Equity in Solar – Using Geospatial and Survey Data to Assess Performance and Identify Opportunities

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ABSTRACT

Residential solar programs that are not specifically targeted to low- and moderate-income (LMI) households are unlikely to effectively serve this important population. Policymakers and program managers need research to understand the extent of the disparity between program participants and the eligible LMI population. This type of research was conducted for the NY-Sun residential rooftop solar program. The research first used public and commercial data to project income levels for rooftop solar program participants based on their geographic location. Next, the research team conducted a survey with more than 900 solar program participants and compared the income projections to reported income data. The research found that the NY-Sun residential rooftop solar program had limited market penetration among the eligible LMI population.

The research also found that the geographic-based projections did not provide a reliable estimate of income levels for program participants, which limits the ability of using geographic-based estimates to identify or qualify potential participants for income-based incentives. For example, geographic-based analysis estimated 35% of the participants were projected to be LMI, but only 15% were found to be LMI based on reported household income levels. The findings from this research were used to assess how to target solar opportunities and benefits to LMI households and disadvantaged communities that have been historically underserved by past solar programs. In this paper, we review the results of the research, assess strengths and limitations, and identify how this framework can be useful for other solar programs aiming to increase LMI participation.

Introduction

Residential solar programs that are not specifically targeted to low- and moderate-income (LMI) households are unlikely to effectively serve this important population. Policymakers and program managers need research to understand the extent of the disparity between program participants and the eligible LMI population. This type of research was conducted for the NY-Sun residential rooftop solar program. Since 2012, NY-Sun has provided financial incentives and support for the deployment of solar in New York State (NYSERDA 2022). One major NY-Sun program is the residential rooftop solar program, which provides incentives to solar contractors and developers to offset costs paid by homeowners for the installation of a solar system. The residential rooftop solar program includes standardized incentives, as well as also additional affordable solar incentives for qualifying LMI households.

The research used public and commercial data to project income levels for program participants based on their geographic location, compared the results with participant survey

reports, and assessed the reliability of the projected LMI solar program participation rate which had been based on geographic information. The goals of this research were to answer the following questions:

1. What is the state and region-level income distribution based on Census data?
2. What is the projected income distribution of the residential rooftop solar program participants based on their geographic location and publicly available Census data?
3. What is the projected income distribution of the residential rooftop solar program participants based on data from a commercial database?
4. What is the income distribution of the residential rooftop solar program participants based on self-reported participant income collected via survey?
5. How do the projected income distributions based on geographical information compare to the survey-based estimates?
6. How do the results compare by region within the state?

The results of the analysis would be used to examine the extent to which geographic-based income projections can reliably be used to determine program eligibility or assess success in LMI participation.

Overview of Sources and Methodology

The following data sources were used to examine and answer the research questions:

Data sets on income and geography:

1. HUD LMI Special Tabulations. The U.S. Department of Housing and Urban Development (HUD) provides estimates of persons in each Census Block Group with income at or below 50% Area Median Income (AMI), 80% AMI, and 120% AMI (HUD 2022).[1] The estimates published by HUD for use in FY 2020 programs were based on the 2011-2015 5-Year American Community Survey (ACS). This source was used to examine the income distribution for the state and regional population, estimate the distribution of program participants by AMI level, and estimate the share of the population and program participants who live in highly concentrated LMI areas.
2. DOE LEAD Tool. The Low-Income Energy Affordability Data (LEAD) Tool from the U.S. Department of Energy (DOE) provides estimates of the number of households in each Census Tract by AMI level, Poverty level, and State Median Income (SMI) level (DOE 2022). These estimates can be further broken down by household demographics including owner/renter status, housing unit type, age of

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[1] These estimates are based on HUD's Section 8 Housing Assistance Program definitions of "very low income" and "low income". The number of low-income persons in the HUD Special Tabulations are those whose family income would qualify under the "very low income" limits for Section 8, or 50% of area median income (AMI). The number of low-to-moderate-income persons are those whose family income would qualify under the "low income" limits for Section 8, or 80% of AMI.

structure, and heating fuel type. The estimates published by DOE were based on the 2014-2018 5-Year ACS. This source was used to estimate the distribution of program participants by AMI level.

3. Data Axle database. The Data Axle database is a proprietary commercial data source that the program purchased to obtain detailed demographic and housing characteristics for households in the state (Data Axle 2022).[2] The data were merged with program data to examine income and demographic estimates for participant households. Approximately 40% of program participants were matched to records in the Data Axle database.

4. NYSERDA Disadvantaged Communities Data File. NYSERDA's interim definition of Disadvantaged Communities combined information on Census Block Groups located in Opportunity Zones and low-income areas located in Potentially Environmental Justice Areas (NYSERDA 2020). This data source was used to estimate the share of the population and program participants who reside in Disadvantaged Communities.

