans, strategies, and implementation tools in place)	86	34
	c. Lack of capacity	32	15
	d. Avoid difficult decisions or courses of action	18	8
3. Information (37)	a. Communication failures (e.g. failure to communicate with local people, manage expectations, seek information)	67	29
	b. Lack of feedback or reflection	47	16
	c. Data collection problems	15	6
4. Funding (34)	a. Lack of funding (e.g. for management, implementation, or to sustain project over longer term)	70	30
	b. Funding misallocation or mismanagement (e.g. corruption, delays)	16	10
	c. Donor conflicts	11	6
5. Economic and political (28)	a. Overriding imperative for production (e.g. no incentive for conservation, economic development trumps conservation) and alternative income problems	60	22
	b. Lack of political support, shifting political conditions, or government policies counter to conservation aims	51	17

Figure 10. Primary and secondary themes used to categorize the causes for failure across 59 failed conservation projects. "Frequency" values represent the number of times a theme was coded, and "No. of articles" values represent the number of project reports that mentioned each secondary theme. Parenthetical values under "Primary theme" represent the number of project reports in which the theme appears (Catalano et al., 2019, p. 4).

Given these results, governments must prioritize building an inclusive and collaborative policymaking infrastructure through which officials can foster strong and lasting relationships with community members. As such, community ownership of energy programming (through intimate involvement in its conception, creation, approval, and deployment) is key for creating a people-centered approach to policy-making and ensuring that programs operate as effectively as possible to benefit communities. What this means is that the community should be self-defined, and members should hold a high level of decision-making power, responsibility, and control over the policies, projects and programming, narrative, and other activities that impact their community (Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe, 2019, p. 22).

VI. Recommendations

A. Strategize and Expand Community Involvement

Environmental and energy equity “requires the provision of conditions and resources” that meets the needs of communities and allows them “to freely express their opinions” (Hampton, 1999). As suggested by the regression results in Section III and Appendix 1, it is important for policymakers to involve underrepresented communities and the communities most affected in the initial stages of any project, program, or policy.

Recall that two programs—SOMAH and Solarize Mass—did not have any significant coefficients that would show bias towards whiter, wealthier, more educated, or more English-speaking communities. These two programs also were specifically designed to engage communities at the grassroots level.

The lessons and best practices we can glean from these programs for the design of future programs include fostering partnerships with local organizations and other leaders that can serve as community liaisons and facilitate communication with residents. Hosting various town halls on the subject and conducting focus groups that cover other preferred methods of public participation for underrepresented communities could also aid in consulting and involving residents, as per the “Spectrum of Community Engagement to Ownership” (González, 2019). Further, establishing an advisory committee that includes experts, government officials, and community members can serve as a way to prioritize collaboration over tokenization (González, 2019).

Certainly, these approaches are not exhaustive or mutually exclusive. Programs can utilize all of them in a thorough and multi-pronged approach to community outreach and involvement.

B. Embark on Grassroots Education and Training Campaigns

DERs and incentive programs can be really difficult to understand without higher education or prior exposure to them due to their degree of technical sophistication. Even tools meant to simplify programs (e.g., SMART's Energy Storage Adder Calculator) require a relatively high level of understanding, and the general public is likely not sufficiently informed to accurately interpret them (Commonwealth of Massachusetts, 2020). Although the regression yielded mixed results for the education variable, programs can adopt similar education and training campaigns as Solarize Mass does. Marketing and application materials can use simple and everyday vocabulary with an overall readability score appropriate for (at most) a high school level of education.

Further, learning from Solarize Mass, programs can design their education campaigns to take a grassroots approach. Holding information sessions at community centers, parks, and other public locations where communities are active can be a useful strategy for spreading knowledge about the programs. Training events can tap into the community's organizing capacity by empowering individuals to engage with their own neighborhoods. Hearing about DERs and state-level incentive programs from active and trustworthy members of the community can, in turn, increase residents' openness to participation. In these cases, it is important to consider the target population when coordinating events. Making these sessions as accessible as possible (e.g., language, geographic location, cultural context, physical accessibility, date and time) will ensure that all members of the community are given equal opportunity to participate.

C. Increase Language Accessibility

Although the regression yielded mixed results for the English proficiency variable, a widely recognized best practice is to make program materials more accessible in languages representative of the population, depending on the languages spoken by local communities (West, 2008). Even beyond limited English-speaking households, people have different language proficiency levels depending on the topic of conversation. This fact reinforces the recommendation that materials use plain language and be accessible in multiple languages.

