A Case Study of Community Solar's Impact on the Energy Affordability of Minnesota's Low to Moderate Income households

by Annie Jung

Advisor: Dalia Patino-Echeverri

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Nicholas School of the Environment

Master's Project

Abstract:

Community solar gardens have been adopted by many states in the United States of America. They are an innovative way for utility ratepayers to have a direct role in the energy transition and support deployment of solar power onto the grid. However, the renewable energy industry has been criticized for the lack of low-to-moderate income household participation. To examine this further, I analyzed the participation rate of low-to-moderate income households in a sample set of Minnesota community solar subscriber data. This was achieved by translating the threshold for low-to-moderate income households to a housing price value. Furthermore, a model was created to assess the financial impact of various community solar tariffs on all the stakeholders involved. Analysis of data from 306 credit scores and 185 addresses of community solar garden subscribers showed that even with a credit score minimum requirement, almost 31% of subscribers were low-to-moderate income households. The results of the model showed that non-subscribing ratepayers pay at least 5% more in annual utility bills than subscribers, regardless of their income level. I also found that utilities and developers have competing interests when setting community solar tariffs, even after the Value of Solar was implemented. Overall, these findings support the low-to-moderate income ratepayer advocates and arguments for community solar reform.

1. **Introduction and objectives: The energy transition and CSG as an avenue to increase low-to-moderate income household participation**

Since the beginning of the electrification of the United States (US), fossil fuels have been the dominant energy source. However, in the last decade renewable resources have been introduced into the energy mix, as part of an "energy transition" to reduce greenhouse gas emissions from the electric power sector and ameliorate the threat of climate change.[1]

In the US, renewable portfolio standards (RPS) implemented at the state level, have proven effective in increasing adoption of low-carbon electricity sources. RPS require that state electric utilities procure a certain percentage of the electricity they distribute to final consumers from renewable sources, such as solar and wind. Currently, 10 states and territories have a 100% RPS (California, Colorado, Hawaii, Maine, Nevada, New Mexico, New York, Washington, Washington, DC, and Puerto Rico) and only 14 states and territories don't have an RPS or target.[2] This is a significant improvement from just 6 years ago, where only 18 states had RPSs implemented to encourage renewable generation.[3]

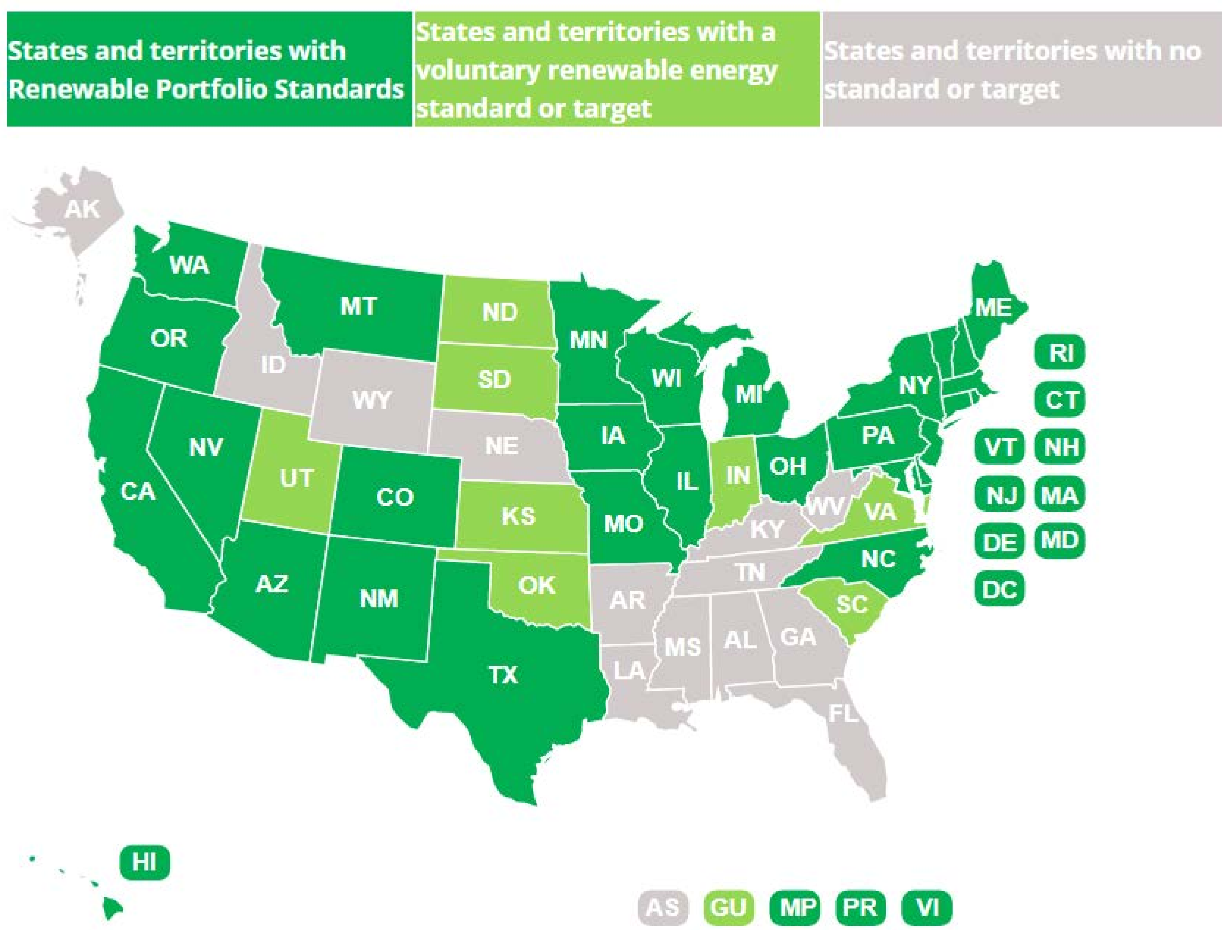

Figure 1 - 2020 RPS status of US states and territories. Map presented by National Conference of State Legislatures.[2]

The energy transition has doubled the amount of renewable energy generation in the US from 382 million megawatt-hours (MWh) of renewable energy produced in 2008, to 742 MWh in

2018. Electricity generated from renewables accounted for 17.6% of all electricity generation in the US in 2018 and this share is only continuing to grow.[4] According to the Energy Information Administration's 2019 Annual Energy Outlook Report, renewable energy is projected to grow to account for 31% of the energy mix by 2050. The share of electricity generated from coal is projected to drop significantly from 28% to 17%, while the percentage of natural gas in the generation mix is projected to grow from 34% to 39% at a growth rate of 14%, which is much lower than that of renewable energy's (72%) (see Figure 2 below). This is indicative of the accelerated growth in the renewables industry, which will change the energy landscape in the country.[5]

