Exploring Equity in Residential Solar

A preliminary examination of who is installing solar in the Commonwealth of Massachusetts

Synapse whitepaper

July 22, 2019

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1. SUMMARY OF FINDINGS

As the price of solar photovoltaics (PV) has decreased, more and more households have installed solar to reduce their electricity bills, reduce emissions associated with electricity, or improve their property values.[1] As of November 2018, Massachusetts was home to over 83,000 residential solar installations with a total installed capacity of 618 megawatts (MW_{DC}). But who, specifically, has installed solar? Do solar installations vary with income, homeownership, or race and ethnicity? Are the low- and moderate-income and environmental justice communities installing solar?

Using data from the Massachusetts Clean Energy Center (MassCEC) and the U.S. Census Bureau, Synapse conducted a first-cut statistical and geospatial analysis to begin to answer these questions. Our analysis finds that:

- There is a very strong relationship between homeownership and solar installations. For every 1 percentage point increase in a community's level of homeownership, we can expect solar installations to increase by 0.6 installations per 1,000 households.
- The relationship between income levels and solar installations is complex. Solar installation rates are highly correlated with income up to a median income level of approximately $100,000 per year. Beyond this level of income, solar installation rates flatten and eventually decline.
- There is a modest relationship between solar installations and the share of households in a community receiving some amount of social security income. Solar is most likely to be installed in areas where at least 30 percent of households receive some amount of social security income.
- There is also a strong relationship between race and ethnicity and rate of solar installation. Solar is most likely to be installed in communities where are at least 75 percent of the population identifies as white and non-Hispanic.
- In addition, we find that current programs aimed at increasing the number of solar installations at low-income households have had mixed success. While the new SMART program policy aimed at community solar seems to have a large amount of participation (which may increase access to solar for customers who are unable to install solar on their home), the SMART program policies aimed at low-income customers do not appear to have attracted much interest to date. Furthermore, data from the Mass Solar Loan program shows that it has disbursed loans to a small number of solar installations (around 14 percent of all residential installations since June 2016) and that half of these households had incomes at or above $89,000.

While this initial analysis reveals some interesting answers to the question of who is installing solar, we acknowledge that further analysis is essential to determining the exact drivers of solar installation.

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[1] Kavlak, Goksin, et al., 2018. "Evaluating the causes of cost reduction in photovoltaic modules." *Energy Policy*. Available at https://www.sciencedirect.com/science/article/pii/S0301421518305196?via%3Dihub.

Future analysis could include more sophisticated multivariate or nonlinear regressions to better explain trends in the data and identify which variables best explain the variance in solar installations, expanded use of the U.S. Census data (including analyzing variables such as language spoken at home, level of attained education, heating fuel, and population density), or the use of surveys of solar participants and non-participants to better understand the drivers and barriers of residential solar installations in Massachusetts.

2. ANALYSIS OF SOLAR DATA

In 2018, Stanford University researchers released the results of their DeepSolar project, a framework that analyzes satellite imagery to identify the locations and sizes of solar PV panels in the contiguous 48 states. The researchers layered onto this data information about income, education, solar radiation,[2] and other factors, and made the data publicly available.[3] With respect to income and solar adoption, the Stanford researchers found:

> Annual household income is a substantial driver for solar deployment… Low- and medium-income households have low deployment densities despite solar systems being profitable for high-radiation rates, indicating that the lack of financial capability of covering the upfront cost is likely a major burden of solar deployment. Surprisingly, we observe that the solar deployment in high-radiation regions saturates at annual household incomes higher than $150,000 indicating other limiting factors.

Said another way, nationally, even in areas with good solar potential, low- and moderate-income customers are not installing solar PV at the same rates as customers with higher incomes.[4]

Though Massachusetts is one of the leading states for small-scale solar installations, there have been few state-specific analyses to assess whether solar has been installed equally across different populations.[5] To determine if the national trend observed in the DeepSolar project about income holds true for Massachusetts, and to see how solar installation rates compare to other variables (like homeownership, social security income, and race and ethnicity), Synapse performed a statistical and geospatial analysis using data from MassCEC and the U.S. Census Bureau.

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[2] Solar radiation indicates the amount of solar that reached any one spot after accounting for location, season, weather, and other factors. See: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, "Solar Radiation Basics," August 21, 2013, available at https://www.energy.gov/eere/solar/articles/solar-radiation-basics.

[3] Stanford, "The DeepSolar Project" available at http://web.stanford.edu/group/deepsolar/home.

[4] The Stanford researchers hypothesize that this is due to the high upfront cost of installing solar.

[5] See https://www.eia.gov/electricity/data/eia861m/ for data on small scale PV estimates by state.

2.1. Data background

To perform this analysis, Synapse first downloaded and aggregated residential solar installation data from MassCEC and household data from the U.S. Census Bureau.[6, 7] The following sections provide summary information about these two key datasets.

Where is residential solar installed in Massachusetts?

Figure 1 shows the location of residential solar installations across Massachusetts based on data obtained from MassCEC. As of November 2018, Massachusetts was home to over 83,000 residential solar installations with a total installed capacity of 618 MW_{DC}.[8, 9] Solar installations are found most frequently in the Boston metro area (although not necessarily the City of Boston itself) and in other areas with large population centers.