D. Reassess Program Structure

As the regression results reveal, programs tended to be more equitable when specifically designed to serve disadvantaged or environmental justice communities. Even compared to programs open to the general public that offer increased rebate rates for low-income applicants, the programs where only low-income households are eligible ranked higher in terms of equity (i.e., had either a negative, significant coefficient or a non-significant coefficient for income). As such, states may have more success in serving the most vulnerable and under-resourced communities if programs are not open to the general public. This strategy has the additional advantage of focusing program outreach and education efforts on these communities instead of attempting to reach the entire state's population under a limited budget. Further, for programs with a declining block incentive structure, limiting participation to historically under-represented groups would eliminate the possibility that wealthier households occupy the first blocks and receive the highest rebate rates, leaving lower rates for those who would likely benefit the most from the program.

A second recommendation for rethinking the program structure is to consider an increasing tiered pricing structure (as Solarize Mass uses) by which the rebate rate for a community increases as the number of participating households grows. This structure employs a similar incentive theory that businesses' referral programs employ, tapping into the community's organizing power and benefitting all parties with a higher rebate rate.

E. Better Data Collection & Regular Reporting

As learned throughout the completion of this study, data on DER incentive programs are not universally available, varies in quality, and may be inconsistent across programs or jurisdictions. For example, because program data did not include demographic data and listed zip codes (in some cases, census tracts) as the lowest geographic level, I was unable to create a data set and regression model with a finer level of detail. If incentive programs tracked demographic information for each application, policymakers could create more accurate evaluations of the equity of their DER deployment program.

Additionally, studies on the equitability of these programs—like this one—can be conducted on a continuous or regular basis. States can require program managers to publish a publicly available report every six months or on a yearly basis. Additionally, the state could require these programs to have a visualization tool on their website that uses continuously updated data.

VII. Conclusion

The results revealed that, when programs were broad and open to the public without a structure that specifically supports low-income populations, whiter and wealthier populations yielded a higher average incentive amount and a higher likelihood of being served. Conversely, when states were intentional about involving communities and serving EJ populations, their programs were successful in reaching BIPOC and lower-income communities.

The analysis of DER incentive programs in this study can be expanded upon in a variety of ways. Most clearly, performing the statistical analysis at a finer level—either census tract or household—would yield more accurate results. Additionally, future research could include independent variables that were not available through the ACS, including: household size in square footage,[21] households with older people and persons with disabilities,[22] and urban/rural status.[23]

Further, pursuing questions related to the time variable may allow for the evaluation of the adoption rate for different demographic groups. This kind of time-series analysis may reveal trends about the implementation of DER technologies and could answer questions, such as whether areas with larger white non-Hispanic populations tend to utilize state-level incentive programs earlier than communities of color. Especially important for programs with a declining block incentive structure, his type of improved understanding of early adopters versus late

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[21] The essay discusses household size in square footage as a potentially significant independent variable in greater detail in Section II.F.6, infra.

[22] Power outages are expected to happen more frequently given the increasing frequency and severity of weather conditions due to climate change. The elderly and persons with disability are especially vulnerable to these outages if they rely on assistive technologies that require a constant flow of electricity (Fuller, 2019). Therefore, DERs would increase their resilience and preparedness for these kinds of situations, and they could make the difference between life and death.

[23] Barbose et al. (2021, p. 30) found that solar adoption tends to skew slightly towards urban households compared to the United States as a whole, although it varies at the individual state level.

adopters would reveal whether certain groups have prime access to the highest available rebate rates while others may be subject to lower incentive rates after the first and highest-paying capacity blocks have been exhausted. Such a study can inform recommendations regarding targeted marketing strategies and program eligibility.

Lastly, this study can be replicated for other DER incentive programs offered in California and Massachusetts, or in other states or cities. One area of interest for further study is programs that support community choice aggregation (CCA). CCA programs increase energy democracy and prioritizes community ownership above community engagement. Specifically, California offers two CCA programs: Solar Green Tariff Program (CSGT) and Disadvantaged Communities - Green Tariff Program (DAC-GT), specifically designed so that households that are not physically able to install rooftop solar systems are able to come together and install a shared solar array that provides electricity for the entire community. The reason for their exclusion in this study is that they have yet to begin accepting applications. That said, both programs are expected to open in the coming months. Future studies can also evaluate programs for other kinds of DER technologies, including EVs. Specifically, analyzing the Clean Vehicle Rebate Project (CVRP) in California and Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) would be a great addition to this study of incentive programs for solar PV and battery storage systems in the two states.