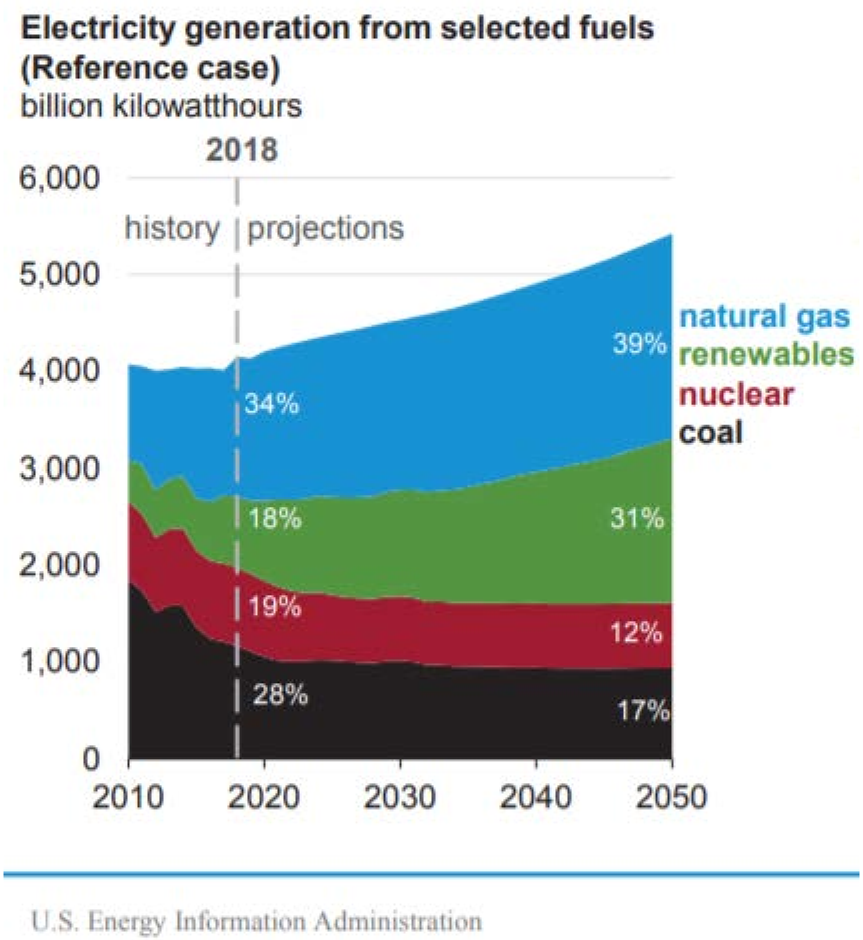

Figure 2- EIA projection of energy mix in the US from Annual Energy Outlook 2019.[5]

Unfortunately, this observed and projected growth in renewable energy has garnered some criticism due to its high costs. A common criticism is that renewable energy is for the rich. This is particularly true for distributed renewable generation. According to EnergySage, the cost of solar installation on a home rooftop is around $13,000.[6] When the poverty line for a family of 4 is $25,750[7] and the median household income in the US is $61,937,[8] spending 50% or 21%, respectively, on purchasing and installing solar panels would be difficult for most families. This has led to the perception that distributed renewable energy is only for high income households and hence is not promoting environmental justice.

As mentioned before, RPS is an effective way to add renewable energy to the electricity generation mix. This way, the utilities are responsible for procuring renewable energy in a proportion that meets or exceeds state mandates. Because these utilities pass the cost of new generation to ratepayers these are the ones ultimately paying for renewable energy. Traditionally, renewable energy has been more expensive than fossil fuels, so subsidies and incentives have been put in place to encourage development and drive down the cost to be competitive with fossil fuels.[9] These incentives are also paid for by the taxpayers and ratepayers. However, the extra costs passed onto the ratepayers are particularly onerous on the low-income segments of the population because in the U.S. every ratepayer pays the same rate regardless of their income status. Furthermore, customers also pay for the cost of running opt-in programs for renewable energy without receiving any direct benefits unless they choose to opt-in. One example of such opt-in programs allows consumers to subscribe to community solar gardens (CSG), which are the focus of this Master's Project.

CSGs are centrally located solar photovoltaic (PV) systems that provide electricity to participating subscribers. To illustrate how CSG work it is useful to examine an example. The electric utility Xcel has played a stellar role in its service territories in Minnesota and Colorado building and operating CSGs (today there are CSG programs run by a number of utilities and private entities in a total of 19 states, but Minnesota leads by installed capacity). To run this program, Xcel ratepayers in MN are charged approximately $36 a year. If ratepayers do not opt into the program, they do not recoup the cost nor see any financial benefits.[10] The chances of having households bearing the costs of but not receiving any benefits from CSG programs raises questions of energy justice in pursuit of a cleaner and greener energy portfolio. The conservative think-tank American Experiment in Minnesota (MN) called the cost structure of CSGs unethical because "1) It forces lower income households to pay more in order to reduce the costs for wealthier ones, and 2) It hides the true (and enormous) cost of the community solar boondoggle that has been sold to Minnesota ratepayers." Essentially, they argue that CSGs make it harder for low-income families to pay their bills by increasing their energy burden.[11]

In response to these criticisms, the MN legislature created an initiative called Connecting Low-Income Communities through Efficiency and Renewable Sources (CLICERS), which developed strategies to help more low-to-moderate income (LMI) households adopt solar energy (including CSG) and lower their energy burden.[12] Implementation has been taken throughout 2019.[13] At the federal level, two senators have introduced the Low Income Solar Energy Act, which would create energy financing programs for LMI households and expand current assistance programs.[14] Acts and initiatives like these are a step forward in the path to avoid unfair distribution of the costs of the energy transition.

2. Objective

As mentioned above, CSG programs are already part of the energy transition. They have received wide attention from the energy community in the last few years and have been heralded as a way for ratepayers to source clean solar power and save money on their electricity bills without having to install solar panels on their roofs. The case of MN shows that CSGs can be successful in driving rapid solar energy development. Indeed, in MN, the CSG program accounted for 2.5 gigawatts (GW) in 2019 and hence is the largest program in the country by installed capacity. Different factors have contributed to this success, such as the lack of state-wide system CSG capacity cap and properly placed incentive structures.[15] However, the large solar PV installed capacity through CSG programs in MN is only one indicator of success; whether LMI households have been part of this expansion is still questionable. LMI household inclusion in CSG programs would allow this population segment to play a role in the bigger energy transition and break the stereotype that clean energy is only for the rich.

