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Building Solar Capacity in Maine: The Greater Bangor Solarize Case Study

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by Thomas E. Stone, Sharon J.W. Klein, and Kim K. McKeage

Abstract

Despite being a mature technology with significantly decreasing costs over the last decade and various financial incentives available periodically, solar photovoltaic energy systems currently generate approximately 1 percent of Maine's electricity. There have been eight Solarize campaigns in Maine, which aimed to increase residential- and commercial-scale solar adoption through group purchasing. In 2017, the Greater Bangor Solarize campaign increased the number of residential solar installations by 63 percent and solar power capacity by 52 percent in the participating towns compared to the previous seven years. We surveyed the Greater Bangor Solarize participants to better understand the motivations, concerns, and barriers to residential solar adoption in central Maine. We find a significant demographic divide exists between the Solarize participants and the general Maine population. We also observe that environmental stewardship and energy security are the primary motivations for considering solar and that overall cost remains the primary concern.

INTRODUCTION

Residential solar photovoltaic (PV) costs have recently decreased to a point where the technology is not only environmentally sustainable but also cost-effective (Hernandez et al. 2014). Residential and commercial solar PV has long been seen as environmentally important for its role in reducing greenhouse gas emissions that cause climate change, other air pollutant emissions, water pollution, water use, and land transformation associated with fossil fuel-fired electricity production (Klein and Whalley 2015). Due to dramatic recent reductions in the installed cost of PV panels, Mainers can expect to pay back the cost of a residential rooftop solar array in around eight years.[1] With existing panels typically having a 25-year warranty, after the eight-year payback period solar owners can expect to enjoy an additional 17 years of electricity savings, for a total 25-year lifetime net present value of between $5,000 and $20,000, depending on the discount rate[2] used in the calculation.[3]

Despite these environmental and economic benefits, residential and commercial solar PV adoption rates lag due to social barriers: lack of awareness or understanding; time needed to individually research options without peer or social support; lack of access to technological experts; technology distrust; inability or unwillingness to pay upfront costs despite favorable payback periods; fear of long-term investment; lack of consistent policy support; misperception of technical factors (e.g., roof orientation or condition, shading, grid integration); few peers with similar experiences; and a tendency to wait for technology to improve further (Klein and Coffey 2016). Solarize campaigns are a growing opportunity for enabling grassroots community action toward decarbonization that has the potential to overcome many of these adoption barriers. They are a type of bulk-purchase approach in which a community of prospective solar adopters form a purchasing group to solicit multiple-buyer installation discounts from a solar installer. The purchasing group and installer agree to a limited time period (i.e., six to twelve months) for signing up for and completing installations.

Recent research demonstrates the importance of peer effects (the social influence of neighbors, friends, roommates, and others on individual actions) in overcoming individual barriers to solar energy adoption. In a study in California, for example, Bollinger and Gillingham (2012) found the likelihood of residential solar adoption increased by 0.78 percentage points with each additional existing solar installation in a given zip code. A study by Rai and Robinson (2013) from Texas showed that active peer effects (direct, in-person interactions between potential and existing adopters in the same neighborhood) and passive peer effects (just seeing PV installations around town) reduced the average adopter decision period from nearly nine months to just over two months. In essence, a major factor in predicting solar adoption is whether there is already solar adoption in a given area. With this in mind, it is reasonable to expect that Solarize campaigns could accelerate peer effects because multiple installations are occurring in the same geographic area in a short period, visually supporting an everybody-is-doing-it mindset.

Our study builds on a growing body of literature that seeks to understand the motivations, concerns, and barriers to residential solar PV adoption, with a unique focus on the Solarize collaborative framework for solar adoption. We surveyed participants (solar adopters and nonadopters) in the Greater Bangor Solarize (GBS) campaign, which ran from 2017 to 2018 across 18 municipalities including and surrounding Bangor, Maine (Marysdaughter 2018).[4] The survey asked participants to describe the elements that factored into their decision to adopt or not adopt, their energy behavior actions before and after their GBS experience, any areas of concern regarding solar energy, whether various aspects of their GBS experience were positive or negative, the cost and performance of their solar array (adopters only), and their demographic information. We believe the responses to these questions will help inform continuing research on peer effects, adoption motivation and barriers, and especially provide some initial insight into why Mainers choose or do not choose to adopt solar through Solarize campaigns.

BACKGROUND

A group of residents of Portland, Oregon, started the first Solarize campaign in 2009; they wanted to install solar but did not know where to begin and thought that if they worked together they could make an informed purchase and reduce the overall cost. A neighborhood coalition approached Energy Trust, an independent nonprofit organization that is accountable to the Oregon Public Utility Commission, for help (Energy Trust 2018). The six-month grassroots campaign resulted in 130 home installations that totaled 350 kilowatts of power capacity in Portland and led to 18 new professional jobs in the city. Building on this success, the city of Portland secured a grant from the US Department of Energy, which enabled it to add another 400 installations through additional Solarize campaigns in 2010 (Irvine et al. 2012). By 2016, Oregon had increased its number of Solarize campaigns to 27, and solar bulk-purchase groups (mostly Solarize) had spread to 21 states and Washington, DC, with a total of 267 campaigns across the United States. Most of this growth (63 campaigns) occurred in Massachusetts, as the Massachusetts Clean Energy Center took a state-led, top-down approach to systematically deploying (and funding) Solarize campaigns in different municipalities each year.[5]

The first Solarize campaigns in Maine began in 2015, and there have been a total of eight Solarize campaigns in the state since then (Table 1) though none has occurred in the last three years. Solar installers use the geographic co-location of a Solarize campaign to lower the soft costs associated with a solar project, such as permitting, financing, and finding additional clients (Ulrich 2016). Having a high population density should help lower these soft costs and encourage the peer effects discussed above, but Maine Solarize campaigns have not yet focused on the most densely populated area: Portland.