In summary, to create more equitable incentive programs for DERs and support communities in the necessary and inevitable transformation of the energy system, states must build equity into every level of programming—from development to implementation and accountability. This is the way forward.

Appendix 1: Results

	General Market	SASH	MASH	DAC-SASH	SOMAH	Commonwealth Solar	Solarize Mass	SMART
white non-Hispanic	0.078** (0.02)	-0.010 (0.00)	-0.011** (0.00)	-0.008** (0.00)	-0.080 (0.05)	-0.002 (0.01)	-0.062 (0.06)	1.361 (3.90)
median income	0.000* (0.00)	-0.000** (0.00)	-0.000 (0.00)	0.000 (0.00)	-0.000 (0.00)	-0.000** (0.00)	0.000 (0.00)	-0.013* (0.00)
education	-0.134 (0.07)	-0.022** (0.00)	0.005 (0.01)	-0.007** (0.00)	-0.062 (0.11)	0.204** (0.04)	0.093 (0.09)	13.600 (8.92)
English-speaking	0.012 (0.03)	-0.034* (0.01)	0.012 (0.01)	-0.000 (0.01)	-0.222 (0.24)	-0.071 (0.04)	-0.221 (0.22)	-5.841 (11.54)
owner-occupied	0.006 (0.03)	0.010 (0.01)	-0.002 (0.00)	0.004* (0.00)	-0.020 (0.07)	0.204** (0.03)	0.065 (0.07)	22.182* (7.68)
household size	-0.054 (0.03)	-0.011** (0.00)	-0.005 (0.00)	0.020 (0.01)	-0.271 (0.29)	0.027** (0.01)	0.043 (0.04)	0.554 (1.50)
constant	-5.671** (1.36)	4.429** (0.95)	-0.296 (0.64)	0.368 (0.53)	36.415 (20.08)	0.684 (2.48)	14.797 (16.09)	-367.358 (716.91)
N	21606	21484	21516	4878	1621	5199	2951	2059
R^2	0.008	0.004	0.017	0.015	0.111	0.002	0.002	0.21
F	118.0**	13.25**	6.374**	9.286**	2.982**	27.50**	1.019	7.376**

Table 9. Regression output for all six solar photovoltaic incentive programs when the dependent variable was the amount of money given per household within each zip code. The numbers in parentheses are the standard error for each coefficient. The single asterisk (*) indicates a significant p-value ≤0.05 and >0.01. The double asterisk (**) indicates a significant p-value ≤ 0.01.

	General Market	SASH	MASH	DAC-SASH	SOMAH	Commonwealth Solar	Solarize Mass	SMART
white non-Hispanic	0.001** (0.00)	-0.000 (0.00)	-0.000** (0.00)	-0.000** (0.00)	-0.002 (0.00)	0.000 (0.00)	-0.003 (0.00)	-0.003 (0.00)
median income	0.000** (0.00)	-0.000** (0.00)	-0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	-0.000** (0.00)	0.000 (0.00)	-0.000** (0.00)
education	-0.001** (0.00)	-0.000** (0.00)	-0.000 (0.00)	-0.000** (0.00)	-0.000 (0.00)	0.004** (0.00)	0.004 (0.00)	0.020** (0.00)
English-speaking	0.001* (0.00)	-0.000** (0.00)	0.001 (0.00)	0.000 (0.00)	-0.006 (0.00)	-0.001 (0.00)	-0.011 (0.01)	-0.002 (0.01)
owner-occupied	0.001** (0.00)	0.000 (0.00)	-0.000 (0.00)	0.000* (0.00)	-0.000 (0.00)	0.003** (0.00)	0.003 (0.00)	0.014** (0.00)
household size	-0.001 (0.00)	-0.000* (0.00)	-0.000 (0.00)	0.000 (0.00)	-0.007 (0.01)	0.000 (0.00)	0.002 (0.00)	0.001 (0.00)
constant	-0.194** (0.02)	0.040** (0.01)	-0.023 (0.01)	0.004 (0.00)	0.847 (0.41)	-0.038 (0.04)	0.705 (0.74)	0.101 (0.58)
N	21606	21484	21516	4878	1621	5199	2951	2059
R^2	0.162	0.009	0.002	0.017	0.015	0.111	0.02	0.067
F	227.4**	13.73**	8.035**	8.610**	3.723**	39.17**	1.014	25.74**

Table 10. Regression output for all six solar photovoltaic incentive programs when the dependent variable was the percentage of households served in a zip code. The numbers in parentheses are the standard error for each coefficient. The single asterisk (*) indicates a significant p-value ≤0.05 and >0.01. The double asterisk (**) indicates a significant p-value ≤ 0.01.