This Master's Project explores whether MN's CSG program indeed excludes LMI households and what policy makers and developers could do to encourage LMI household participation in the program in the future. Because MN's is the most established and robust CSG program in the country, its analysis is useful for other states that are contemplating CSGs as an option in their energy strategy.

3. Background

This chapter summarizes the key features of CSGs as well as its status of implementation in the US.

3.1. Introduction to community solar

Electricity sourced from solar PV systems is playing a major role in the energy sector's transition from fossil-based to carbon-free.[1] However, the use of solar PV to power electric systems can be traced back to the mid-1990's, and the sophistication and efficiency of PV panels have improved since then.[16] This has made possible the installation of solar panels on private homes and utility-scale solar farms that generate enough electricity to be sold at competitive rates to utilities. Despite the improvements and lowering costs, many customers who want to source their power from solar energy cannot install or do not want solar panels on their rooftops or do not have an option to explicitly choose solar energy as their source.

As the solar energy market evolved, CSG programs became one of many solutions to the challenges mentioned above. As the name suggests, CSG programs offer customers an option to source a portion of their power use from a solar garden that is shared by other customers. CSG systems are typically remote off-site solar systems that are interconnected to the existing grid and owned and operated by a utility or a third-party with a set number of customers who are signed up as subscribers of the energy produced by the CSG system. This set up is enabled by the existence of the virtual net-metering rules, which allows remote sites to put power back on the grid as a net-metering system, without it being behind-the-meter of a customer's site. CSG subscribers will receive a credit on their electricity bills from the utility for their share of power produced each month. However, because the subscribers don't own the PV systems to which they are subscribed, they will have to pay the owner of the system (Sponsor) the amount credited on their bills. Typically, the third-party Sponsors will offer a discount (e.g., 10%) on this amount to attract subscribers to their programs. For example, if a five megawatt (MW) CSG system produces 500,000 kilowatt-hours (kWh) of electricity a month, and subscriber A is entitled to 1% of its production, this subscriber will get a bill credit for 5,000 kWh worth of electricity. For simplicity's sake, we will assume that 5,000 kWh is worth $10, so this is the credit the subscriber gets in the utility bill. In return, subscriber A will have to pay the Sponsor of the CSG system $10 for the power generation. However, the CSG system Sponsor offers a 10% discount, so subscriber A only pays $9, resulting in a $1 net saving. If the fees to join the CSG program are low or non-existent, then the reduction in their utility bills will lower the energy burden faced by subscribers.

A third-party Sponsor is typically a solar investment firm that owns and operates CSG projects. Oftentimes, the Sponsors are developers that continue to own and operate the projects. CSG is an attractive investment opportunity for Sponsors because of its predictable cashflow. As it will be discussed below, subscribers are often locked into a long-term contract (20 to 25 years) with the Sponsor, which guarantees a steady cashflow. Furthermore, the rate at which the contract is set trends higher than a typical rate from a Power Purchase Agreement (PPA) signed with an electric utility. Fixed revenues and high returns make CSG projects an attractive investment option for Sponsors, especially for those with higher costs of capital. Sponsors for whom it is hard to get large PPA projects - due to their inability to lower costs - see in CSG a profitable alternative. This has contributed to the growth of CSG, especially in Minnesota.[15]

The figure below illustrates the main stakeholders of an example CSG program, and the flows of information and cash among them.

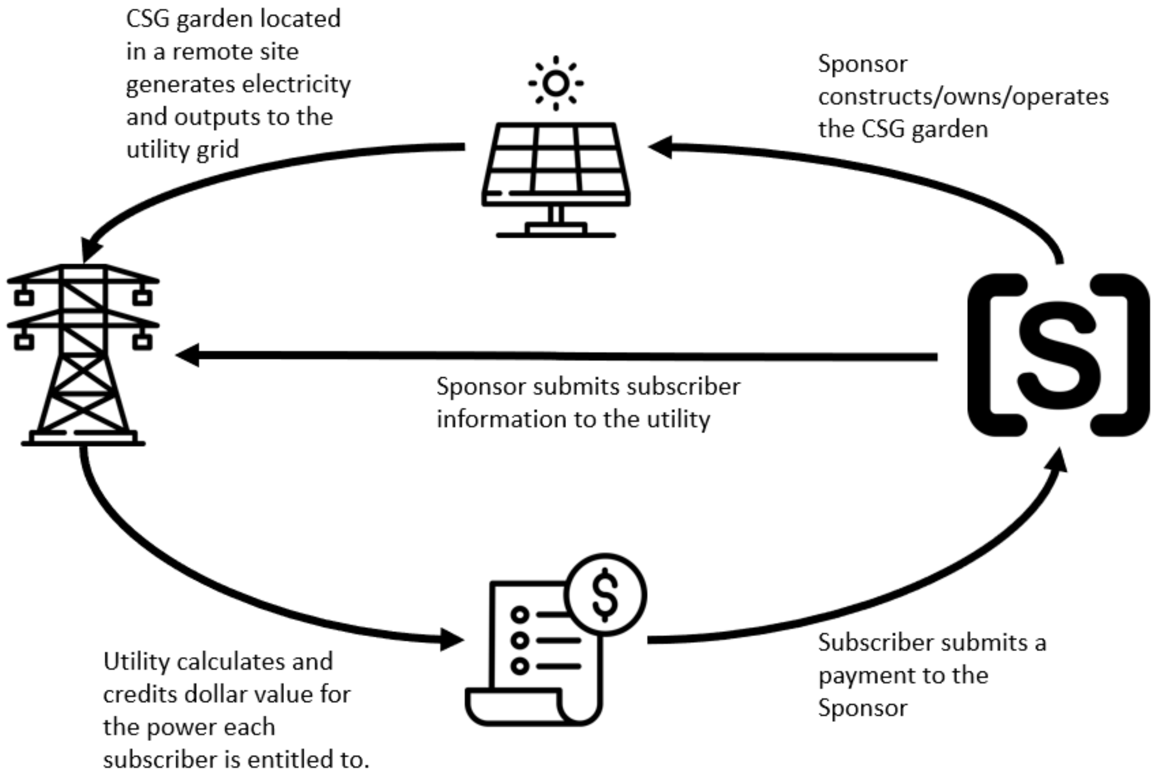

Figure 3: CSG Stakeholders and Operations. Created by the author.

