# PREFERENCES IN THE METROPOLITAN REGION ABOUT LOCAL SOLAR PV

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**Abstract**

We study the preferences in the city of Santiago of Chile about local Solar PV energy. We use an online survey (distributed during August and October 2018, with 99 valid responses) to identify prevalent perceptions, barriers, and opportunities related to local solar PV projects in the Santiago Metropolitan Region of Chile. We analyze survey results to explore heterogeneity in willingness to pay for energy from a local solar project and willingness to devote time to community led solar developments. Results can provide a better understanding of who is and is not interested in local solar energy options, informing public policy makers.

*Keywords: Chile, Distributed generation, Residential customers, Solar PV*

## 1. Introduction

At a national scale, Chile is in the midst of a rapid technological transition to more environmentally-sustainable energy generation sources, with a particular emphasis on solar photovoltaic (PV) technologies. However, the degree to which this macroscale transition will be socially sustainable and inclusive on the micro scale remains to be seen. Who will benefit from new jobs and revenue streams created by this massive growth in the solar industry? Will everyone who wishes to have access to solar power be able to do so? In recent years, "community solar" has emerged as an alternative business model to utility-scale solar and residential systems, offering promise for more inclusive solar development.

In the community solar model, individuals can finance or rent portions of a solar panel array—in some cases playing an active role in project management—and receive compensation for the generated clean electricity. The community solar approach reduces costs through economies of scale and expands solar energy access to portions of the population who are unable to purchase solar panels of their own due to physical, financial, or time constraints. As such, community solar has potential to provide voice and agency to local communities to secure their desired energy future, as well as economic and educational opportunities stemming from project development. However, this evolving business model is inherently contingent upon community buying and, hence, social and attitudinal factors that are not well-understood in their relation to local, shared solar initiatives.

The objectives of this work are: (i) Use a survey tool to assess respondents' interest in participating in local solar PV initiatives in both places (ii) Identify most influential factors in (1) interest in participating in local solar PV initiatives, (2) willingness to dedicate time and money to such projects, and (3) willingness to collaborate with community members, and compare between Chilean and Scottish respondents, (iii) Can trust and/or sense of ownership explain/affect/predict these elements? (iv) Test specific hypotheses about differing answers of Chilean and Scottish respondents, and influential factors/correlations for 3 dependent variables listed above (v)


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Assess and compare potential for varying forms of citizen-led/individual PV initiatives or projects in Santiago and Edinburgh based on consumers' perspectives.

## 2. Methodology

We implemented an online survey that was distributed during August and October 2018. We obtained 99 valid responses. The variables used are:

(i) Dependent: Degree of interest in participating in a local solar PV initiative if time or money were not factors (those with a high degree of interest can be thought of as the most broad segment of the sample population that could be targeted for residential or community solar projects) / factor analysis, multiple linear regression, descriptive statistics

(ii) Dependent: Willingness to participate (time and money, separately) in local solar PV initiatives

- Which factors explain why someone who is interested in participating local solar PV initiatives is or is not willing to dedicate time or invest money? / factor analysis, multiple linear regression, descriptive statistics
- H: Chilean residential electricity customers are more willing to invest time and money in local solar PV initiatives, in comparison with Scottish residential electricity customers / Student's t-test, ANOVA, Student's t test effect size

(iii) Dependent: Willingness to collaborate with other community members

- Which factors explain why someone who is interested in participating local solar PV initiatives is or is not willing to collaborate with other community members on a local solar PV initiative? / factor analysis, multiple linear regression, descriptive statistics
- H: Chilean residential electricity customers are less willing to collaborate with others to develop a community solar energy project, in comparison with Scottish residential electricity customers / Student's t-test, ANOVA, Student's t test effect size
- The difference between one's interest in local solar PV initiatives
- The willingness to dedicate time and/or money in local solar PV initiatives
- The willingness to collaborate with community members in local solar energy projects?

(v) Independent variables:

- Socio-Demographic: Income, % of income used for electricity, Age, Education level, Urban vs Suburban, Type of dwelling, Ownership vs rental of home, Likelihood of moving
- Other: Familiarity with solar PV, Environmental concern, Attitude towards solar, Community identity, Desire for energy independence, Perceptions of profitability, Sense of Ownership, Trust (in people), Perceived financial return, Peer influence.