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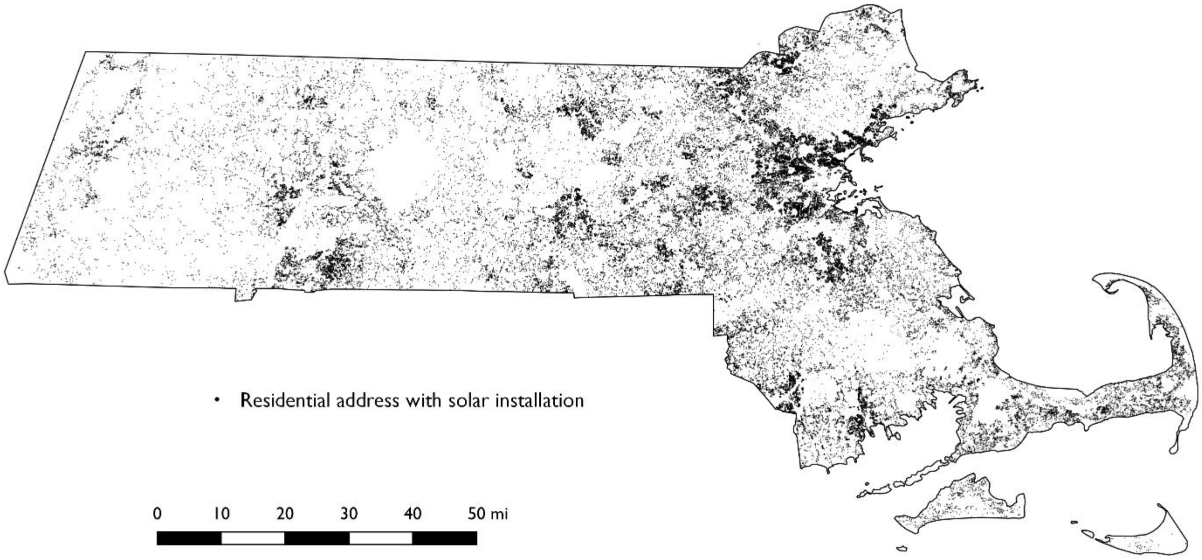
[6] MassCEC Production Tracking System, Accessed March 2019 via a Public Records Request. See https://www.masscec.com/data-and-reports. Note that the publicly available data is not listed with addresses; therefore, a public records request was necessary to acquire data with addresses. The Production Tracking System (PTS) tracks residential solar installations as well as other installation types (commercial, industrial, institutional, etc.).

[7] U.S. Census Bureau, American FactFinder, Accessed March 2019. See https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

[8] In this context "DC" stands for direct current, or the quantity of power that is produced from a system before it is passed through an inverter and converted to alternating current (AC). According to ISO New England, this conversion is estimated to result in power losses of 17 percent, on average (see https://www.iso-ne.com/static-assets/documents/2019/04/final-2019-pv-forecast.pdf).

[9] In this analysis, we filtered the data to focus on only those residential solar systems that are eligible to receive SRECs. This represents 98 percent of all residential solar systems and primarily excludes older systems or systems with missing data (e.g., installation date).

Figure 1. Geographical distribution of residential solar installations in Massachusetts as of November 2018

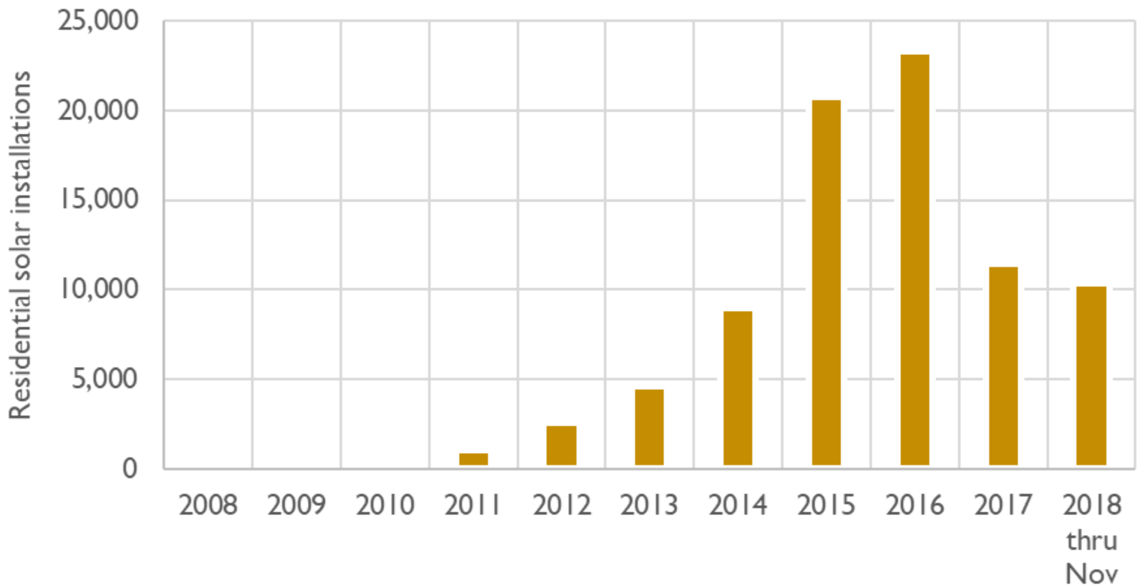


Source: Created using data from Massachusetts Clean Energy Center

Figure 2 shows the number of residential solar installations in Massachusetts from January 2008 through November 2018. Over this time period, the median installed residential system size was 6.7 kilowatts (kW_{DC}), while the average installed residential system size was 7.4 kW_{DC}. Of all residential solar installations, nearly 95 percent of them were installed on buildings with three or fewer units. 2015 and 2016 saw the largest number of solar installations, in part due to declining solar costs and aggressive expansion from third-party solar installers.[10]

[10] See https://www.greentechmedia.com/articles/read/solar-loans-to-become-1-consumer-finance-solution-for-residential-solar-in#gs.n1on4u for more information on the role of third-party installers on solar expansion in 2015 and 2016.

Figure 2. Temporal distribution of residential solar installations in Massachusetts



Notes: Although included in our analysis, relatively few solar installations took place in 2008 through 2010. As a comparison, there were about 350 solar installations in this three-year period, while there were nearly 1,050 solar installations in 2011 alone. 2018 data does not include any installations in December 2018.

Overview of U.S. Census block group data

Synapse also obtained data from U.S. Census Bureau's five-year American Community Survey (ACS) for the data year 2017. This dataset contains a wealth of demographic information at several different levels of geography, including "block groups." A census block group is a geographical unit used by the U.S. Census Bureau defined as the aggregation of several census blocks. Census block groups typically have a population of 600 to 3,000 people and are the smallest geographical unit for which the bureau publishes detailed data. Synapse obtained this data for all 4,985 block groups in Massachusetts.

The U.S. Census Bureau categorizes homes as either occupied or vacant. If the owner is not present at the time of the survey, then the home is recorded as vacant, unless the occupants are only temporarily absent. If there are homes in a block group that are vacant, we excluded these homes from our statistical and geographical analysis.[11]

Each block group contains several associated datasets, including total number of households, number of occupied households, median household income, number of households owner occupied and rented, number of households receiving some amount of social security income, and number of individuals of

[11] Note that "vacant" households may include seasonal households, as well as truly vacant dwellings.