Bangor resident and solar advocate Karen Marysdaughter started the GBS campaign to accelerate solar adoption in the Bangor area. She recruited the city of Bangor and the Eastern Maine Development Corporation to be GBS partners and assembled a GBS advisory committee, composed of six local individuals interested or working in the area of solar energy (including herself and two authors of this paper). The advisory committee prepared and released a request for proposals (RFP) in May 2017, to the list of solar installers in northern Maine maintained by the Efficiency Maine Trust. After the RFP period concluded, the committee narrowed the list to three companies, which they interviewed in June 2017, and ultimately selected one installer for the campaign: Insource Renewables of Pittsfield, Maine (Marysdaughter 2018).

The first GBS campaign ran from June 2017 to December 31, 2017, and a second round focused on Orono and University of Maine employees continued into 2018. After a kick-off event at the Bangor Public Library, a number of open houses, open installations, public information sessions, and media events were held during the summer of 2017 to promote the campaign. Signage on lawns where installations were occurring directed those interested in learning more to online resources, including

TABLE 1: **Solarize Campaigns in Maine**[1]

Solarize events in Maine (population density[2])	Year	Installer	Total installed capacity (kW)	Total number of installations
Solarize Brunswick (1,206)	2015–2016	Revision Energy	450	70
Solarize Central Lincoln County (75)	2015–2016	Revision Energy	106[3]	20[3]
Solarize Freeport (578)	2016	Insource Renewables[4]; Assured Solar Energy	240	41
Solarize Seacoast Maine (1,623)	2016	Revision Energy	320	34
Solarize Mid-Maine (1,222)	2016	Insource Renewables[4]	180	28
Solarize Midcoast Maine (945)	2016–2017	Sundog Solar	167	15
Solarize Mount Desert Island (810)	2017	Revision Energy	634[3]	73[3]
Greater Bangor Solarize (926)	2017–2018	Insource Renewables[4]	275	37
TOTAL			2,372	318

[1] Data for installed capacity and number of households were collected via email (V. Woodruff, September 8, 2020; C. Piper, August 4, 2020; J. Albee, June 30, 2020; J. Hatch, July 28, 2020) and one article (Woodruff 2016).

[2] Maximum population density for area served (measured in people per square mile) is from http://www.city-data.com. For comparison, Maine's most populated city, Portland, has a population density of 3,153 people per square mile.

[3] Includes residential, commercial, a community solar farm, and a power purchase agreement (PPA) project.

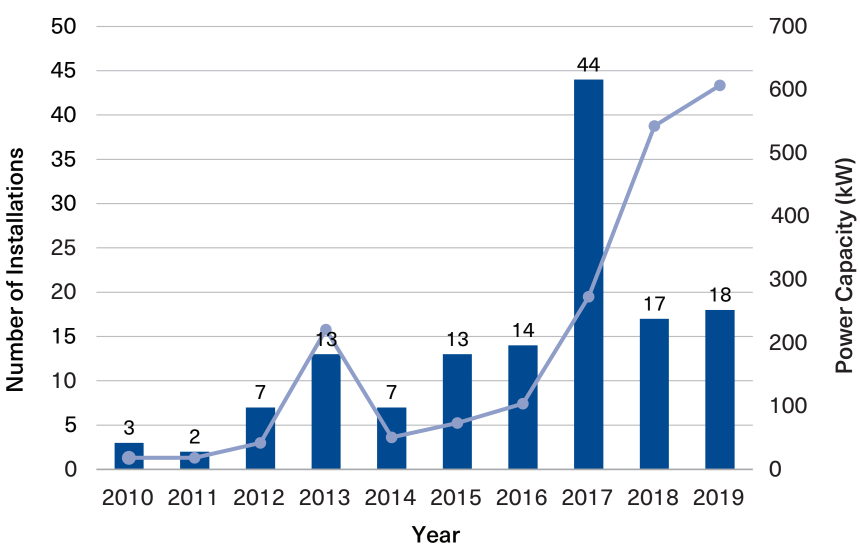
[4] In 2021, Insource Renewables merged with Revision Energy, bringing both employee-owned companies under the Revision Energy brand.

social media and the city of Bangor's website. By the end of September 2017, enough households had signed up so that the lowest pricing tier ($2.45 per watt for baseline system sizes of at least 4700–6400 watts; prices were higher or lower for capacities smaller or larger than this baseline) had been met for all participants (Marysdaughter 2018; personal communication, V. Woodruff, September 8, 2020).

Before the GBS campaign began, there were 59 solar installations (residential and commercial) in the participating municipalities completed between 2010 and 2016, totaling 528 kilowatts (Figure 1). Thirty-seven GBS solar installations totaling 275 kilowatts in power capacity were recorded by the end of 2017, a 63 percent increase over the number of existing 2010–2016 installations, 52 percent increase over the 2010–2016 power capacity in the region, and representing 91 percent of the total power capacity added in the region in 2017 (Marysdaughter 2018). This additional power capacity also represents about 3.7 percent of the total installed residential solar capacity of 7,500 kilowatts in Maine in 2017 (SEIA 2021). For comparison, those same 12 municipalities represent 6 percent of the total state population, suggesting the GBS region, even with the GBS campaign, is underutilizing solar as an energy source;[6] this sentiment was heard anecdotally from the solar industry (which is one reason the GBS campaign was initiated). Furthermore, if the GBS year (2017) is excluded from the data set, solar adoption in the Greater Bangor area has only increased about an additional two installations per year over the previous year; the growth that the GBS campaign provided does not appear to have been sustained in 2018–2019. These trends will not lead to a large-scale deployment of solar in the Bangor region within the timeframe of necessary climate change mitigation (IPCC 2018).