3.2. CSG in the US

CSG programs have been implemented in 19 states since 2010 and there is supportive legislation in other 23 states. While Colorado led the charge in implementing the country's first community solar program,[17] MN has become the state with the most installed capacity. Other than Colorado and Minnesota, Massachusetts and New York also lead the pack in installed capacity. Even though other states have CSG programs, they haven't been fully effective and will need to adjust accordingly. Some states without a state-wide CSG program, such as Texas and Arizona, have independent CSG projects established by utilities. These programs started largely due to customer demand of clean energy and more creative solutions for LMI households. Figure 4 below illustrates the national community solar landscape.[18]

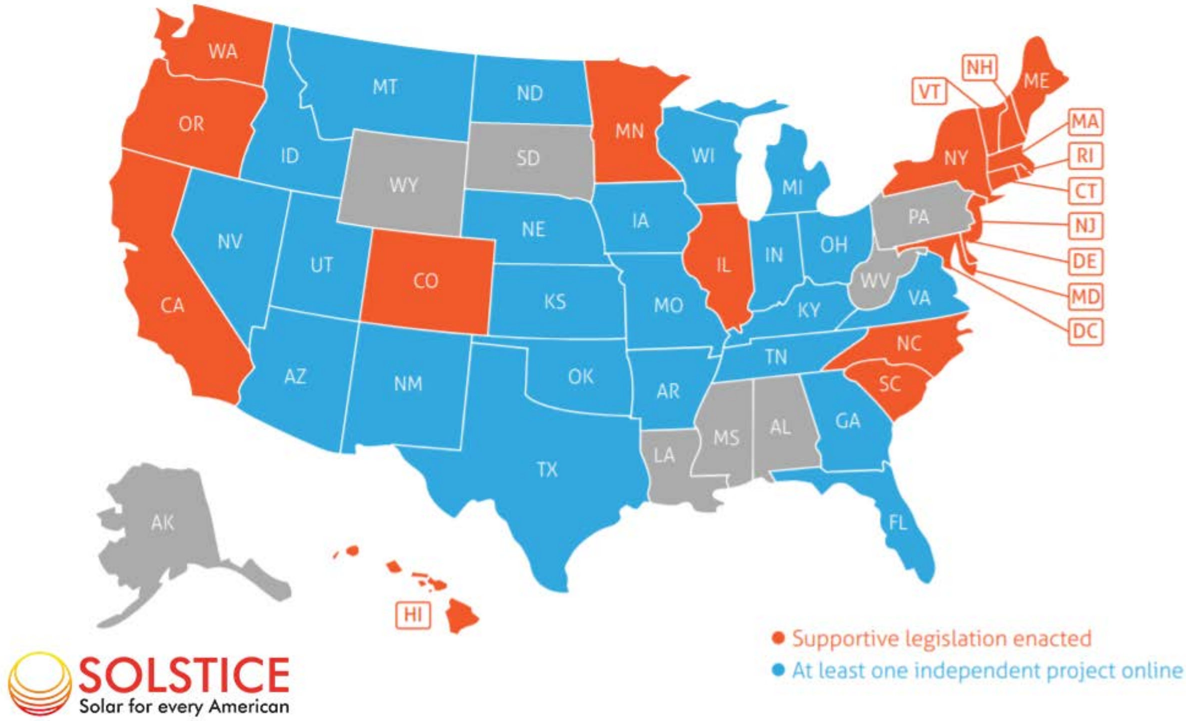

Figure 4 - 2020 CSG status of US states. Map presented by Solstice.us.[18]

3.3. Arguments in favor and against CSG

Before discussing the benefits and challenges that CSGs present to the energy transition, it is important to clarify that as evidenced by the description of the CSG program, the subscriber is not necessarily physically sourcing electricity from solar energy, since there may not be a physical connection from the subscribers home to the CSG site. Hence, Figure 3 above depicting the CSG operation describes an accounting methodology developed to encourage deployment of solar energy through ensured cashflows to the CSG projects in the same way that cash flows are guaranteed for residential roof-top systems.

CSG programs are widely welcomed by customers for a variety of reasons. First, there is a financial incentive. CSG programs in MN typically do not require subscribers to pay a subscription fee or for any upfront costs (e.g., panel costs, installation, labor), eliminating one of the biggest barriers for households to source power from solar energy. Furthermore, as mentioned before, CSG Sponsors typically offer a discount on the power consumed by the subscribers; therefore, the subscribers ultimately see a reduced power bill each month. Second, CSG programs eliminate the need to install PV panels on the roofs, giving renters, apartment dwellers, or roofs without adequate solar coverage the flexibility and option to participate in the solar program. Third, CSG programs allow subscribers who are more environmentally conscious to feel like they're reducing their carbon footprint. Although it's an accounting methodology and not a direct electron transfer, this psychological factor contributes greatly to the support of the program.[19] The two financial incentives alone make CSG programs a mutually beneficial way for LMI customers to participate in the energy transition, especially if they are environmentally conscious, but did not have the means to do so.

CSG programs are also attractive to solar developers and investors for multiple reasons. First, since CSG is solar energy, investors qualify for the investment tax credit (ITC). ITC allows investors to deduct 26% of solar installation costs from their federal taxes, which is a great financial incentive. Second, the modest project size (1-5 MW) allows smaller project developers with limited capital to compete in the solar industry. Large developers and utilities have the capital and resources to carry out utility-scale projects that cost hundreds of millions of dollars and drive down engineering, procurement, and construction (EPC) costs. Small developers, however, may not have the capital or have a higher cost of capital, which limit the size of the projects they can develop. By having a solar market that is capped at 5MW, CSG programs provide the perfect opportunity for them to grow a business and participate in the energy transition. Finally, CSG programs provide a guaranteed and steady stream of cash flow to the developers and investors. Because the subscribers are locked into a contract at a set rate designated by the commission or the utility, developers see a predictable inflow of cash every month. This significantly decreases the default and uncertainty risks for investors.

Finally, CSG programs are beneficial to society for a myriad of reasons. First, it's a renewable carbon-free source of electricity, aiding MN to meet its renewable energy standard (RES) goal of sourcing 30% its energy from renewable sources.[20] Second, CSG systems serve as a form of distributed generation, which provides benefits that large utility-scale power plants may not provide. For example, the CSG systems may be sited closer to loads than traditional power plants or utility scale renewables, possibly allowing for better resiliency, reliability, and power quality. Given the increasing need and demand for reliability in case of natural disasters or blackouts, distributed generation is becoming more and more attractive to customers and grid operators.[21]

Although CSG programs offer a wide range of benefits to MN customers, many issues have surfaced that have encouraged critics to speak out. First, the contract structure is often complicated. As mentioned above, subscribers have a contractual relationship with both the utility and Sponsor, adding a layer of complexity to power purchasing. Furthermore, contracts with Sponsors come with other conditions, such as lock-in periods and exit fees. The cost of electricity generated by CSG systems is also typically higher than the cost of electricity from other sources of renewable energy, such as utility-scale solar farms due to economies of scale which makes this alternative a more economic option than CSGs.