Program specific Data:

5. NY-Sun Participant Data File. The NY-Sun program data file of residential rooftop solar participants included addresses and participation details. We used the address information to geocode participant locations using the Census Bureau Geocoder tool, and to match records to the commercial database (US Census Bureau 2022). A representative sample of participants was selected for the participant survey.[3]

6. Participant Survey. We conducted a participant survey with a representative sample of residential rooftop solar participants. The online survey asked participants about their program experiences as well as detailed demographic questions including their income and household size. The results of the participant survey were used to estimate the SMI and AMI levels of participants.

Program Survey Results

APPRISE conducted the Solar Participant Survey in January and February 2021. The self-administered web survey was programmed and conducted using the Qualtrics platform. All participants selected for the survey sample were mailed letters on program letterhead inviting them to complete the survey online and including contact information for questions or assistance. In addition, the sample with email addresses were emailed survey invitation emails and up to two reminder emails.

The Solar Participant Survey disposition outcomes are summarized in Table 1 by available contact mode (Email and Mail; or Mail Only). The final survey completion rate was

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[2] Data Axle was previously called Infogroup.

[3] Using address information from the program data and the Census Bureau's Geocoder tool (https://geocoding.geo.census.gov/), we were able to geocode addresses for 81,916 residential solar participants out of 92,138 total. The geocoding match rate was consistent with expectations that a limited portion of addresses cannot be geocoded due to the use of postal boxes, address spelling variations not resolved through standardization, or other reasons.

33% for the group with email addresses and 13% for those with mail outreach only, yielding an overall completion rate of 28%. Because the survey was conducted as a web-based survey, limited information was available about participants who did not respond or complete the survey. However, based on the email bounce back rate, the estimated response rate excluding invalid contact information was approximately 29%.

Table 1 – Disposition results

Disposition results	Email & mail		Mail only		Total	
	Number	Percent	Number	Percent	Number	Percent
Total released	2,494	100%	926	100%	3,420	100%
−Ineligible – invalid email / bounce back	161	6%	NA[4]	-	161	5%
−Refusal (unsubscribe / spam)	32	1%	NA	-	32	1%
−Partial interview	14	1%	2	<1%	16	<1%
−Completed interview	820	33%	122	13%	942	28%
Survey completion rate	33%		13%		28%	
Survey response rate	35%		-		29%	

Source: NYSERDA October 2020, NYSERDA 2021

Table 2 presents the final number of completed survey interviews by region and incentive type. A total of 786 surveys were completed by regular incentive participants and 156 were completed by affordable solar participants. The survey successfully obtained more than 190 interviews per region, ensuring that the comparative income analysis could assess results at the regional, as well as state-wide, level.

Table 2 – Surveys completed by program incentive and region

Region	Regular incentive participants		Affordable solar incentive participants		Total	
	Number	Percent	Number	Percent	Number	Percent
Western	239	30%	40	26%	279	30%
Central	217	28%	39	25%	256	27%
Eastern	130	17%	66	42%	196	21%
NYC (combined)	200	25%	11	7%	211	22%
Total	786	100%	156	100%	942	100%

Source: NYSERDA October 2020, NYSERDA 2021

The primary focus of the survey was to collect information on the income levels of residential rooftop solar participants. Tables 3 to 4 present the key income results from the survey.[5] Table 3 shows the annual household income levels in 2019 for regular incentive

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[4] Letters were mailed using program stationary and undeliverable letters were returned to the program. The exact returned letter rate is unknown. Therefore, the total count of dispositions is less than the total released.

[5] Survey results are weighted to produce estimates that account for the sample design and survey response.

participants and affordable solar participants. More than half of the regular incentive participants reported annual income over $100,000, compared to 3% of affordable incentive participants. Only 9% of regular incentive participants reported income below $50,000 per year compared to 56% of affordable incentive participants.

Table 3 – Household income (2019) by program incentive

Household income	Regular incentive participants	Affordable solar incentive participants
Less than $50,000	9%	56%
$50,000 to $99,999	26%	39%
$100,000 or more	52%	3%
No answer provided	13%	2%
Total	100%	100%

Source: NYSERDA October 2020, NYSERDA 2021

The survey also asked about more recent household income levels in 2020 during the coronavirus pandemic. Table 4 presents the income distribution based on the survey responses. The results show small changes from the 2019 income levels, suggesting that while household incomes may have changed recently, household incomes appeared to remain generally stable in their broad income designation in 2019 and 2020, even with the onset of the pandemic.