Despite growth in Solarize campaigns throughout the United States, there has only been one published study about the motivations, perceptions, behaviors, and peer effects or contagion associated with Solarize campaigns and no studies yet about why interested parties chose not to participate (Bollinger et al. 2020). Moreover, in Maine there is no central group or agency (such as the Massachusetts Clean Energy Center) that keeps track of Solarize campaigns or the individual installations resulting

FIGURE 1: **Number of Solar Installations and Power Capacity (Kilowatts) in the Participating GBS Region from 2010 to 2019 (Includes Residential and Commercial Installations)**



Source: Email from Versant Power, July 22, 2020

from them. We anticipate our small study will be a springboard for future larger studies and will help inform ongoing solar policy decisions in Maine and beyond.

SURVEY METHODS

We base our survey analysis on responses to a questionnaire sent via email to all of the first round (2017) GBS participants, with additional email and telephone conversations as questions arose.[7] The solar installer, Insource Renewables, provided a list of the 37 households that installed a solar array (adopters) through the 2017 GBS project and the 120 participants that showed some level of initial interest but ultimately did not install an array through this project (though they might have adopted via another installer, we call them "nonadopters" in this paper for simplicity). We received responses from 5 of the 37 adopters and 24 of the 120 nonadopters for response rates of 13.5 percent and 20 percent; overall, we collected data from 29 out of the 157 total participants, for an 18.5 percent response rate. Our survey questions probed participants' demographic backgrounds, their interactions with the GBS campaign, their motivations for considering and then either pursuing or not pursuing an installation, and any lifestyle changes they made in conjunction with their involvement with GBS. We used a five-point Likert scale for nondemographic questions, and each section of the survey also contained a free-response area for participants to expound on a particular point or question or to provide additional feedback. We asked solar adopters to provide sample electrical data pre- and post-installation, but we do not consider that data here due to a low response rate.

We want to acknowledge three principle limitations to the data quality. First, the overall sample size was relatively small (N = 157 households surveyed, 29 responded). Second, the survey participants only represent a sample of those interested in adopting solar power in the Bangor region and cannot be taken to represent a random sample of Maine residents. Put another way, our data represents the attitudes of a segment of the population that is already aware of and interested in residential solar power. Finally, we surveyed the GBS participants (one time) approximately one year after the program concluded. Ideally, we would have asked the before and after and motivation and concern questions at the corresponding times in the project timeline, so that the responses were in situ instead of all being taken afterwards.

SURVEY RESULTS

There were 29 total respondents in this study: 24 who did not install solar arrays and 5 who did. In terms of geographic location, respondents were from Bangor (12), Orono (7), Hampden (3), Brewer (2), Dedham (1), Veazie (1), and no town indicated (3). These responses include three adopters from Orono, one from Bangor, and one who did not specify location.

In many ways, respondents were typical of Maine residents (US Census Bureau n.d.). They were predominantly White (82.1 percent compared to Maine's 94 percent; other races selected included American Indian/

Alaskan Native [1], Asian [2], and multiethnic or two or more races [2]). They were split evenly between male and female. However, in other regards they were quite atypical. The most frequent response in the sample to "What is the highest level of formal education you have attained?" was a master's degree (10), with those possessing a master's degree or higher constituting 62.1 percent of the sample. Those with a bachelor's degree or higher were 89.7 percent of the sample, compared with the state share of 31 percent. The median reported household income was $105,000, with only two responses reporting less than $50,000, compared to Maine's median household income of $55,425. The median age (47) was only slightly higher than Maine's 45 years (Statista 2021), with respondents' ages ranging from 30 to 79 years old. Adopters were highly educated (one bachelor's, one master's, three doctorates), 60 percent male, 80 percent White (one Asian), 40 years old or older, with household income ranging from $60,000 to more than $150,000 per year.

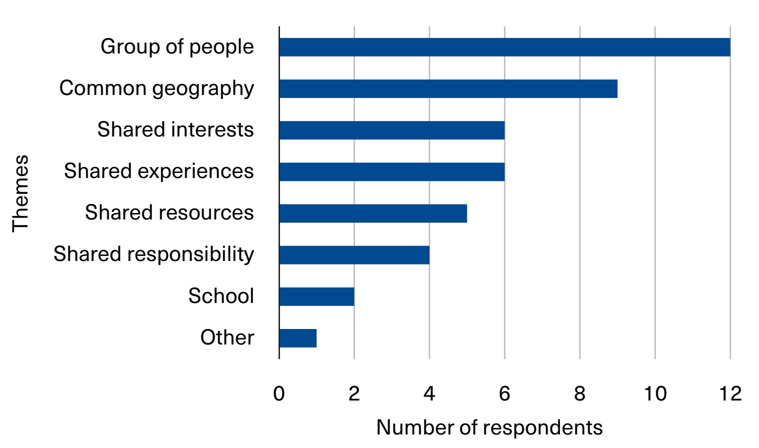
Respondents had generally lived at their current address for eight or more years (51.7 percent), with only one adopter reporting less than two years. We also asked how long they had lived in the Bangor area, as that could be longer than in their current house. Indeed, half of the respondents reported that they have lived in the Bangor area for 25 years or more, and most (83 percent) of the responses specified 8 years or more. For solar adopters, the shortest tenure was one person who reported 2–4 years.