As mentioned before, the cost of administrating CSG programs, just like the cost of utility-scale solar, is passed onto utility ratepayers, even if they are not signed up as subscribers. This socialization on costs results in reduced bills for subscribers, but increased bills for non-subscribers. Once again, the reduced bills for the subscribers come from the difference between the credit they receive from the utility and the payment they make to the Sponsor. Because the payment made to the Sponsor is lower than the credit received from the utility, subscribers see a benefit every month, that usually compensates any upfront membership fees they may have paid to join the program. For example, if set rate of electricity for CSG programs is $0.13 per kWh and one month's subscription was 5,000 kWh, the subscriber would get a credit of $650 from the utility. In return, the subscriber would pay the Sponsor $585 -after the 10% discount provided by the Sponsor to make the program competitive- resulting in $0.117 per kWh for the 5,000 kWh of power. If the upfront costs of becoming a subscriber are lower than the benefits from bill reductions, then subscribers receive a net benefit. But even if CSGs benefit subscribers, they impose high costs to all utility rate payers who are forced to pay for more expensive electricity. Given that utility-scale solar farms generate electricity at a far lower cost than CSGs, the net economic outcome from CSGs for non-subscribers is negative. For example, a 2018 news alert showed that utility solar projects in a Minnesota Xcel territory will deliver power at $0.035 to $0.044 per kWh, less than a third of the CSG cost example above.[22] Furthermore, CSG programs are often criticized for the lack of LMI household subscribers.[23] Because Sponsors require subscribers to have high credit scores to participate in the program, LMI households are often overlooked as potential subscribers. It is seen as a failure that the intended audience is not being reached due to financial reasons and overhaul of the program is needed.[24]

3.4. CSG in MN

In 2013, MN statute 216B.1641 required public utilities to file a plan to operate a community solar program.[25] This statute jumpstarted the CSG industry in MN and became the catalyst to the current CSG program. The figure below shows the exponential growth MN saw in the solar installed capacity after this statute was enacted (CSGs fall under the category of Non-Residential).[26]

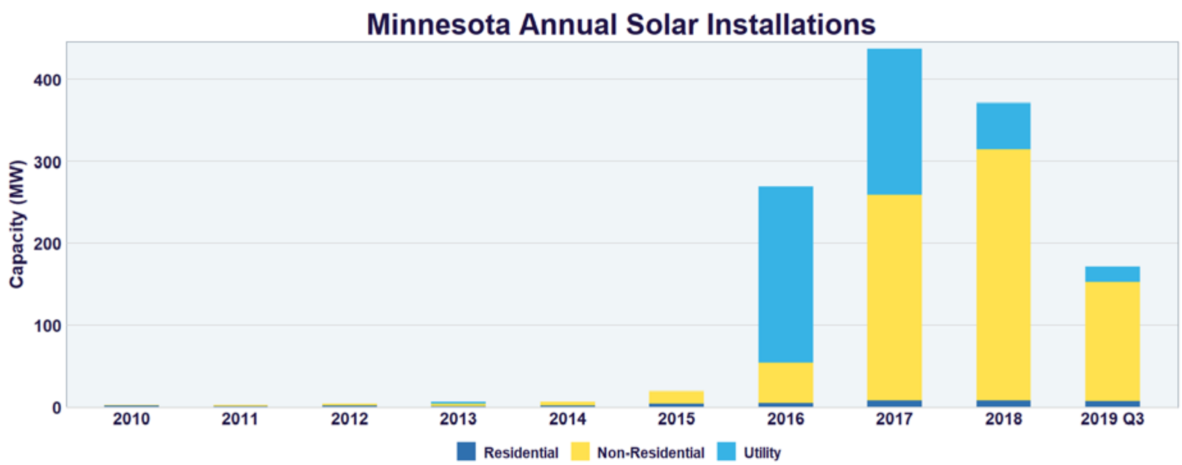

Figure 5 - Minnesota Annual Solar Installations. Graph presented by Solar Energy Industries Association[26]

The real noticeable growth happened in 2015 when MN's biggest utility Xcel Energy started its CSG program. It quickly became the largest operator of CSGs, accounting for up to 99% of all CSG projects in the state. Since the inception of the community solar statute, MN's CSG capacity has reached 2.5 GW and a total solar installed capacity of almost 2.8 GW, which ranks MN at 12th in the country for the most installed capacity. [27] This shows that the solar legislation aggressively pushed MN's utilities to maximize on the state's limited solar potential (17th in the US).

When the Xcel CSG program started, the rate subscribers would receive as a credit was set by the MN Public Utilities Commission (PUC). After much back and forth, the rate was set at $0.15033 per kWh. This rate was highly advantageous for subscribers, because the retail rate of electricity was about $0.12 per kWh.[28] In 2017, Xcel began to credit its subscribers at the new value of solar (VOS). VOS was developed by the MN Department of Commerce in 2014 and gave the utilities the option to adopt the new tariff in lieu of the CSG rate set by the PUC. The purpose of VOS was to incentivize solar energy producers with the true cost of solar and benefits to the grid than other rates. The components of VOS include:

- Avoided fuel cost
- Avoided plant operation and maintenance cost
- Avoided generation capacity cost
- Avoided reserve capacity cost
- Avoided transmission capacity cost
- Avoided distribution capacity cost
- Avoided environmental cost.

When all these costs were calculated, the VOS was set at $0.1033 per kWh for calendar year 2017 and $0.1006 for calendar year 2018. In comparison to the 2014 rate, the VOS offers significant savings for Xcel, and lowered incentives for subscribers and developers; hence, the reason why there is a drop in CSG installations from 2018 to 2019. However, when the VOS was calculated for the following years there was a significant increase, resulting in $0.25 per kWh for projects coming online in 2020[29] – much higher than the retail rate of $0.13 per kWh.[30] While this is great news for project developers and subscribers, Xcel would be paying almost double the retail rate for power generated by CSG projects. In response to this spike in projected rates, Xcel opened a rate case docket with the MN PUC asking to lower the rate.[31] PUC accepted the request[32] and reached a compromised rate that is 4% higher than 2019's rate ($0.0904 per kWh).[33] Due to this uncertainty in the value of solar, the rate of CSG installations has slowed down and the future of the program remains uncertain.