Table 4 – Household income (2020) by program incentive

Household income	Regular incentive participants	Affordable solar incentive participants
Less than $50,000	9%	54%
$50,000 to $99,999	26%	37%
$100,000 or more	47%	3%
No answer provided	17%	6%
Total	100%	100%

Source: NYSERDA October 2020, NYSERDA 2021

Geo-Based Income Projection for Program Participants

To assess whether Census-based tools could be used to project the income of residential rooftop solar program participants and estimate the share of participating households that are LMI, we first examined how those tools characterized the overall population. We then used those tools to project the income of program participants and examined the resulting income distributions in comparison to results from the participant survey. We also examined the feasibility of using non-public data to estimate LMI program participation. The following sections describe the results from these analyses.

Income Projections Based on HUD LMI Special Tabulations Compared to Participant Survey

Table 5 shows how the income projections from the HUD LMI Special Tabulations compare to the results from the participant survey. Statewide, based on the HUD LMI Special Tabulations, about 48% of the population had income at or below 80% AMI, the threshold often used in housing programs to define low- and moderate-income (LMI) households. When we applied the AMI distribution for each Census Block Group from the HUD LMI Special Tabulations to the geocoded residential rooftop solar program participants, we projected that about 35% of residential rooftop solar participants had income at or below 80% AMI. However, only 15% of residential rooftop solar participants who responded to the participant survey reported income and household size that would categorize them at or below 80% AMI. This means that the residential rooftop solar participants have incomes that are higher, on average, than the income of other households in the same Census Block Group. While the specific estimates and projections varied by region, this finding was consistent across all regions of the state. The implication of this finding is that the program cannot use the HUD LMI Special Tabulations as a projection tool to estimate the share of residential rooftop solar participants who are LMI – doing so would result in an overestimate of LMI participants in the program.

Table 5 – Comparison of participant survey results to projections using HUD LMI Special Tabulations

		Respondents to participant survey	
AMI category	New York State population based on HUD LMI Special Tabulations	Estimates based on self-reported income	Projections based on Census Block Group income distribution from HUD LMI Special Tabulations
0-50% AMI	32%	5%	20%
>50-80% AMI	16%	10%	15%
>80-120% AMI	18%	20%	20%
>120% AMI	34%	65%	46%
Total <=80% AMI	48%	15%	35%

Source: HUD 2022, NYSERDA October 2020, NYSERDA 2021

Income Projections Based on DOE LEAD Tool Compared to Participant Survey

Table 6 shows how the income projections from the DOE LEAD Tool compare to the results from the participant survey. Statewide, based on the DOE LEAD Tool, about 46% of the population had income at or below 80% AMI. When we restricted the AMI distribution from the DOE LEAD Tool to occupants of single-family homes and applied the AMI distribution for each Census Tract to the geocoded residential rooftop solar program participants, we projected that about 31% of residential rooftop solar participants had income at or below 80% AMI. Like the HUD LMI Special Tabulations, the projection from the DOE LEAD Tool, even when based on the AMI distribution for occupants of single-family homes, overestimated the share of residential

rooftop solar participants that would be considered LMI. This finding was consistent across regions within the state, and the implication is that the program also cannot use the DOE LEAD Tool as a projection tool to estimate the share of residential rooftop solar participants who are LMI – doing so would result in an overestimate of LMI participants in the program.

Table 6 – Comparison of participant survey results to projections using DOE LEAD Tool

| | | Respondents to participant survey | |
AMI category	New York State population based on DOE LEAD Tool	Estimates based on self-reported income	Projections based on Census Tract income distribution for occupants of single-family homes from DOE LEAD Tool
0-60% AMI	36%	8%	21%
>60-80% AMI	10%	7%	10%
>80-100% AMI	9%	10%	10%
>100% AMI	44%	75%	59%
Total <=80% AMI	46%	15%	31%

Source: DOE 2022, NYSERDA October 2020, NYSERDA 2021

Income Estimates Based on Data Axle Database Compared to Participant Survey

Table 5 and Table 6 show how the income projections based on geo-based AMI distributions from public data sources compare with results from the participant survey. The question arises whether there are other, non-public data sources available with information that could be used to better estimate the AMI level of residential rooftop solar participants. Table 7 shows the estimated AMI level for residential rooftop solar participants who responded to the participant survey and were matched to household records from the Data Axle database. On average, the Data Axle database produced an estimate of the AMI level which was consistent with the AMI level reported by the survey respondents. For example, 11% of the residential rooftop solar participants who responded to the survey and were matched to the Data Axle database were estimated to be LMI compared to 15% of these participants based on the data available from Data Axle. However, when the Data Axle data were compared to the survey data on an individual household basis, the was little agreement between the data, suggesting that the Data Axle methodology might be used to predict average AMI levels in a geographic area but may not be reliable for predicting the AMI level for an individual household.