In terms of political orientation, the sample skewed Democratic (16 total respondents; 4 adopters), with six nonadopters (zero adopters) identifying as Republican, two Independent, two other, and three choosing not to respond. Most respondents (77.8 percent) said they had not been involved in political action related to solar energy in the past, but three out of five adopters indicated they had. Three respondents specified writing emails to or calling elected officials, and three specified voting on people or issues in support of renewable energy.

People heard about the GBS campaign in various ways, most frequently by seeing an installation in progress (37.9 percent), hearing about it through social media (37.9 percent) or through word of mouth (34.5 percent). Less frequent were through a paper (17.2 percent) or radio (0 percent) advertisement, or through the city of Bangor website (6.9 percent). Of those who did not install solar through this program and answered the question, 24 (100 percent) requested information about the GBS project; 18 (75 percent) filled out an electricity usage questionnaire; and 6 (25 percent) had a site visit. While 9 (37.5 percent) respondents reported they were not planning to install solar in the future, 11 (45.8 percent) others were still considering a solar installation at some future time, and 2 (8.3 percent) installed solar through a different company (2 did not respond to this part of the question).

Because Solarize is a type of community-based (as opposed to individual) solar adoption, the survey also asked respondents to share their definition of "community" (Klein and Coffey 2016). Out of 15 responses to this question, 12 included a description that conveyed the meaning *a group of people* (Figure 2); i.e., "looking out for immediate neighbors," "people with a shared space," or "a group of one's choosing." Some responses included multiple themes. For example, the response "looking out for immediate neighbors" conveys *group of people* because neighbors is plural, but it also conveys *shared responsibility* in looking out for, and immediate conveys *common geography.* We coded responses in this way, counting individual responses in as many common themes as appropriate, given the terminology used by the respondent. In other words, while 12 respondents included words related to the

FIGURE 2: **Survey Respondents' Themes Related to the Definition of "Community" (N = 15).**



theme of group of people, their individual responses may have also included other words related to other themes. The most common themes were people, geography, shared interests and experiences (Figure 2). Interestingly, one-third of the respondents (including half of the four adopters who responded) also discussed shared responsibility, mainly for neighbors and the environment. The one "other" response defined community as "part of the three pillars of sustainability."

One adopter respondent did not know the power rating of their array, and one other respondent entered a power rating/cost combination that did not match the cost per watt tiered pricing structure of the GBS campaign (e.g., reported cost of $0.26/watt, compared to a baseline GBS cost of $2.45/watt, or $1.72/watt after the 30 percent federal Residential Renewable Energy Tax Credit that was in place at the time is included). These responses illustrate a broader issue related to energy literacy in residential solar adoption: adopters and potential adopters face a steep learning curve for new terminology and concepts related to power, energy, and economics (Brounen et al. 2013; Demeo et al. 2013).

Respondents were asked to rate on a scale of one to five the importance (5 = most important) of 16 factors on their decision to install (adopters) or consider installing (nonadopters) a solar array (Table 2). Top factors were to reduce dependency on fossil fuels, to benefit the environment, and to support renewable energy. These results contrast with the only other published Solarize survey study, which identified financial benefit as the strongest decision factor for most of the nearly 200 Solarize participants (adopters) in Connecticut who responded to the survey (Bollinger et al. 2020). We examined the importance of the factors presented in Table 2 to determine whether those who did and did not install solar panels assessed the factors differently—in all cases the difference

TABLE 2: **Factors in Decision to Install Solar Array (by Decreasing Importance)**

Factor	N	Mean	Standard error*	Median
Benefit the environment	29	4.34	.194	5
Support renewable energy	28	4.34	.194	5
Reduce dependency on fossil fuels	29	4.28	.222	5
Increased energy security	28	4.07	.224	5
Desire to reduce electricity costs	28	3.96	.227	4
Availability of economic incentives (such as tax credits)	27	3.93	.266	4
Overall decrease in the cost of solar in the last few years	28	3.89	.195	4
Payback period or return on investment	28	3.89	.243	4
Timing with respect to current household finances	29	3.48	.261	4
Support for the local economy	28	3.25	.222	3
Increased home value	28	2.93	.230	3
Generally interested in energy	28	2.93	.252	3
Being able to educate others about solar energy/demonstrating the feasibility of solar energy**	28	2.79	.259	3
Generally interested in trying out new technologies	28	2.79	.264	3
Knew friends/family that were satisfied with their solar installation**	29	2.41	.274	2
Being seen as a community leader (setting an example in the community)**	28	2.32	.252	2

*Approximately 95 percent of responses will be found within ± 2 standard errors from the mean.

**Relates to peer effects.

TABLE 3: **Significant Reported Knowledge and Awareness Changes after Installing Solar Array (Before – After) (Adopter N = 5; Nonadopter N = 21)**

Factor	Adopter?	Difference[a]	Test Statistic t =	p-value
I was knowledgeable about solar energy.	Y N	-1.800 -0.810	-4.811 -2.364	.009** .028*

[a] Since Difference = Before – After, negative numbers indicate that the score went up after participation in GBS.
*Significant at the 95 percent confidence level.
**Significant at the 99 percent confidence level.

between adopters and nonadopters was not significant, and the rank order of factor importance holds for both groups. Notably, the three factors that directly relate to peer effects (indicated by the asterisk in Table 2) scored low relative to other mainly environmental and financial factors, suggesting if peer effects are at play, respondents are not consciously registering their importance in their own decision-making.