As a result of this uncertainty and seemingly increasing cost of CSG rates, lawmakers in MN have proposed several legislations to limit the growth of CSG, such as putting a cap on the total CSG capacity per year. Coupled with the criticism that CSG doesn't benefit LMI ratepayers, as well as the fact that only 13% of CSG capacity serves residential ratepayers, MN's CSG program has been labeled as "a big bonus for businesses."[10]

4. Analysis

This Master's Project presents two pieces of analysis that aim at exploring the extent to which CSGs are effectively including LMI households as active participants of the energy transition in MN.

The first piece of analysis explores the geographical distribution of the CSG installations in the state of MN and its proximity to wealthy and low-income counties. The second piece assesses the participation of LMI households through the analysis of subscriber data.

4.1. Mapping CSG projects in MN

Figure 6 below, built using Google Earth, illustrates the geographic distribution of CSG projects over MN's utilities service territories and cities (see Appendix C for data).

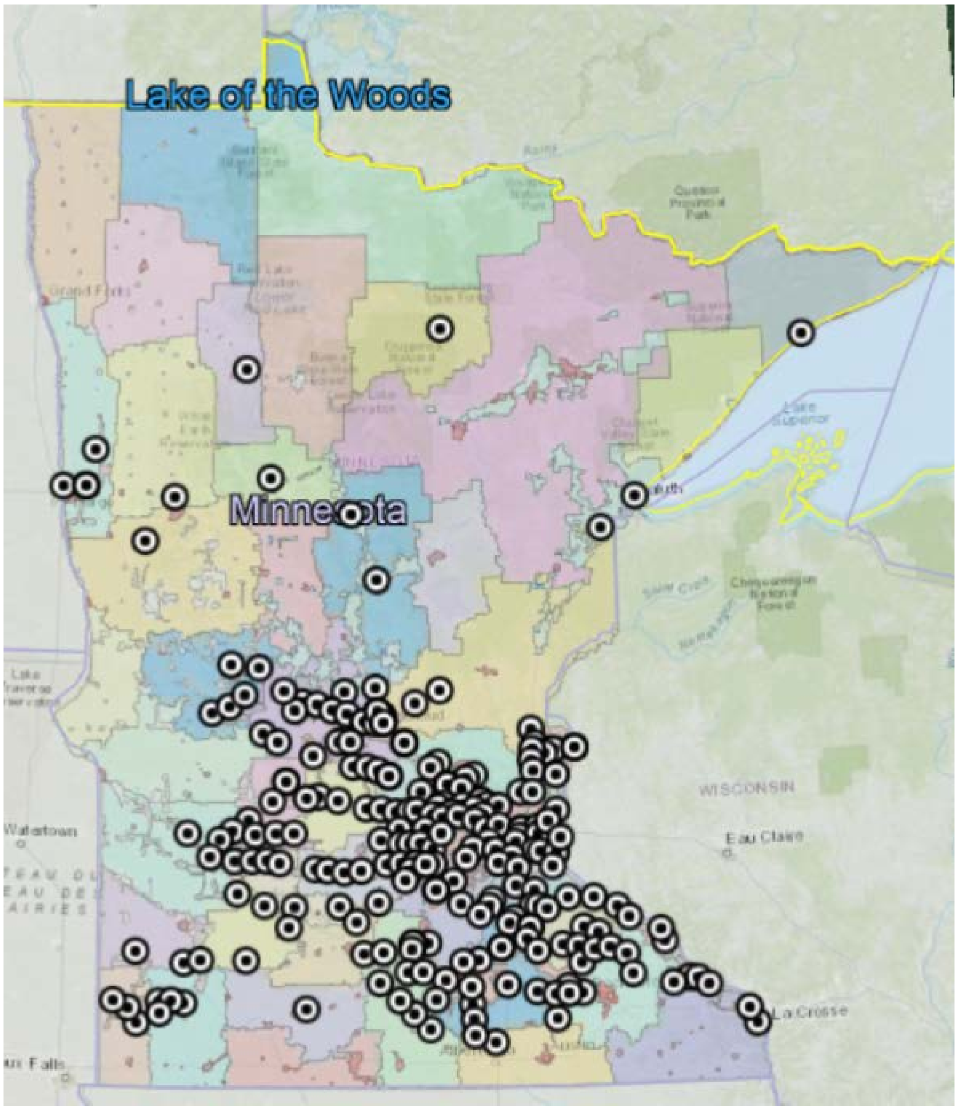

Figure 6 - CSG projects in Minnesota. Generated in Google Earth by the author.

The figure shows a high concentration of projects near the Minneapolis metro area. In order to determine if these projects serve poor or wealthy cities, MN's top 25 wealthy and poor cities were mapped (see figure 7).