U.S. Census-designated races.[12] Table 1 summarizes the statewide statistics for each of the variables analyzed.

Table 1. Summary statistics for Massachusetts

Number of block groups	4,985
Total number of households	2,864,989
Number of occupied households	2,585,715
Median income (2017 $)	$74,167
Percentage of occupied households that are owner-occupied	62%
Percentage of occupied households receiving some amount of social security income	30%
Percentage of population that is white, non-Hispanic	79%
Number of residential solar installations through November 2018	83,416

For each variable analyzed (median income, homeownership status, prevalence of social security income, and race and ethnicity) we aggregated "like" block groups into bins. For example, data from all block groups with homeownership rates between 50 percent and 60 percent are combined. These data bins may include dozens or hundreds of block groups and thousands or hundreds of thousands of occupied households. Different binning of block groups might yield noisier data, less well-correlated trends, and less distinct relationships between variables.[13]

For each residential solar installation, we used the open-source geographic information system (GIS) program QGIS to match each location to a census block group in Massachusetts.[14] For each assembly of block group, we then calculated the residential solar installation rate, measured in total residential solar installations per 1,000 households. Our analysis does not capture the impacts of community solar projects, which are typically not installed at households.

2.2. Solar and median income

Figure 3 demonstrates the median household income of each U.S. Census block group in Massachusetts. Communities with higher median incomes are concentrated primarily in the eastern portion of the state. In particular, the highest income block groups are concentrated within a 30-mile radius surrounding, but

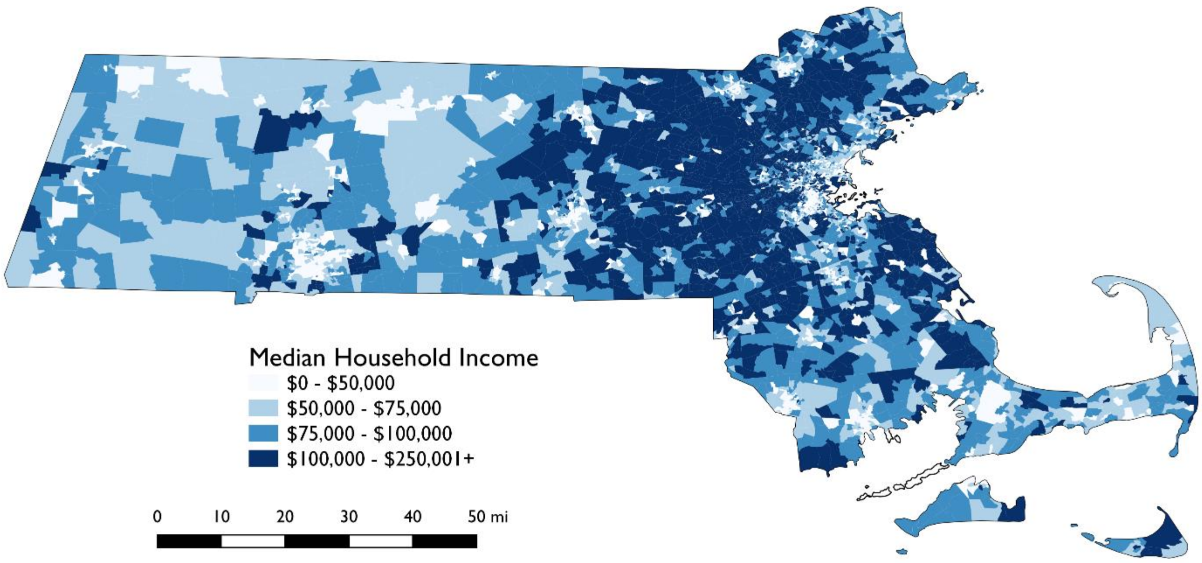
[12] Some statistics are representative of the block group, although they may not necessarily be representative of all households within the block group—for example, actual income in each household could be much higher or lower than the median income associated with a block group.

[13] We note that it would be particularly useful to obtain data on these variables for each specific household, including those with solar installations and those without, which could be collected through a statistically valid survey.

[14] See https://qgis.org/en/site/ for more information on QGIS.

not including, the City of Boston.[15] The lowest income block groups (less than $70,000 per year) are found throughout the state but are more common in western Massachusetts, the Boston metropolitan area, and in Gateway Cities.[16]

Figure 3. Median household income by census block group



Note: 18 block groups (of 4,985 total) have a median income of an unknown value that is greater than $250,000. For purposes of simplicity, these block groups are displayed within the highest income brackets.

Figure 4 compares median income to rates of solar installation. It shows that the variation in solar installations within each bin of block groups is modestly explained by household income (R^2 = 0.282). A linear regression of this data shows that for each $15,000 increase in annual income, we observe an increase in solar installations of 0.08 installations per 1,000 households.[17] However, the relationship is highly non-linear beyond income levels of $100,000. At income levels of $100,000 or more, solar installation rates flatten and eventually decline.

Figure 4 shows that residential customers are most likely to install solar at median household incomes of between $75,000 and $240,000 (the statewide median income is $74,167). Among households in these income levels, we observe an average of about averaging about 38 solar installations per 1,000