Next, respondents were asked to indicate their level of agreement (1 = strongly disagree; 5 = strongly agree) with seven energy behavior statements (turning off electronics when not needed, adjusting the thermostat to a lower temperature in cold months and higher temperature in warm months, unplugging appliances and electronics when not in use, etc.) and seven energy awareness statements (awareness of the amount of electricity used, the amount spent on electricity, knowledge of solar energy, renewable energy, etc.) before and after their experience with GBS. Three statements showed a significant change from pre- to post-installation for adopters (N = 5), and all of them were awareness variables rather than behaviors (Table 3). None of the other statements showed statistically significant differences from before to after solar installation. The nonadopter responses also showed a significant increase in reported level of solar energy knowledge before and after their experience with GBS. However, nonadopter responses (N = 21) were statistically significant for their participation in GBS not increasing their awareness of the amount of money they spend on electricity (the opposite of adopters). In other words, nonadopter responses indicated their participation in GBS did not change their awareness of their own electricity expenditures, while adopters indicated they were more aware of their own electricity expenditures after installing their solar arrays. These results suggest the act of participating in a Solarize campaign may be sufficient for increasing self-perceived solar knowledge, but there may be additional learning about one's own electricity spending that can only be gained through solar adoption. Alternatively, it is possible that whatever characteristics drive people to adopt solar also make them more aware of, or more susceptible to increased knowledge of, their own electricity spending.

Respondents were also asked about their concerns related to solar arrays. The areas of most concern were overall cost, installer expertise, and payback time for the project (Table 4). We use T-tests to identify whether the adopters and nonadopters answered differently on each factor; a negative t-score indicates that the adopters were less concerned with that factor than the nonadopters, thus the negative sign serves as an indicator of that factor being a potential barrier to installation. Only two factors showed a significant difference between the adopters and nonadopters. First, the adopters were significantly less concerned with a long payback period ($t = -2.621$, $p < .05$). Second, the adopters were more concerned about regulatory uncertainty ($t = 1.810$, $p < .10$). Looming changes to Maine solar policy may have been on their minds, as LD 1504—An Act Regarding Solar Power for Farms and Businesses, a policy bill that was generally favorable to solar advocates, was vetoed by Governor LePage on July 10, 2017, and the veto was upheld on August 2, 2017.[8]

Respondents were also given the opportunity to explain more about why they decided to not install solar panels with GBS. Overwhelmingly, respondents restated their concern with economics, including cost, return on investment, financial uncertainty, and payback. Clearly, although the installed cost of solar and payback period

TABLE 4: **Areas of Concern Regarding Solar Arrays and Differences Between Installers and Noninstallers (by Decreasing Concern) (N = 29 Except as Noted)**

Factor	Overall mean	Solar install/ no install difference test t =	p-value
Long payback time	3.86	-2.621	0.014**
Regulatory uncertainty	3.24	1.810	0.081*
Weather (too much snow, too cloudy, not sunny enough) diminishing the effectiveness of solar	3.17	0.486	0.631
Structural concerns about my home	2.69	-1.058	0.300
Unfamiliar/uncomfortable with the operation of a solar array	2.38	-0.748	0.461

†Comparison with the nonadopter group is not possible because they did not answer this question.

*Significant at the 90 percent confidence level.

**Significant at the 95 percent confidence level.

have decreased substantially over recent years, they still are not sufficient for most (65 percent) nonadopter respondents. Four respondents discovered through their GBS experience that they did not have the proper roof orientation or area to achieve the shorter payback period. One nonadopter cited "the tax credit was ending" as a reason for not adopting; however, the federal Residential Renewable Energy Tax Credit was not set to expire in 2017 or 2018. In fact, it is still in place today, although it reduced from 30 percent to 26 percent of installed cost in 2020. The tax credit will decrease again to 22 percent in 2023 and is set to expire in 2024 (EnergySage 2021). This respondent comment is another indicator of the broader issue of energy literacy.

Two respondents indicated that they "dropped the ball" by not following through with their interest to adopt. Two respondents cited issues with getting the installer to respond to them or come out to the property for a site visit, which stands in contrast to an overall positive response to questions about the installer. Out of total respondents to each question, 53 percent (N = 17), 77 percent (N = 13), 78 percent (N = 23), and 86 percent (N = 14), respectively, were very satisfied to extremely satisfied with the GBS overall and found the installer site visit, answers to their questions, and the written proposal received by the installer very to extremely useful. In the additional comments space, one nonadopter wrote about the owner of the installer company Insource Renewables: "Very impressed with Vaughan's attention to detail. He visited our home twice as well as several phone and email conversations. He easily could have persuaded us to install solar, but ultimately helped us to determine solar was not a good option for us due to structural concerns with our roof."

DISCUSSION AND POLICY IMPLICATIONS

Our primary research goal in this study is to better understand what motivates residential homeowners to pursue, or not pursue, a solar installation. Our survey results represent a relatively small sample size (29 respondents out of 157 adopters and nonadopters surveyed) and do not represent a random sampling of Maine residents, but rather a segment of the population already interested in solar power (enough interest to at least contact the GBS program). All the survey results presented can potentially inform the conversations around solar power in Maine, but we highlight four observations in particular.