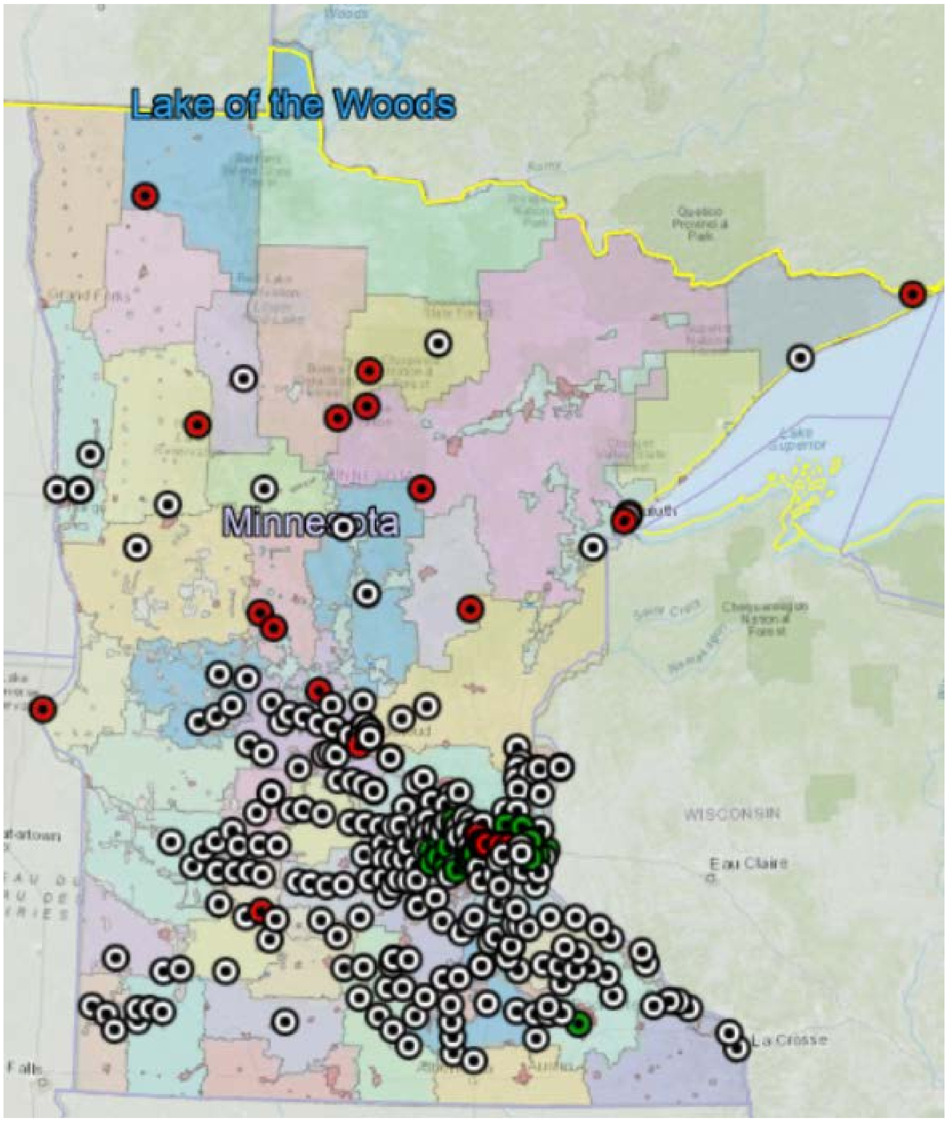

Figure 7 - CSG projects in MN with top 25 wealthiest (green) and poorest cities (red)

A quick visual analysis shows that there are many CSG projects near wealthy zip codes (green), while not all poor neighborhoods (red) are near a CSG project. A deeper data analysis of zip codes showed that 60% of wealthy zip codes had a matching CSG project zip code, but only 40% of poor zip codes did (see Appendix B).

This quick analysis supports the claim that LMI ratepayers do not benefit from CSG programs as much as wealthy ratepayers. As a response to this LMI participation gap, some states have begun to create CSG carveouts for LMI ratepayers; meaning, a certain percentage of CSG subscribership must be LMI households. For example, Colorado's legislation requires 5% LMI subscribership and New York's is 20%. Through this Master's Project, I intend to explore and determine whether the MN CSG program deserves the criticism that it excludes LMI ratepayers. Furthermore, I intend to determine the level of LMI participation, even without the carveout requirement.

4.2. Analyzing CSG's subscriber data to assess LMI participation

An analysis of subscriber data allows determining whether the MN CSG program excludes LMI ratepayers. The analysis uses the same method used by the Chan Lab at the University of Minnesota's Center for Science, Technology, and Environmental Policy to analyze the characteristics of the subscribers, as of May of 2018, of the CSG projects developed by Cooperative Energy Futures (CEF). The method is applied to a proprietary dataset provided by another CSG developer.

4.2.1. Explanation of the method used by the Chan Lab to analyze CSG subscribers

CEF develops CSG projects in South Minneapolis, MN and recruits subscribers without a minimum credit score requirement to actively signs up LMI ratepayers for their programs. The report was written to demonstrate how much of their subscribership is indeed LMI households to qualify for the U.S. Department of Energy's Solar in Your Community Challenge, a $5 million contest to support CSG programs that serve underprivileged neighborhoods. In this report, LMI is defined at 80% of area median income (AMI). The methodology the Chan Lab used in this report was based on "parcel analysis." Since the Chan Lab did not have income information on CEF's subscribers, they developed a method to determine their income category by using the subscribers' addresses and corresponding housing values.

1) Parcel Value and Rent Matching: The Metropolitan Council publishes data on housing and rental affordability based on a household's income. For example, the dataset would establish that a person with an income of $50,000 would be able to afford a house priced at $200,000. Using the Low Income Home Energy Assistance Program's (LIHEAP) data on MN's AMI, the threshold for LMI household categorization was established by taking the 80% value of the AMI. Then, the Metropolitan Council's data was referenced to find the house affordability value for the LMI threshold amount. This value served as the new cut-off point for LMI households.
2) CEF provided the Chan Lab with the addresses of its subscribers. Using county parcel data and online sources (e.g., Zillow), the Chan Lab used the given addresses to find the estimated market value for each house.

If the house value was at or below the cut-off point found in 1), that subscriber would be designated a LMI household. The Chan Lab was able to use this data to determine the percentage of LMI households in their subscribership.[34]

4.2.2. Data

For this Master's Project, I was able to procure two sets of data from a solar developer who owns and operates CSG projects in MN. Unlike CEF, this developer used the FICO credit-risk scores as the basis of screening subscribers.

The first set of data comprised of FICO scores (306 scores total) from every MN subscriber the developer had, regardless of their current subscription status. The second set of data comprised of addresses of currently active subscribers (185 addresses total after data scrubbing and normalization). Using these data sets, I was able to replicate the Chan Lab's methodology.

4.2.3. Analysis

The analysis of the FICO scores showed an average score of 760 and a median score of 780.5, which are considered "very good" credit scores.[35] This was an expected result, since the developer would only accept subscribers with 680 (a "good" credit score) or higher into the program.

The analysis of the addresses followed the Chan Lab's methodology. Because there was no insight into the family makeup of the households, it was assumed that all subscriber addresses were households of four to maintain consistency with the LMI definition. Another assumption was that subscribers would purchase and live in houses at their affordability price instead of living well under their means. The final assumption is that the subscribers would be paying mortgage on the current value of the house, which would be higher than historic housing prices in MN.[36] If the houses are paid off or purchased in the past, their mortgage payments would be lower, thus increasing their disposable income.

1) Median income and affordability threshold

According to the Metropolitan Council, the AMI of the Minneapolis metro area was $100,000 for a family of 4 for the year 2019. This meant that the LMI threshold is $80,000. However, this was capped at the US national median family income of $75,000. This amount corresponded to a housing price of $254,500. This meant that a family of four living in a house that's worth $254,500 or less would be considered an LMI household.[37]

2) Subscriber addresses and house value

Using online resources like Zillow and Trulia, the estimated house value of each address was obtained. Because all the addresses weren't in the metro area, the median income of each corresponding county was taken into consideration to adjust the housing value. This enabled a more accurate comparison of their house value to the threshold value, which was established based on a different county's median income. This was done by calculating the ratio of the county AMI to $100,000, the metro AMI. Then, the adjusted house value was calculated by dividing the Zillow/Trulia house value by the ratio. This adjusted value was compared to the threshold value. The subscribers with an adjusted house value less than the threshold value was flagged as LMI.