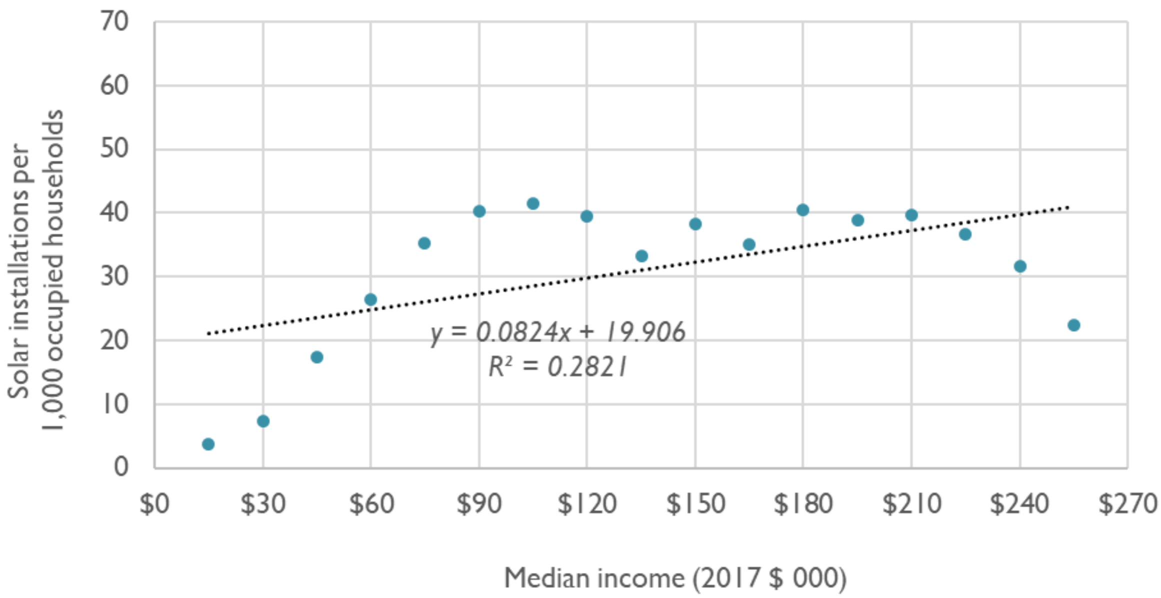
[15] Highest income areas are in the affluent suburbs of Boston. Lower income areas are found throughout the state, including in Western and Central Massachusetts, Cape Cod, the City of Boston itself, and the Gateway Cities.

[16] Gateway Cities are midsize urban centers that stabilize regional economies throughout Massachusetts. Gateway Cities often face social and economic challenges due to infrastructure constraints or lack of resources. Some of the Gateway Cities in Massachusetts include Fall River, Brockton, Lowell, and New Bedford. MassINC, "About the Gateway Cities," available at https://massinc.org/our-work/policy-center/gateway-cities/about-the-gateway-cities/.

[17] This relatively low coefficient and R^2 potentially indicate that a linear regression is not be the best descriptive trend of the relationship between median income and solar installation rate.

households. At the same time, we observe that among households with incomes below $75,000, there are about 13 solar installations 1,000 households.

Figure 4. Rate of residential solar installations relative to household income



2.3. Solar and homeownership

Like income, homeownership varies by community and region in Massachusetts.[18] Figure 5 shows that while most residents in the state own their home, the lowest homeownership rates (i.e., more renters) are concentrated within Boston, Springfield, Worcester, and other Gateway Cities. Across Massachusetts as a whole, the average homeownership rate is 62 percent.

[18] Homeownership is based on the percentage of homes within a Census block group that are owner occupied.

Figure 5. Percentage of owner-occupied homes by census block group

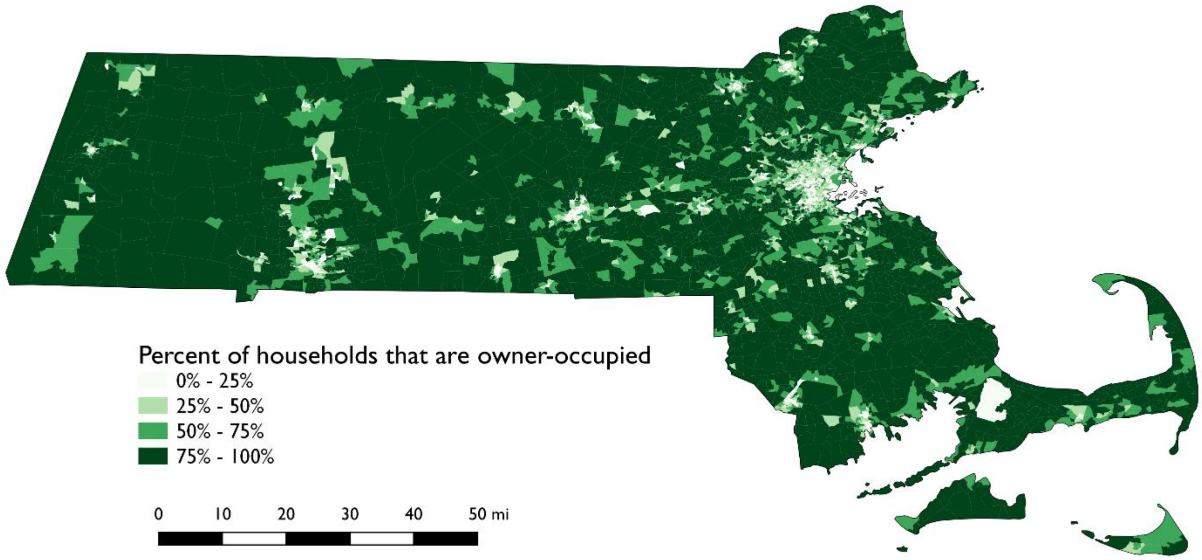
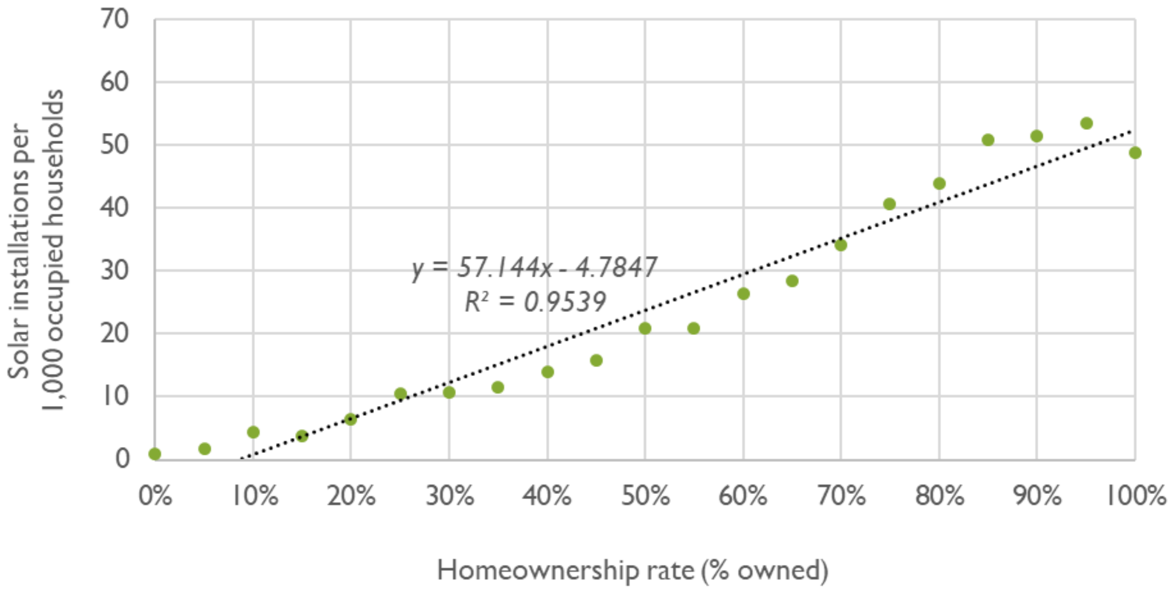