First, some demographics of the GBS campaign do not align with the general population of the state, which suggests that many Maine residents may not perceive solar power as a viable option. The median income in Maine is $55,425, whereas we found the median GBS participants' income to be $105,000. Additionally, in Maine 31 percent of the population has obtained a bachelor's degree or higher (US Census Bureau n.d.), but 89.7 percent of the GBS survey participants had attained this same level of education. The higher salaries and additional education that we found among GBS participants may be due in part to the project's proximity to the University of Maine (Orono), Husson University (Bangor), and other higher education institutions in the area. However, the magnitude of the differences leads us to conclude that solar is currently more appealing to those with above-average salaries and educational attainment, which makes sense due to the high initial upfront cost ($10,000 to $20,000 with no loan for adopters from our survey) and anecdotal evidence discussed earlier related to the need for participants to learn about energy, power, and economics as they consider whether to adopt. It is also consistent with income findings in other solar adoption studies (Bollinger et al. 2020). If this demographic observation is indeed true for Maine (a larger sample size is needed to verify), it may present an opportunity for the solar industry or government. For example, tax incentives, financing options, and advertising could target more typical Mainers. Efficiency Maine does offer some low-income energy rebates, but none related to solar PV.

Second, we found the leading concern for both adopters and nonadopters to be overall cost, with long payback time important for nonadopters. This was despite declining solar costs and a federal Residential Renewable Energy Tax Credit of 30 percent of the installation cost being in place while the GBS campaign was underway. Even if solar costs continue to decrease, an elimination of the federal tax credit may be a significant barrier to residential solar PV in Maine since overall cost was the primary concern in this survey. State or local financial incentives, additional Solarize campaigns, creative financing, and other methods should be explored to mitigate the loss of the federal tax credit. It is interesting to note that a long (eight years with the 26 percent tax credit) payback time was more of a concern to the nonadopters, which might represent an educational opportunity for the solar industry. For example, emphasizing a different payback metric (e.g., percentage rate of return, annual system savings, overall system savings, or net present value) could more accurately highlight the long-term benefits of solar. However, if people are used to considering payback period in other big purchase decisions, they might still insist on payback as the primary metric. Moreover, metrics like net present value and rate of return can be confusing to people without a strong financial education, adding to the learning curve burden for potential adopters. Supporting innovative financing strategies (e.g., third-party ownership, subscriber-based community solar farms, low-interest solar loans, including property assessed clean energy (PACE) financing) could help Mainers who cannot afford $10,000 to $20,000 up front still be able to reap the benefits of solar through lower electricity bills (EnergySage 2020).

The state of Maine does not currently have any financial residential solar incentives other than net energy billing, the ability of solar adopters to receive kilowatt-hour or monetary credits on their electricity bills for the electricity produced from their solar arrays that they do not use.[9] The $2,000 solar rebate administered by Efficiency Maine expired in 2015, due to Governor LePage's veto of a bipartisan bill to extend it (Wright 2015). Since then, 12 bills have been introduced to the Maine Legislature in an attempt to increase financial support for solar in Maine. Ten of these bills died in committee, were voted not to pass by the House and/or Senate, or were vetoed by Governor LePage, and one has been carried over to the next legislative session. In 2019, Maine saw its first solar victory in many years, with the passage of LD 1711—An Act to Promote Solar Energy Projects and Distributed Generation Resources in Maine. While LD 1711 directs the Maine Public Utilities Commission to procure 375 megawatts of power by July 1, 2024, from distributed renewable energy (including but not limited to solar) generators, it essentially excludes individual residential solar installations like those seen in GBS. Residential solar adopters do have the opportunity to participate in shared programs, which could include community solar farms in which multiple subscribers share the benefits and costs of a solar array that is not on their own property. Furthermore, LD 1711 specifies that 5 percent to 10 percent of total power from a shared facility must "be subscribed by households with low or moderate income or by organizations serving households with low or moderate income if the subscriptions serve to directly reduce the electricity costs for households with low to moderate income." Community solar farms have been deployed via a variety of financial and organizational structures across the United States in recent years and have the potential to provide residential subscribers with solar access without large (or sometimes any) upfront costs or proper roof orientation; quicker payback periods; and larger return on investment than individual residential solar sited on their own property (Feldman et al. 2015). However, the financial and organizational structure, as well as the outreach approach, for a community solar farm all influence the degree to which participants of varying income levels experience these benefits.

Maine Climate Council's (2020) four-year climate action plan somewhat addresses the demographic divide we observed between Maine residents and the participants in the GBS campaign. The plan acknowledges that "incentives that support targeted programs for low- to moderate-income access to cleaner, money-saving electricification technologies in heating and transportation will be key." It also calls for "price stability and affordability for all ratepayers" with respect to energy generation but does not lay out any specific solar PV incentives with respect to low- to moderate-income households (MCC 2020: 57). For individual residential solar, it will be important that the Governor's Energy Office include residential solar in the targets recommended by the Climate Council. Notably, around the time that the Climate Council was working on recommendations related to distributed energy, LD 564—An Act To Encourage the Installation of Solar Panels on Residential Property, which would have implemented a "property tax exemption for solar panels and associated equipment installed on residential property that qualifies for a homestead exemption," was defeated in February 2020 with an ought-not-to-pass ruling by the Committee on Taxation. In addition, on August 28, 2020, the Maine Public Utility Commission (MPUC) declared the distributed generation procurement process, which resulted from LD 1711 and included community solar farms, was not competitive due to high bidding prices, low numbers of applicants relative to initial interest, and several other factors (including COVID-19). The MPUC suspended the procurement for up to nine months until they have had time to conduct a thorough review of the first attempt.[10] Clearly, there is opportunity for overcoming financial barriers to solar for Mainers (especially low- to moderate-income households), but there are many legislative and governmental challenges related to implementing those types of policies in Maine.