Table 7 – Comparison of participant survey results to estimates using Data Axle database

| | Respondents to participant survey who matched to Data Axle | |
AMI category	Estimates based on self-reported income	Estimates based on Data Axle database
0-50% AMI	2%	5%
>50-80% AMI	9%	10%

AMI category	Respondents to participant survey who matched to Data Axle	
	Estimates based on self-reported income	Estimates based on Data Axle database
>80-120% AMI	20%	19%
>120% AMI	70%	67%
<=80% AMI	11%	15%

Source: Data Axle 2022, NYSERDA October 2020, NYSERDA 2021

Participation in Disadvantaged Communities

Table 8 compares the share of residential rooftop solar participants located in Census Block Groups designated by the NYSERDA as Disadvantaged Communities (DACs) or where there is a high concentration of the population (at least two-thirds) with income at or below different AMI thresholds (50% AMI, 80% AMI, and 120% AMI) and compares this to the share of the total population in the state.[6] Compared to the population, residential rooftop solar participants are less likely to reside in DACs or Census Block Groups where there are high concentrations of LMI households. For example, only 8% of residential rooftop solar participants live in DACs compared to 28% of the population, and only 6% of residential rooftop solar participants live in Census Block Groups where at least two-thirds of the population is LMI (at or below 80% AMI) compared to 25% of the population.

Table 8 – Comparison of residential rooftop solar participants to New York State population by Census Block Group status

Block Group status	Residential rooftop solar participants	New York state population
Share in DAC Block Groups	8%	28%
Share in Block Groups with >66% population <50% AMI	1%	9%
Share in Block Groups with >66% population <80% AMI	6%	25%
Share in Block Groups with >66% population <120% AMI	30%	51%

Source: HUD 2022, NYSERDA 2020, NYSERDA October 2020, NYSERDA 2021

Summary

The following are the main findings and recommendations regarding the geo-based income projection methodology for the NY-Sun residential rooftop solar program:

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[6] Census Block Groups designated as Disadvantaged Communities (DACs) are based on an interim definition provided by NYSERDA. The definition was focused on locations within Economic Opportunity Zones and Potential Environmental Justice Areas (PEJAs). The final definition of DACs used by NYSERDA has evolved to include different criteria.

1. Residential rooftop solar participants
    a. Reside in higher income Census Block Groups than average.
    b. Are less likely to reside in Disadvantaged Communities or in highly concentrated LMI areas than the overall population.
    c. Have higher income than other households in their Census Block Groups and Census Tracts.
2. Projecting income for rooftop solar participants
    a. Both the HUD LMI Special Tabulations and DOE LEAD Tool overestimate the share of residential rooftop solar participants who would be considered LMI (income at or below 80% AMI) based on geographic location. As such, these tools are not suitable for projecting the AMI levels of participants and estimating the participation of LMI households in the residential rooftop solar program.
    b. This analysis suggests that projecting program participant or applicant income levels based on income data for geographic locations has limitations. Additional research should explore the accuracy of projecting income for solar program participants based on more detailed characteristics available from program data and public data.
    c. Commercial databases like Data Axle could be suitable as projection tools to estimate the share of participants that are LMI because, on average, there was general agreement between the share of residential participants estimated to be LMI using the Data Axle database and the share estimated to be LMI based on the participant survey.
    d. The Data Axle database cannot be used to qualify individual participants for income-based incentives because, on a household-by-household basis, there was little agreement between a respondent's AMI level determined using the Data Axle database and their AMI level determined from the participant survey. Further research is needed to assess the agreement or accuracy of other comparable commercial datasets.
3. Marketing and outreach
    a. The HUD LMI Special Tabulations can be used to identify Census Block Groups where there is a highly concentrated LMI population. This can be useful for program outreach and marketing, assisting solar programs with better targeting resources and identifying gaps in LMI targeting.
    b. The DOE LEAD Tool can be used to identify Census Tracts where there is both a high concentration of LMI households and households who own their homes and reside in single-family housing units. This can be useful for marketing to the households most likely to participate in the residential rooftop solar program (owners of single-family housing units) and who have a high likelihood of being LMI.
4. LMI Identification and Income verification
    a. While this analysis shows the limitations in projecting or imputing income for specific households, the results from the participant survey suggest that

having participants self-report their income and household size may be a valid way to collect income information and qualify participants for income-based incentives. This approach, with verification to confirm the accuracy of self-report income for a sample of participants, would allow a program to identify income-qualified households without the barriers associated with income verification.

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