Figure 6 shows that the variation in solar installations is strongly explained by homeownership rates (R^2 = 0.954) and that homes occupied by their owners are more likely to have solar than homes occupied by renters. For example, in binned block groups with average homeownership rates of about 10 percent, there are about 4 solar installations per 1,000 households. In comparison, in binned block groups with average homeownership rates of about 90 percent, there are 52 solar installations per 1,000 households. In other words, for every 1 percentage point increase in a community's level of homeownership, solar installations are likely to increase by 0.6 installations per 1,000 households.

The trend between solar installations and homeownership is stronger than the relationship estimated between solar installations and median income levels—solar installations tend to increase as homeownership rates increase, and installation rates plateau only at high levels of ownership (e.g., 85 percent or greater).

Figure 6. Massachusetts residential solar installations relative to homeownership



2.4. Solar and social security income

Of the 2,500,000 occupied households in Massachusetts, about 30 percent are occupied by an individual who receives social security income. According to data from the Social Security Administration, nearly three-quarters of 2019 social security funds are anticipated to go to retired individuals or their dependents and could be viewed as a proxy variable for households with retired individuals on fixed incomes.[19] As with median income and homeownership rates, the percentage of households receiving social security varies by community and region in Massachusetts. Figure 7 shows that the communities with more than 50 percent of their residents receiving social security income are mostly concentrated on Cape Cod and in Western Massachusetts.

[19] See https://www.ssa.gov/news/press/factsheets/basicfact-alt.pdf

Figure 7. Percentage of households receiving social security by census block group

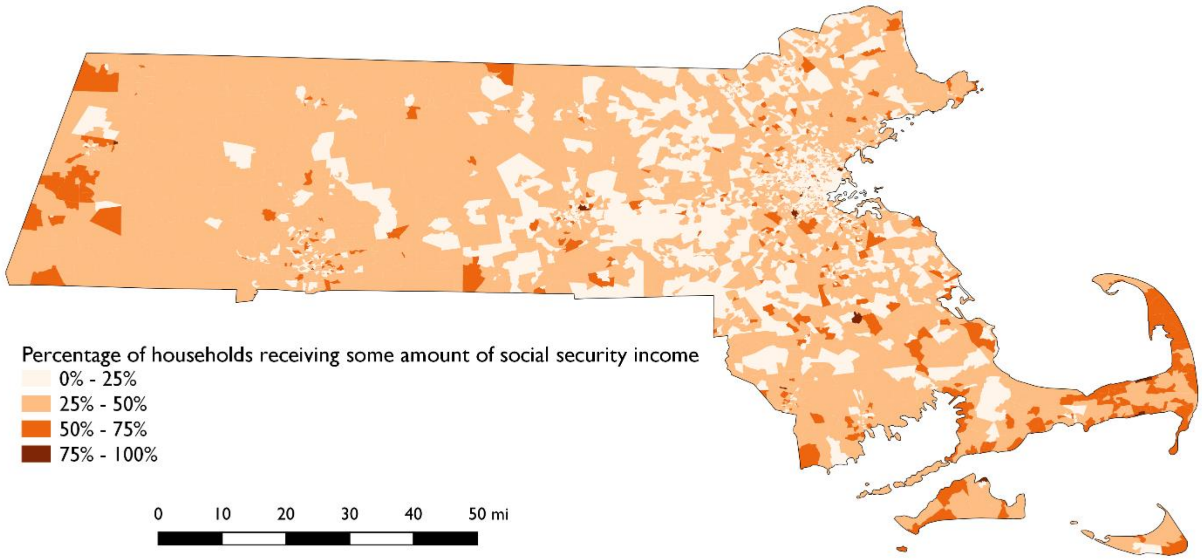
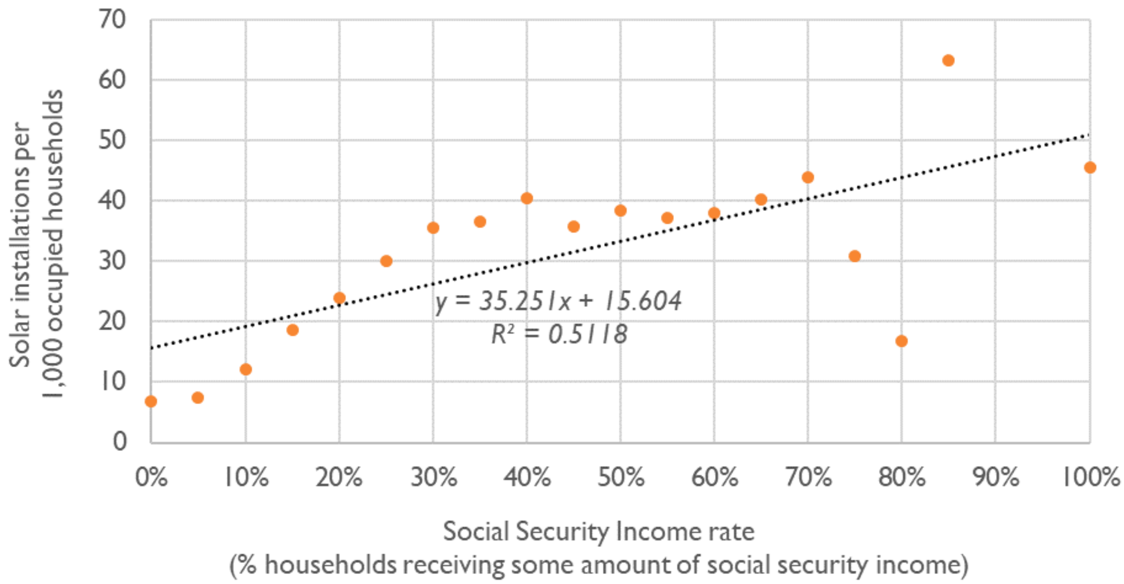


Figure 8 shows that solar is most likely to be installed in binned block groups where 30 percent or more of households receive some amount of social security income (note that the statewide average is 30 percent). We observe a similar rate of solar installations (38 installations per 1,000 households) for communities where 30 to 70 percent of households receive some amount of social security income.