## 3. Results

3.1. Descriptive statistics

Descriptive statistics was performed in order to better understand the magnitudes of each variable declared by the respondents. As can be seen below in Table 1, respondents present a "high" environmental concern (with mean 6.06 and standard deviation 1.44), perceived usefulness of solar PV technology (with mean 6.08 and standard deviation 1.49), and desire for energy independence (with mean 5.97 and standard deviation 1.65). Respondents' sense of ownership reaches a mean 5.26 with standard deviation 1.58 and trust presents a mean 4.86 with standard deviation 1.49. Community identity obtains a mean 5.20 with standard deviation 1.46. These three variables can be catalogued within a "neutral and slightly high zone". It is interesting to note that the lowest score and highest dispersion is obtained by the buying solar technology expertise variable, with a mean 3.29 and standard deviation 1.85.

Tab. 1. Descriptive statistics for variables that hypothetically would affect electricity residential customers' WTDT and WTDM to LSIPV

| Type of variable | Variable | N | Mean | SD |
|---|---|---|---|---|
| Social | Community identity | 98 | 5.20 | 1.46 |
| | Trust | 99 | 4.86 | 1.49 |
| | Willingness to collaborate with community in a LSIPV | 99 | 5.61 | 1.71 |
| | Perceived community interest in solar energy | 99 | 3.76 | 1.77 |
| Environmental | Environmental concern | 99 | 6.06 | 1.44 |
| Socio-technical | Desire for energy independence | 99 | 5.97 | 1.65 |
| | Sense of ownership | 99 | 5.26 | 1.58 |
| | Perceived usefulness of solar PV technology | 98 | 6.08 | 1.49 |
| | Perceived solar energy profitability | 99 | 5.70 | 1.42 |
| | Buying solar technology expertise | 98 | 3.29 | 1.85 |

In terms of respondents' WTDT and WTDM to LSIPV, according to Table 2, the first variable presents a mean 5.41 with a standard deviation 1.53. The distribution of the respondents' scores indicate that most of them are willing to devote time (76.8%) and the rest are neutral or more unwilling to do so. The second variable reaches a mean 4.78 with a standard deviation 1.52. The distribution of the respondents' scores indicate that 61.6% of the respondents are willing to devote money to LSIPV but a considerable rise of indecisive people can be noted at the same time (24.2%).

Tab. 2. Respondents' WTDT and WTDM to LSIPV

| N=99 | Very Low | Low | Slightly low | Neutral | Slightly high | High | Very High | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|
| WTDT (%) | 4.0 | 1.0 | 6.1 | 12.1 | 18.2 | 32.3 | 26.3 | 5.41 | 1.525 |
| WTDM (%) | 6.1 | 2.0 | 6.1 | 24.2 | 30.3 | 18.2 | 13.1 | 4.78 | 1.522 |

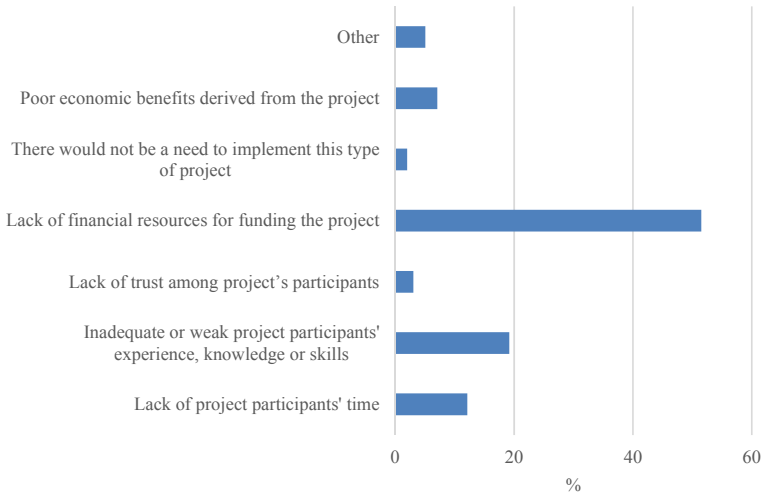


Fig. 1. Main barriers for respondents to be willing to participate in a LSIPV.

Figure 1 shows the main barriers for the respondents to be willing to participate in a LSIPV. As can be seen here, the most important barrier for them is "lack of financial resources for funding the project" (more than 50% of the choices). It is followed by "inadequate or weak project participants' experience, knowledge or skills" (about 20% of the choices), and "lack of project participants' time" (nearly 15% of the choices).