	SGIP	**SMART**
white non-Hispanic	0.279** (0.06)	-0.184 (0.40)
median income	-0.000 (0.00)	-0.001 (0.00)
education	-0.126 (0.15)	0.887 (0.98)
English-speaking	-0.048 (0.11)	0.895 (1.00)
owner-occupied	0.195* (0.07)	1.329 (0.93)
household size	-0.525 (2.56)	-0.048 (0.13)
constant	-12.995 (11.72)	-105.851 (65.99)
N	3991	2059
R^2	0.102	0.004
F	---	1.961*

Table 11. Regression output for the two battery storage incentive programs when the dependent variable was the average amount of money per household given. The numbers in parentheses are the standard error for each coefficient. The single asterisk (*) indicates a significant p-value ≤0.05 and >0.01. The double asterisk (**) indicates a significant p-value ≤ 0.01.

	SGIP	SMART
white non-Hispanic	0.002** (0.00)	-0.000 (0.00)
median income	-0.000 (0.00)	-0.000 (0.00)
education	0.001 (0.00)	0.002 (0.00)
English-speaking	0.000 (0.00)	-0.000 (0.00)
owner-occupied	0.002** (0.00)	0.001* (0.00)
household size	0.017 (0.02)	0.000 (0.00)
constant	-3.17* (0.10)	-0.042 (0.03)
N	3991	2059
R^2	0.138	0.040
F	---	11.28**

Table 12. Regression output for the two battery storage incentive programs when the dependent variable was the percentage of households served in a zip code. The numbers in parentheses are the standard error for each coefficient. The single asterisk (*) indicates a significant p-value ≤0.05 and >0.01. The double asterisk (**) indicates a significant p-value ≤ 0.01.

Appendix 2: List of Abbreviations

Abbreviation	**Term**
AC	alternating current
ACS	United States Census Bureau American Community Survey
Berkeley Lab	Lawrence Berkeley National Laboratory
BIPOC	Black, Indigenous, and people of color
CalEnviroScreen 3.0	California Communities Environmental Health Screening Tool Version 3.0
CalEPA	California Environmental Protection Agency
CCA	community choice aggregation
CSGT	Community Solar Green Tariff
CSI	California Solar Initiative
CVRP	Clean Vehicle Rebate Project
DAC	disadvantaged community
DAC-GT	Disadvantaged Communities - Green Tariff
DAC-SASH	Disadvantaged Communities - Single-family Affordable Solar Housing
DC	direct current
DER	distributed energy resource
DOER	Massachusetts Department of Energy Resources
EJ	environmental justice
EPA	United States Environmental Protection Agency
FSC	Fisher, Sheehan, and Colton
GMP	Green Mountain Power
IPCC	Intergovernmental Panel on Climate Change
IOU	investor-owned utility
kW	kilowatt
kWh	kilowatt-hour
LIHEAP	Low-Income Home Energy Assistance Program
MASH	Multifamily Solar Housing

MassCEC	Massachusetts Clean Energy Center
MOR-EV	Massachusetts Offers Rebates for Electric Vehicles
OEHHA	Office of Environmental Health Hazard Assessment
PCBs	polychlorinated biphenyls
PV	photovoltaic
SASH	Single-family Solar Housing
SGIP	Self-Generation Incentive Program
SMART	Solar Massachusetts Renewable Target
Solarize Mass	Solarize Massachusetts
SOMAH	Solar on Multifamily Affordable Housing