Relatively few solar installations (e.g., fewer than 13 percent) occur in binned block groups where 20 percent or fewer households receive social security income. Figure 8 indicates wide variation in solar installation rates in communities where 75 percent or more of households receive some amount of social security income—however, data in these bins represent just 0.4 percent of all solar installations, and just 0.4 percent of households. Notably, even without these last data points, Figure 8 shows a trend of increasing solar installation rates alongside increasing percentages of households receiving social security income.[20]

[20] As with with median income, the relatively low coefficient and R^2 in this regression potentially indicate that a linear regression is not be the best descriptive trend of the relationship between numbers of households receiving some amount of social security income and solar installation rate.

Figure 8. Massachusetts residential solar installations relative to households receiving social security income



2.5. Solar and race and ethnicity

Massachusetts identifies a community as an environmental justice community if any of the following criteria are true: it is a block group with a median household income less than or equal to 65 percent of the statewide median (a household income level of about $48,200 in our dataset), 25 percent or more of the residents of that block group identify as a race other than white, or if 25 percent of the households in that block group have no one over the age of the 14 who speaks English only or very well.[21] For the purposes of this section, we focus on the environmental justice criteria related to race. Of the 6.8 million residents in Massachusetts, about 79 percent identify as non-Hispanic white. As with other variables previously analyzed, race and ethnicity vary across Massachusetts. As defined by Massachusetts' environmental justice criteria, communities of color are primarily found in Boston, Springfield, Worcester, and other Gateway Cities (see Figure 9).

[21] For more information on Environmental Justice communities in Massachusetts, see https://www.mass.gov/info-details/environmental-justice-communities-in-massachusetts

Figure 9. Percentage of population that is white and non-Hispanic by census block group

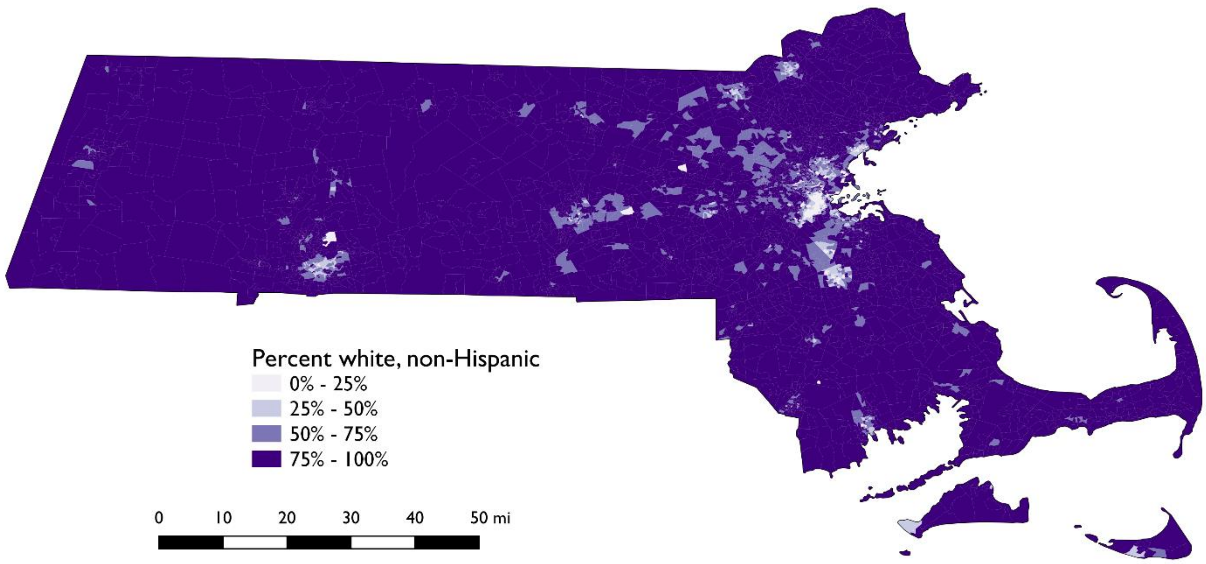
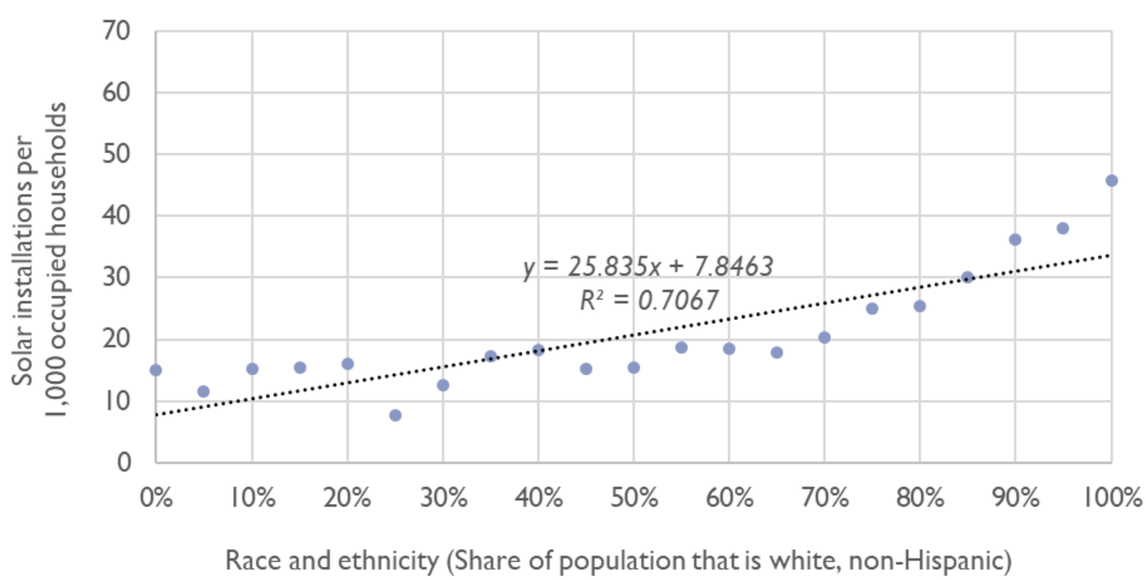


Figure 10 shows that race and ethnicity appears to strongly explain the variation in solar installation rates (R^2 = 0.707) in Massachusetts. In particular, Figure 10 shows solar is most likely to be installed in bins of block groups where populations are 75 percent white or higher.