3.2. Regression Analysis

As shown below in Table 3, the regression model reasonably explains part of the variance ($adjusted\ R^2 = 0.287, F(4) = 10.759, p < .001$) in WTDM to LSIPV. The standardized coefficients show that the most important or significant variable is willingness to collaborate with community in a LSIPV ($\beta = 0.461, p < .001$), followed by community identity ($\beta = -0.301, p < .05$), sense of ownership ($\beta = 0.266, p < .05$), and Education - Postgraduates v/s Secondary school or below ($\beta = -0.256, p < .01$). The rest of the variables, namely trust, perceived community interest in solar energy, environmental concern, desire for energy independence, perceived usefulness of solar PV technology, perceived solar energy profitability, buying solar technology expertise, house ownership, electricity payer, education (other categories), income, age, and gender are not significant and, therefore, they are not included in Table 3. After checking the case-wise diagnostics and residuals statistics, we found six potential cases to be catalogued as influential or outlier. Nevertheless, none of these six cases presented a Cook's distance greater than one, so we can conclude there is no influential case or outlier that justifies a removal.

Tab. 3. Significant coefficients of the regression analysis for WTDM

| | Unstandardized Coefficients | | Standardized Coefficients |
|---|---|---|---|
| | B | Std. Error | Beta |
| Constant | 2.884** | .545 | |
| Community identity | -.314* | .125 | -.301 |
| Sense of ownership | .256* | .107 | .266 |
| Willingness to collaborate with community in a LSIPV | .409*** | .117 | .461 |
| Education (Postgraduates v/s Secondary school or below) | -1.626** | .550 | -.256 |

Dependent Variable: WTDM

*** p < .001

** p < .01

* p < .05

As can be seen in Table 4, the regression model explains a relevant part of the variance ($adjusted\ R^2 = 0.506, F(6) = 17.541, p < .001$) in WTDT to LSIPV. The standardized coefficients show that the most important or significant variable is willingness to collaborate with community in a LSIPV ($\beta = 0.808, p < .001$), followed by sense of ownership ($\beta = -0.220, p < .05$), trust ($\beta = -0.206, p < .05$), buying solar technology expertise ($\beta = 0.180, p < .05$), house ownership ($\beta = -0.167, p < .05$), and electricity payer ($\beta = -0.167, p < .05$). The rest of the variables, namely community identity, perceived community interest in solar energy, environmental concern, desire for energy independence, perceived usefulness of solar PV technology, perceived solar energy profitability, education, income, age, gender are not significant and, therefore, they are not included in Table 4. After checking the case-wise diagnostics and residuals statistics, we found six potential cases to be catalogued as influential or outlier. Nevertheless, again, none of these six cases presented a Cook's distance greater than one, so we can conclude there is no influential case or outlier that justifies a removal.

Tab. 4. Significant coefficients of the regression analysis for WTDT

| | Unstandardized Coefficients | | Standardized Coefficients |
|---|---|---|---|
| | B | Std. Error | Beta |
| Constant | 3.278*** | .493 | |
| Buying solar technology expertise | .150* | .063 | .180 |
| Trust | -.211* | .084 | -.206 |
| Sense of ownership | -.213* | .092 | -.220 |
| Willingness to collaborate with community in a LSIPV | .722*** | .087 | .808 |
| House Ownership (Owner = 0, Tenant = 1) | -.658* | .289 | -.167 |
| Electricity payer (Respondent = 0, Someone else = 1) | -.575* | .248 | -.167 |

Dependent Variable: WTDT

*** $p < .001$

* $p < .05$

## 4. Discussion and Conclusions

Regarding the results shown above, people have a high score for all variables, generally speaking, with the exception of two variables: perceived community interest in solar energy and buying solar technology expertise. Here, it is interesting to see that the respondents might not have enough knowledge about what their neighbours think about solar energy development, which would denote a need for improving the communication among the neighbours. This may imply a cultural change that may take a huge effort, but it should be possible. Moreover, respondents do not think or feel they know enough to buy solar energy technology. This means that the government and/or private sector should strengthen the current communication channels and deploy an effective marketing strategy that targets potential customers of solar energy technologies, especially taking into account that there would be a potential market to explore, as respondents would be willing to participate in LSIPV. In terms of trust and community identity, both variables are closer to the "neutral" score. In this sense, the government should deal with this matter by encouraging and facilitating the communication as well as deeper connections or relationships among the neighbours of a particular community. Of course, this does not exclusively depend on specific activities carry out by some public or private entity; rather, there are more profound cultural, psychological, historical, and sociological aspects that also need to be properly addressed in the context of LSIPV emergence. This might take longer, but it should be considered and promoted, especially in the context of community energy emergence in Chile.