Appendix 3: Glossary

Term	**Abbreviation**	**Definition**
adaptation	---	(in the context of climate change) “In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects” (IPCC, 2018, p. 542)
adder	---	additional incentives incorporated into the program structure that can increase the rebate amount for applications that meet certain predetermined criteria, as per the program guidelines
alternating current	AC	flow of electric charge that periodically reverses direction, as in home appliances; state-level incentive programs specify rebate amount as a specific dollar amount per AC or DC watt; see also “direct current”
American Community Survey	ACS	survey program conducted every year by the US Census Bureau that gathers detailed demographic and housing information about the nation’s population
battery storage system	---	rechargeable battery system that stores electrical energy for use at a later time
California Communities Environmental Health Screening Tool Version 3.0	CalEnviroScreen 3.0	most recent version of California’s place-based screening tool that depicts the distribution of negative environmental impacts across communities by census tract; released by the Office of Environmental Health Hazard Assessment within the California Environmental Protection Agency
cap-and-trade	---	market-based approach to regulating and gradually reducing greenhouse gas emissions by which a declining limit (i.e., cap) of permissible emissions is set, and by which allowances equal to the cap can be bought and sold (i.e., traded) among emitters to comply with the limit
clean energy	---	energy from sources that emit little to no greenhouse gas emissions; includes solar, wind, water, geothermal, and nuclear energy; excludes fossil fuels and biomass energy
Clean Vehicle Rebate Project	CVRP	California-based incentive program for electric vehicles
climate anxiety	---	psychological impacts of climate change as a result of both direct and indirect experiences; “a chronic fear of environmental doom,” as defined by the American Psychological Association (Clayton et al., 2017, 68); also referred to as eco-anxiety

climate change	---	long-term changes in local, regional, or global average weather conditions, such as temperature and rainfall; caused by increased greenhouse gas emissions primarily due to human activity, particularly the burning of fossil fuels, agriculture, and land-use change (NASA, 2021; UN, 1992, p. 3)
Commonwealth Solar II	---	Massachusetts-based incentive program for solar photovoltaic systems at residential, commercial, industrial, institutional, and public facilities; administered by the Massachusetts Clean Energy Center
community choice aggregation	CCA	program that allows individuals within a service area to purchase electricity in bulk from an alternative supplier while the existing utility continues to control and operate transmission and distribution infrastructure; mechanism that increases communities' agency and local control over their electricity generation, sources, and costs; also referred to as municipal aggregation (Fairchild & Weinrub, 2017, p. 140)
community engagement	---	degree of participation in which the community is consulted, but ultimately holds a low to moderate level of decision-making power, responsibility, control over policies, projects, programs, and other activities that impact the community
community ownership	---	degree of participation in which the community holds a high level of decision-making power, responsibility, and control over policies, projects, programs, and other activities that impacts the community
Community Solar Green Tariff	CSGT	California-based incentive program for community solar photovoltaic projects with a specific focus on households in disadvantaged communities who are limited in their ability to install solar on their roof; will launch in the coming months as of April 2021
declining block incentive structure	---	program structure in which incentive amounts decline as predetermined capacity blocks are exhausted
direct current	DC	flow of electric charge in only one direction, as in a battery; state-level incentive programs specify rebate amount as a specific dollar amount per AC or DC watt; see also "alternating current"
disadvantaged community	DAC	(in California) highest scoring 25 percent of census tracts from California Communities Environmental Health Screening Tool Version 3.0 as disadvantaged communities; includes some exceptions to this rule depending on the reliability of available data; designated by California Environmental Protection Agency
Disadvantaged Communities - Green Tariff	DAC-GT	California-based incentive program for community solar photovoltaic projects with a specific focus on income-

		qualified households in disadvantaged communities who are limited in their ability to install solar on their roof; will launch coming months as of April 2021
Disadvantaged Communities - Single-family Affordable Solar Housing	DAC-SASH	California-based incentive program for solar photovoltaic systems on income-qualified single-family households in disadvantaged communities; designed to be the successor to Single-family Affordable Solar Housing
distributed energy resource	DER	small-scale units of local electricity generation or storage either connected to the electric power grid at the distribution level or isolated in stand-alone applications
distributive justice	---	fairness in the allocation of burdens and benefits
duck curve	---	graph of power production showing the discrepancies between peak supply from renewable energy sources and peak demand throughout the day
energy burden	---	percentage of gross household income spent on energy costs
energy democracy	---	movement towards a more intersectional understanding of decarbonization that merges the technological energy transition with increased public participation and community engagement in decision-making; "climate resilience initiative to address the existential consequences of the extractive economy through the creation of a new regenerative economy, one based on a decentralized renewable energy model that advances ecosystem health, economic sustainability, and social justice through the empowerment of our communities, and the democratization of our society" (Fairchild & Weinrub, 2017, p. 14)
energy insecurity	---	"inability to adequately meet basic household energy needs" (Hernández, 2016)
energy justice	---	application of justice principles to the energy systems and every step in the full lifecycle of energy resources
environmental justice	EJ	"fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA, 2021)
environmental justice population	EJ population	(in Massachusetts) a community that meets the set criteria based on annual median household income, racial and ethnic composition, or English proficiency, as per Section 56 of Bill 9 (192nd General Court of the Commonwealth of Massachusetts, 2021); disproportionate exposure to environmental hazards and increased vulnerability to these hazards are both