...motivations for considering solar were related to environmental stewardship and increasing energy security not reducing energy costs

Our third overarching observation was that the top four motivations for considering solar were related to environmental stewardship and increasing energy security not reducing energy costs (see Table 2). While these factors may suggest potential marketing strategies for the solar industry, they also underscore the importance of understanding what drives local adoption of solar or other energy-related projects, which can vary significantly by region. For example, a study of early adopters of solar PV in Wisconsin revealed a number of trends that were not observed in our study in central Maine (Schelly 2014). In the Wisconsin study, the timing of the solar purchase was found to be more important than payback time or return on investment, whereas in our study, timing was a minor concern. Many in the Wisconsin study also indicated an interest in technical innovation and being viewed as an early adopter, neither of which were significant factors with GBS respondents. Environmental concern was an important motivation in both groups, though Schelly noted observing some strong anti-environmental views as well (those solar adopters were motivated by other reasons, including saving money, energy independence, and religious considerations). In addition, a recent Connecticut study found financial benefits to be the strongest motivator (Bollinger et al. 2020). Establishing a central state-level organization, similar to the Massachusetts Clean Energy Center, that keeps track of Solarize program (as well as community solar farm) installation numbers, power capacity, and maintains a participant list could help the state better understand adopters vs nonadopters through future surveys.

Finally, although survey respondents did not recognize peer effects in their responses to motivational factors, the rate of increase in solar installations in the towns participating in GBS and some of the open-ended survey responses suggest peer effects may be in play and there may be an opportunity to harness them further in the future. For example, responses to the question concerning the definition of community recognized "group of people" as a primary characteristic of community, with several respondents adding "shared responsibility" and "shared experiences." In addition, the nonadopter respondent who did not receive a response from the installer stated, "This was disappointing considering the program was a community effort." And, two respondents noted dropping the ball as a main reason they did not adopt during GBS, with one of those respondents and one other asking to be contacted if GBS is ever offered again. Also, three respondents included information that demonstrated some deficiency in understanding of energy, power, and/or energy economics.

Taken together, these anecdotal narrative responses suggest potential Solarize participants recognize the value of a group of people working toward a common goal and could be motivated by a program that highlights community effort and follow through, that keeps them on track with their own learning, and that presents complex energy and economics information in an easier-to-understand way. Marketing, policy, and programs that highlight the environmental benefits of solar, offer financial incentives that further reduce the payback period, and harness peer effects through group learning and awareness have the potential to increase solar adoption in Maine. One area in which GBS was particularly successful was with inviting potential participants to watch installations in action; 11 respondents (2 adopters) identified this as one way that they learned of GBS. One adopter recommended a couple of other ways these peer effects could be harnessed by future programs, including "some kind of incentive for people to get a neighbor or friend/family in the area on board with the program. Maybe there could also be some kind of community financing program." Certainly Solarize in Maine could benefit from a more centralized and formal process or agency that keeps track of statistics for each program and helps facilitate learning across geographic areas, similar to what the Massachusetts Clean Energy Center does. Maine could also benefit from something similar to the Vermont Energy and Climate Action Network (VECAN), a network of more than 136 local energy committees that are trying to advance renewable energy and energy efficiency, which hosts an annual conference and other information-sharing events.[11]

CONCLUSION

In 2017, the Greater Bangor Solarize campaign added 37 new residential solar PV installations (an increase of 63 percent over 2010–2016 in the same region) and 275 kilowatts of electrical power to central Maine (increase of 52 percent). However, this did not jump-start growth in solar adoption after the campaign ended, and solar energy generally remains an underutilized resource in Maine. Maine only gets 1.09 percent of its electricity from solar, which includes both residential and industrial-scale projects, and is currently ranked 39th nationally in solar adoption (SEIA 2021). This is despite adequate insolation (4–4.5 kilowatt-hours per square meter per day depending on location according to the Direct Normal Solar Irradiance map on the National Renewable Energy Laboratory website) and a price decrease of approximately 40 percent in the last five years.

We surveyed the GBS participants, both those who ultimately installed a solar array and those who did not, to better inform continuing research on peer effects, adoption motivation and barriers, and especially to provide some initial insight into why Mainers choose or do not choose to participate in Solarize campaigns. Our findings show that those who chose to install solar had higher income and more education than most Mainers, identified as members of the Democratic political party (though six potential adopters identified as Republican), and had taken some political action in support of solar or thought solar should be paired with incentives. They also were less concerned with long payback periods and more concerned with regulatory uncertainty than nonadopters. In addition to the primary concern regarding economics for the nonadopters, they also cited roof orientation, roof area, bad timing, installer issues, new house, dropping the ball, and living outside the GBS area as reasons they chose not to adopt solar through GBS. The most critical motivations for all respondents (including adopters and nonadopters) for considering a solar installation were reducing fossil fuel dependency, benefiting the environment, and supporting renewable energy. Most respondents found out about GBS through social media, word of mouth, or seeing a solar installation in progress, which support the notion of peer effects related to solar. Participation in GBS increased respondents' reported awareness of their own electricity expenditures and their knowledge of solar and other renewable energy (though participation did not change reported environmental behaviors). However, two adopters who reported increased knowledge of solar or renewable energy also demonstrated misunderstanding of solar power rating in their survey responses, and one nonadopter who reported increased knowledge of renewable energy demonstrated a misconception about the Residential Renewable

Tax Credit. These anecdotal results illustrate a common issue in renewable energy and energy efficiency adoption—a steep learning curve. While the GBS Solarize campaign has helped participants feel they know more about solar and other renewable energy, there is still work to be done in ensuring all participants understand key concepts required for effective decision-making.