We can also highlight that people in this study has a high WTDT but a lower WTDM, in comparative terms. This might be influenced by the fact that people have different disposable income, knowledge or education, or other things not accounted in this study. However, it is interesting to see that the most relevant barrier for them is "lack of financial resources for funding the project", which would indicate that financial constraints, some reluctance about spending money in such initiatives, or just uncertainty about how the project is going to be completely funded, could strongly be influencing the final choice. In this sense, the last two elements could have more relevance due to most people have undergraduate and/or postgraduate studies (82%) what would indicate a better access to financial resources, a better wage, so it would be possible a situation where people have the money but they just do not want to spend it in LSIPV. Another interesting thing is that, even when people is

willing to spend time in LSIPV, they are worried about the project participants' time, so here the focus should be on promoting an equal participation of people in such initiatives in case of having a collective project like a community energy project. At the same time, improving and strengthening people's expertise should be a priority, at least, at a basic level that is enough for knowing the project management main aspects. In any case, it is not necessary that all people have to know everything about how to manage a project. Some people can volunteer, some public/private organisation can provide advice, etc.

Nevertheless, according to the aforementioned results, respondents would participate in LSIPV anyway. Of course, the next question is how (or alternatively, through which scheme) would people participate in LSIPV? We encourage further research in this sense for Chile, particularly addressing social elements like sense of ownership as mentioned beforehand.

Concerning the regression analysis results, we can highlight that willingness to collaborate with community in a LSIPV, community identity, sense of ownership, and education (postgraduates v/s secondary school or below) are significantly related to WTDM to LSIPV. Willingness to collaborate with community in a LSIPV offers the largest positive contribution to WTDM, which is expected. On the other hand, the largest negative contribution to WDTM is given by community identity. This might be explained by the fact that respondents would not have a strong identity or attachment with their closest community or group of neighbours. However, they might be willing to collaborate with others by devoting money only if they develop a specific initiative with others (community), such as a LSIPV. In the same vein, when respondents present a lower education level, they would not be willing to give money, which can be seen through the coefficient for education (postgraduates v/s secondary school or below). Finally, sense of ownership is positively related to WTDM. This might be reasonably explained by the fact that respondents that want to make decisions and assume benefits, costs, and risks (derived from a LSIPV), would contribute money in order to get more rights (more ownership) and then, they would see their (financial) contribution rewarded by the LSIPV not only financially, but also "administratively". In other words, they would be willing to put money if they feel that they would have enough rights or ownership.

In terms of the second regression model, we notice that willingness to collaborate with community in a LSIPV, sense of ownership, trust, buying solar technology expertise, house ownership, and electricity payer are significantly related to WTDT to LSIPV. Willingness to collaborate with community in a LSIPV offers the largest positive contribution to WTDT, which is expected. Buying solar technology expertise is the second positive contribution to WTDT in terms of magnitude. This might indicate that respondents with knowledge about what, how and where to buy solar technologies, would be willing to contribute to LSIPV by spending time and delivering their knowledge as well. The coefficients for house ownership and electricity payer negatively contribute to WTDT indicating that when respondents are not the owners or are not paying the electricity bill, they are not willing to spend time in a LSIPV. Trust is also negatively related to WTDT and this might be explained by the fact that respondents that trust in others could spend time in other activities instead of spending time in LSIPV, given that they actually trust in others' actions (within a LSIPV). In the same vein, sense of ownership negatively affects to WTDT. This might be seen as respondents with the chance of making decisions and assuming the benefits, costs, and risks (derived from a LSIPV), would not like to spend time in a LSIPV because they feel they have enough rights to be rewarded without being involved too much time.

Based on the above, some recommendations can be given in order to encourage the emergence of citizen participation in energy production initiatives:

1) Foster deeper communication and connections within the communities and let them know the advantages of that and the initiatives they might conceive in terms of energy production.
2) Give more information about solar energy technologies as well as the opportunities that

energy/electricity markets could provide for people.

3) Delve into and analyse more social elements (especially taking the concept of sense of ownership into account) that may influence WTDT and WTDM, broadening the scope and collecting more representative data from Chilean residential customers.

4) Design and implement specific tools based on social and/or economic variables, for example, that help people to decide which scheme would be the best for them. This can be seen as an analogy of the customers risk profiles for financial investments, made by some financial companies.

5) Define specific and verifiable policies (and procedures) for promoting citizen participation in energy production jointly with Chilean communities.

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