It is likely that several of our examined variables are multicollinear. For example, race and ethnicity may be highly correlated with income and homeownership, meaning that race and ethnicity (on its own) may have very little explanatory power when it comes to solar installations (see section 3.1). That said, this particular analysis highlights a different perspective on inequities in solar development that some may find useful.

Figure 10. Massachusetts residential solar installations relative to race and ethnicity



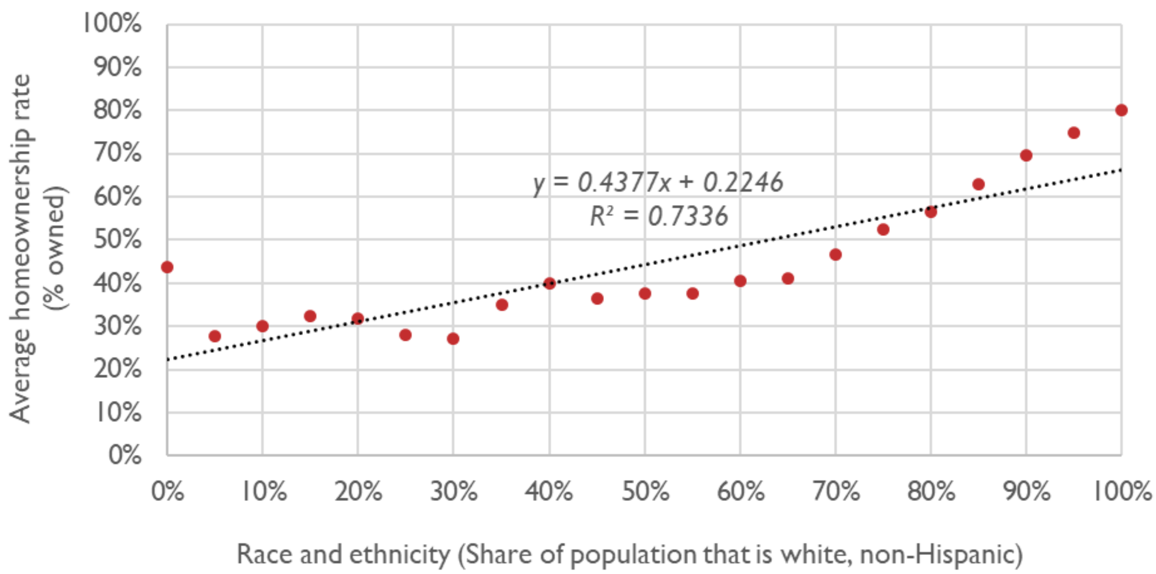
3. DRIVERS, LIMITATIONS, AND NEXT STEPS

The first-cut analysis conducted in this report indicates modest or strong correlations between higher rates of solar installations in (a) communities with higher-than-average median incomes, (b) communities with higher-than-average homeownership rates, and (c) communities with populations made of higher-than-average percentages of white, non-Hispanic residents. There are likely several different, interrelated drivers of these trends. First, households with lower median incomes may have difficulty overcoming upfront costs related to solar. Even in situations where households elect to pay for a solar system using a third-party or a solar loan (wherein they may pay for their solar installation over a decade or more), barriers such as bad credit or risk of taking on more debt may be impediments to installing solar. In addition, there may be other difficult-to-quantify upfront barriers that inhibit solar installation, such as lack of time to research solar installers or incentives. Second, in communities with lower levels of homeownership, customers may not be installing solar because (1) they are renters who may not have permission to make the property investment, (2) as renters, they may not live in the property long enough to benefit from an investment in solar, and (3) landlords may have little incentive to install solar on properties that they are renting out and may not directly benefit from.[22] Third, solar installation rates in communities of color are disproportionately lower-income and have disproportionally lower levels of homeownership than statewide averages (see Figure 11 and Figure 12), meaning that income and homeownership may be better explanatory variables of solar installations than race and ethnicity alone.

[22] See: Low-income Solar Policy Guide, "Unlocking Participation," available at https://www.lowincomesolar.org/why-act/unlocking-participation/.

Figure 11. Race and ethnicity relative to average household income

Figure 12. Race and ethnicity relative to homeownership rate



At the same time, our analysis indicates a relationship between higher rates of solar installations and higher rates of households receiving social security income. Contrary to our expectations, solar installation rates increase as the percentage of households receiving some amount of social security income increases.[23] It is possible that in addition to receiving some amount of social security, these households have additional sources of income. Or, perhaps households receiving some amount of social security are inhabited by retirees who are more likely to own homes than the average population.

3.1. More comprehensive statistical analysis

Although our first-cut analysis highlights several interesting trends in solar installation patterns in Massachusetts, it does have several limitations that should be examined in more detail in further analysis.

First, our analysis makes use of linear regressions between two variables (e.g., median income and solar installations per 1,000 households). More sophisticated statistical analysis (such as ANOVA or T-tests) could potentially better describe trends in our data, such as highlighting the degree to which there are statistical differences between different populations. Or, analysis of the data using nonlinear regressions may demonstrate that other functions more accurately describe the variances in data.