Our findings speak to a critical need to extend Solarize programs beyond a niche market to the greater population of the state, especially to more densely populated areas, like Portland. The cumulative installed power capacity (2.4 megawatts) of the eight Solarize campaigns that have been implemented in Maine represents 6 percent of all existing residential solar power (40 megawatts) in Maine as of April 2020 (SEIA 2021). With an estimated total installed power capacity potential of 2 gigawatts (2,000 megawatts) for rooftop PV in Maine, Maine Solarize campaigns have reached less than 1 percent of their potential (Lopez et al. 2012). If Maine wants to reach more of this potential, future efforts should focus on reducing financial hurdles through creative financing or direct incentives particularly for low- to middle-income households; increasing awareness, education, and motivation by addressing key concerns of the broad populace; creating a central state-level database of Solarize (as well as community solar and other residential and commercial) solar installations that includes a list of adopters and nonadopters willing to be surveyed about their motivations, behaviors, and perceptions; and harnessing peer effects in program development to increase overall adoption. It is our hope that Maine residents, the state's solar industry, and policymakers can use the findings presented here to help Maine reach its potential for energy independence and make solar energy accessible to all Mainers.

NOTES

1 "Payback period" (sometimes called "payback time" or "simple payback") is a commonly used economic metric that tells the purchaser approximately how many years it takes to recoup the initial cost of the solar system via reduced electric bills. Consider a 6,500-watt solar array (the average size of the residential 2017 GBS installations); for this size array, the Solarize pricing would have been ($2.45/W) (6500W) = $15,925. However, this cost would have been reduced by the current 26 percent federal Residential Renewable Energy Tax Credit to $11,785 = (0.74 × $15,925). A 6500-watt array in Bangor, Maine, is expected to generate 8,133 kilowatt hours per year, which annually saves $1,464, based on the current cost of residential energy of $0.18/kWh (https://pvwatts.nrel.gov/, https://www.maine.gov/mpuc/electricity/delivery_rates.shtml). If the initial array costs $11,785 and it saves $1,464 per year in avoided electricity costs, the payback period is approximately 8 years. The payback period will thus depend on system size, initial cost, location, and the price of purchasing electricity.

2 Net present value (NPV) is the sum of the present value of all benefits minus costs over the lifetime of an investment (https://www.investopedia.com/terms/n/npv.asp). Consider a solar PV investment in which you pay a large lump sum (cost) at the start (year 0) and then for 25 years of operational lifetime you earn an annual benefit (electricity bill savings). The present value (what the value is to you today) of the cost is going to be the installed cost of the solar array (e.g., $11,785 for a 6,500-watt solar PV system) because you pay the cost now (year 0). But, the present value of future benefits depends on your time value of money. How much is $1,464 worth to you in year 1 compared to year 20? Generally, people want benefits sooner and want to pay off debts (costs) later. A discount rate accounts for this time value of money (and for things like inflation, risk, etc.). A higher discount rate makes the present value of far-future benefits smaller than a lower discount rate would. Any discount rate greater than zero makes the present value of benefits in year 20 smaller than those same benefits in year 1. We can do a simple NPV calculation by adding the installation cost as a negative quantity to the sum of the electricity bill benefits discounted to the present value using a discount rate of 1 percent to 7 percent (typically used for individuals, although individuals with no upfront cash could have discount rates approaching infinity since they cannot trade cash now for benefits later): $NPV = -C_0 + \sum_{t=1}^{25} \frac{1}{(1+d)^t}$, where C_0= installed cost in year 0; t = year 1,2,3...25; d = discount rate. A positive NPV indicates a good investment. A negative NPV indicates money will be lost over time. In this example, even with a discount rate as high as 7 percent, a Mainer can expect to earn a net present value of $5,000 on their investment during the 25-year warranty period (more after this period and more with a lower discount rate: $20,000 with a 1 percent discount rate).

3 More information about the growth of the solar industry is available on the Solar Energy Industries Association website (https://www.seia.org/solar-industry-research-data) and information about the lifespan of solar panels comes from EnergySage (https://news.energysage.com/how-long-do-solar-panels-last/).

4 The Greater Bangor Solarize campaign was open to residents and businesses in the following towns in central Maine: Bangor, Bradley, Brewer, Carmel, Dedham, Eddington, Glenburn, Hampden, Hermon, Holden, Hudson, Levant, Newburgh, Old Town, Orono, Orrington, and Veazie. However, solar installations did not occur in Carmel, Dedham, Eddington, Hampden, or Veazie, and we were unable to get pre-2017 data for Hudson or Newburgh, so we have excluded those towns from our analysis of number of installations and power capacity pre- and post-GBS. Some nonadopter survey results are from towns where no installations occurred.

5 More information about community solar projects is available on the Statistics page of this website: http://www.communityenergyus.net/. Information about the Massachusetts projects is available here: http://www.masscec.com/solarizemass.

6 From http://www.city-data.com [Accessed July 29, 2020]

7 Husson University Institutional Review Board approval #18SH02.

8 https://legislature.maine.gov/legis/bills/display_ps.asp?LD=1504&snum=128

9 https://www.maine.gov/mpuc/electricity/renewables/neb/index.shtml

10 https://www.maine.gov/mpuc/electricity/rfps/dg-procurement

11 https://vecan.net/energy-committes/

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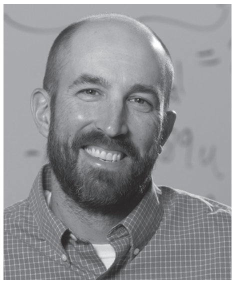

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