		considered when identifying environmental justice populations; also referred to as environmental justice community
fossil fuels	---	fuel formed by the decomposition of organic matter; human use (burning) of fossil fuels for energy emits greenhouse gases and is a leading driver of climate change; considered neither clean nor renewable, as they release greenhouse gases and are depleted at a much rate faster than they are formed
greenhouse gas	GHG	gas that absorbs and emits infrared radiation, resulting in the greenhouse effect; increased atmospheric concentration of greenhouse gases due to human activity have led to raised global mean temperature in recent decades
Home Energy Affordability Gap	---	model by Fisher, Sheehan, and Colton that estimates the gap between "affordable" home energy bills and "actual" home energy bills (FSC, 2003)
investor-owned utility	IOU	private utility company that generates electricity and distributes it to electric customers over a defined service territory
kilowatt	kW	unit of power; equivalent to 1,000 watts of electrical power
kilowatt-hour	kWh	unit of electrical energy; equivalent to 1,000 watts of electrical power sustained for one hour
limited English-speaking household	---	a household where no person 14 years old and over either speaks only English or speaks English "very well" (US Census Bureau, 2021)
Massachusetts Offers Rebates for Electric Vehicles	MOR-EV	Massachusetts-based incentive program for electric vehicles
mitigation	---	(in the context of climate change) "human intervention to reduce emissions or enhance the sinks of greenhouse gases" (IPCC, 2018, 554)
Multifamily Affordable Solar Housing	MASH	California-based incentive program for solar photovoltaic systems with a specific focus on qualifying affordable multifamily housing properties; see also Single-family Affordable Solar Housing and Solar on Multifamily Affordable Housing
procedural justice	---	fairness in decision-making processes
renewable energy	---	energy from natural sources or processes that replenish themselves at a rate equal to or faster than the rate of extraction; includes solar, wind, water, geothermal, and biomass energy; excludes fossil fuels and nuclear energy

resilience	---	(in the context of climate change) ability to prepare for, recover from, and adapt to climate change impacts (Center for Climate and Energy Solutions, 2019, p. 1; IPCC, 2018, p. 557)
seeding	---	phenomenon where initial adoption of solar panels at the residential level inspires neighbors to follow; seeding potential additionally exists for other distributed energy resource technologies
Self-Generation Incentive Program	SGIP	California-based incentive program for distributed energy resources, including wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells, and advanced energy storage systems
Single-family Affordable Solar Housing	SASH	California-based incentive program for solar photovoltaic systems with a specific focus on qualifying affordable single-family housing; see also Disadvantaged Communities - Single-family Affordable Solar Housing and Multifamily Affordable Solar Housing
Solar on Multifamily Affordable Housing	SOMAH	California-based incentive program for solar photovoltaic systems with a specific focus on multifamily affordable housing properties; designed to be the successor to Multifamily Affordable Solar Housing
Solarize Massachusetts	Solarize Mass	Massachusetts-based incentive program for solar photovoltaic systems that aims to increase solar adoption through grassroots educational campaign and reduced pricing; partnership between Massachusetts Clean Energy Center and Green Communities Division of the Massachusetts Department of Energy Resources
Solar Massachusetts Renewable Target	SMART	Massachusetts-based incentive program for solar photovoltaic systems; offers an increased rate for battery storage systems
solar photovoltaic system	solar PV	clean and renewable energy system consisting of photovoltaic panels, an inverter, and other hardware that generates electricity from solar energy
split incentives	---	circumstance between owner and tenant, where capital investments that yield energy improvements (e.g., reduced utility bills, increased resilience) result in one party bearing the cost while the other receives the benefits

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