In addition, tests for multicollinearity among variables can provide information on the degree to which any one variable is influencing the observed trends. For example, we performed a separate multivariate regression of the discrete block group data (i.e., not grouped into "like" bins). We found that a regression including race and ethnicity was not statistically significant in its relationship to solar installations per household and had a correlation of 0.546 with owner occupancy. After dropping this variable from our regression, we observed statistical significance in all remaining observed variables with an adjusted R^2 value of 0.286.[24]

More extensive statistical analysis could be of use to help policymakers in terms of ascertaining which variables are most responsible for driving trends in solar installations.

3.2. Expanded analysis

Our analysis of U.S. Census data focused on four variables (median income, homeownership, social security income, and race and ethnicity). However, the U.S. Census provides a wealth of data on other variables which may be drivers of solar installations, including language spoken at home, level of attained education, heating fuel, and population density.

In addition, our analysis of solar data focused on residential installations. In the data attained from MassCEC, 95 percent of solar installations occurred on residential properties, although nearly 75 percent

[23] Note that we also examined a separate variable—percentage of households receiving any type of retirement income—and found very similar trends. Future analyses could explore the correlation of other variables with solar installation rates, such as age.

[24] Although the explanatory variables and solar installations are less correlated when data is broken out into individual block groups, the usefulness of this detailed perspective is potentially limited by the somewhat arbitrary delineation of block groups themselves.

of solar capacity was installed on non-residential properties. Statistical and geospatial analysis of commercial and governmental solar installations could reveal additional trends that could help inform policymakers on ways to make solar installations more equitable across multiple customer classes. In addition, expanding this analysis to include community solar facilities could reveal increased solar participation from customers whose solar facility is not co-located with their household.

Finally, our demographic data relies on household information collected, aggregated, and anonymized via the U.S. Census. Surveys of participants in Massachusetts solar programs (anonymous or otherwise) could provide insight on specific reasons customers installed solar and barriers they encountered. Expanded surveys of participants and non-participants alike could shed light on why certain customers have installed solar, while other customers have not.

3.3. Analysis in light of Massachusetts solar incentives

Massachusetts provides several incentives to residents interested in installing solar PV on their home. These incentives include net metering, tax credits, low-interest loans, and other financial incentives. Preliminary analysis of two of these incentives reveals interesting trends.

First, beginning in November 2018, Massachusetts instituted its new Solar Massachusetts Renewable Target (SMART) program.[25] This new incentive program replaced Massachusetts' older solar renewable energy credit (SREC) program. Under this new policy, the Commonwealth has created specific carve-outs and higher incentives for LMI customers and community solar, aiming to (a) ensure that at least some amount of incentive is reserved for these customers and (b) provide an additional incentive to encourage the construction of these facilities. However, SMART application data indicates that, of the 62 MW of small solar capacity that have received a Statement of Qualification as of July 10, 2019, just 0.6 MW or 1 percent are in the "Low Income Property" category.[26] In addition, of the 758 MW of large solar capacity that have received a Statement of Qualification as of July 10, 2019, just 18 MW or 2 percent are in the "Low Income Community Share" category and 528 MW or 70 percent are in the "Community Shared" category.[27] These data indicate that while developers and customers are taking advantage of the additional incentives for community solar, relatively few LMI customers have taken advantage of the SMART programs' Low Income Property adder to date.

Second, the Commonwealth has offered a low-interest, fixed solar loan program since June 2016. Under this program, customers can choose from a list of participating banks or credit unions whose terms and

[25] See http://masmartsolar.com/ for the official state website on SMART and https://www.synapse-energy.com/sites/default/files/Getting-SMART-16-069.pdf for an overview of how the SMART program works.

[26] See https://masmartsolareversource.powerclerk.com/MvcAccount/Login for SMART application data. Under the SMART program, "small" solar projects are those less than or equal to 25 kW_{AC} in size.

[27] "Community Shared" solar installations are typically larger projects not sited on buildings. Some customers may find these projects attractive as they circumvent issues related to upfront costs, homeownership, and physical construction.

conditions may vary slightly. The loans range from $3,000 to $35,000, with lenders maintaining the option to go as high as $60,000 and feature 10-year repayment plans at low interest rates. The maximum allowable interest rate is 8.25 percent as of July 2019.[28] LMI customers are eligible for additional benefits under the Mass Solar Loan program as follows:

- Interest rate buydown: Low-income customers are eligible for a 1.5 percent interest rate buydown, wherein the state buys down 1.5 percent reduction of the market-based interest rate, reducing the interest rate paid by the customer. Prior to December 13, 2017, all customers (regardless of income) were eligible to receive the interest rate buydown.[29]
- Income-based loan support: MassCEC buys down between 10 and 30 percent of the loan principle.
- Loan loss reserve: MassCEC sets aside funding for lenders to recover a portion of lost principal in the event of a loan default.[30]

Regardless of income level, a low-interest, fixed loan program may help customers overcome upfront cost barriers that limit access to solar.

An analysis of solar loan data provided by MassCEC indicates that between June 2016 and April 2019 there were nearly 4,900 solar loans disbursed to residential customers throughout the Commonwealth.[31] Over this same time period, there were nearly 34,000 solar installations, indicating that only 14 percent of solar customers took part in the loan program. Of these 4,900 customers, the MassCEC data indicates that 25 percent of them had incomes below 80 percent of the state median income and a further 19 percent had incomes below 120 percent of the state median income. Meanwhile, 50 percent of all residential recipients of solar loans had household incomes greater than 120 percent of the state median (about $89,000).[32] This suggests more action is needed to (1) encourage all customers to take advantage of the solar loan and (2) encourage lower-income customers to use the loan and take advantage of MassCEC's additional incentives.

Given the results of the statistical and geospatial analysis above, further analysis of existing solar incentives could inform policymakers on the efficacy of Massachusetts' solar programs in ensuring equity of solar installations across the Commonwealth.

[28] Mass Solar Loan, "For Consumers and Residents." Available at: http://www.masssolarloan.com/.

[29] See https://www.masssolarloan.com/program-updates.

[30] Kelsey Read, Mass Clean Energy Center, "Solar Access for the Underserved," March 15, 2019 presentation at NESEA BuildingEnergy Boston. Available at http://nesea.org/session/solar-access-underserved.

[31] MassCEC Production Tracking System, Accessed April 2019 via a Public Records Request. This number only includes solar loans disbursed to customers with a residential rate code who had a non-zero loan disbursement.

[32] These percentages do not sum to 100 percent because 6 percent of loan data points do not have data on income level.