In addition to determining the level of LMI participation in CSG projects, this analysis also considers the financial impacts they have on all parties involved (developer, utility, subscribers, and non-subscribers). The following inputs are taken into consideration:

- CSG tariff ($/kWh)
- Retail rate ($/kWh)
- CSG production (kWh/year)[i]
- Average electricity usage per household (kWh)[38] (EIA 2019)
- Subscription (0.5% of CSG output) (kWh/year)

[i] Based on a 1 MW project using NREL's PVWatts tool with Rochester, MN location

- CSG cost to ratepayers ($)

Using the inputs, the following outputs were calculated –

- Developer revenue ($/yr)
  - $10\%\ discounted\ tariff\ \times CSG\ production$
- Cost to utility ($/yr)
  - $CSG\ Tariff\ \times CSG\ production$
- utility net charges to CSG subscribers($/year)
  - $(Average\ electricity\ usage\ per\ household\ \times retail\ rate\ of\ electricity) - (subscription\ \times CSG\ tariff) + (0.9 \times CSG\ tariff\ \times subscription) + CSG\ cost\ to\ ratepayers$
- Utility net charges to non-CSG subscribers ($/yr) bill per year
  - $(Average\ electricity\ usage\ per\ household\ \times retail\ rate\ of\ electricity) + CSG\ cost\ to\ ratepayers$

4.2.4. Results

The analysis of the data showed a mean adjusted house value of $322,256, and median adjusted house value of $298,426, both above the LMI threshold. Further analysis showed that 30.6% of subscribers were LMI. When unadjusted house value was used, 44% of the households fell under the LMI categorization.

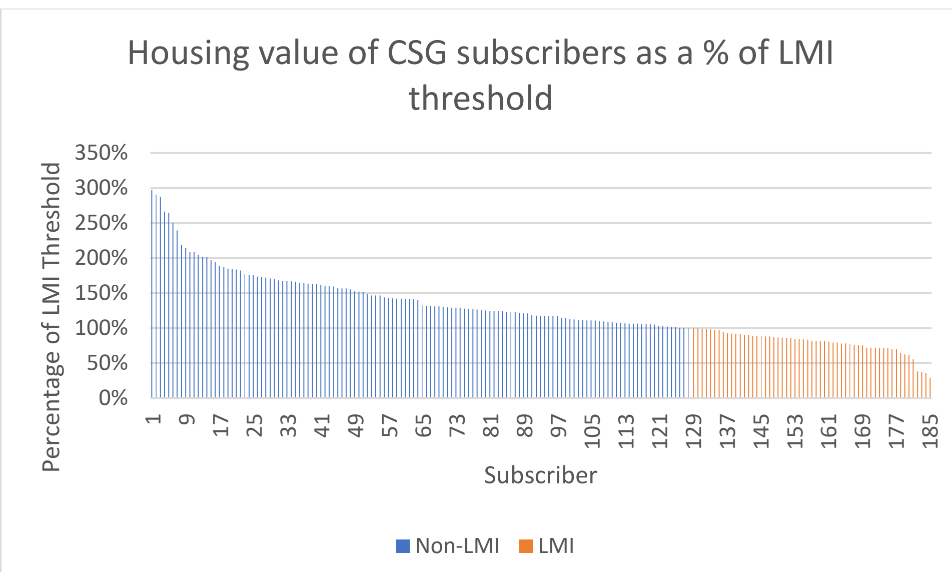

Figure 8 - Graph comparing the housing value of CSG subscribers as a % of LMI threshold. Created by the author.

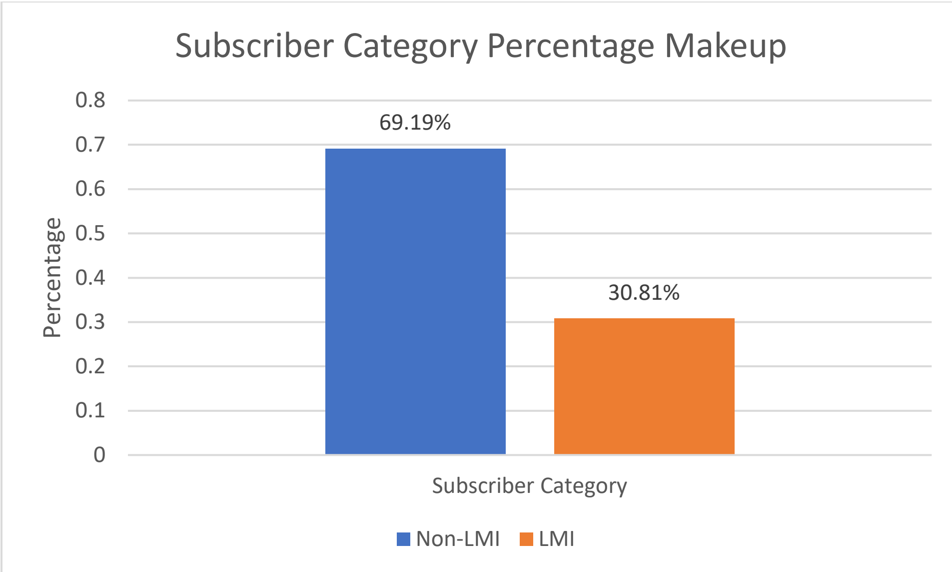

Figure 9 - Graph depicting subscriber category percentage makeup of sample data. Created by the author.

A deeper analysis into the LMI subscribership showed that only one household was under the poverty line ($25,750 which translates into approximately 25% of the AMI). At 30% of AMI, the affordable home price is $92,500. The lowest adjusted home price in the data set was $73,640, which is 20% lower than the lowest affordable home price listed by the Metropolitan Council. Furthermore, there were only 4 subscribers, or 7% of LMI subscribers, who fell under 30% of AMI or below. Using the US Census Bureau's LMI definition, 88% of LMI subscribers fell under the moderate-income household category (50% to 80% of AMI) and only 12% of the LMI subscribers were categorized as low-income (below 50% of AMI). This shows that while the CSG programs do serve the LMI communities more than expected (5% by Colorado and 20% by New York), low-income ratepayers, the class of ratepayers with the greatest energy burden, are still disproportionately underserved. Without subsidy programs to help them with their energy bills, their burden is increased by having to pay for the cost of CSG programs.

Although studies have shown a high correlation between credit scores and income,[39] this analysis showed that LMI households with good credit scores exist and are able to meet financial obligations. This analysis showed a surprising outcome of LMI inclusion through the FICO score screening process. However, further challenge lies in finding and recruiting LMI households with good credit scores into CSG programs.

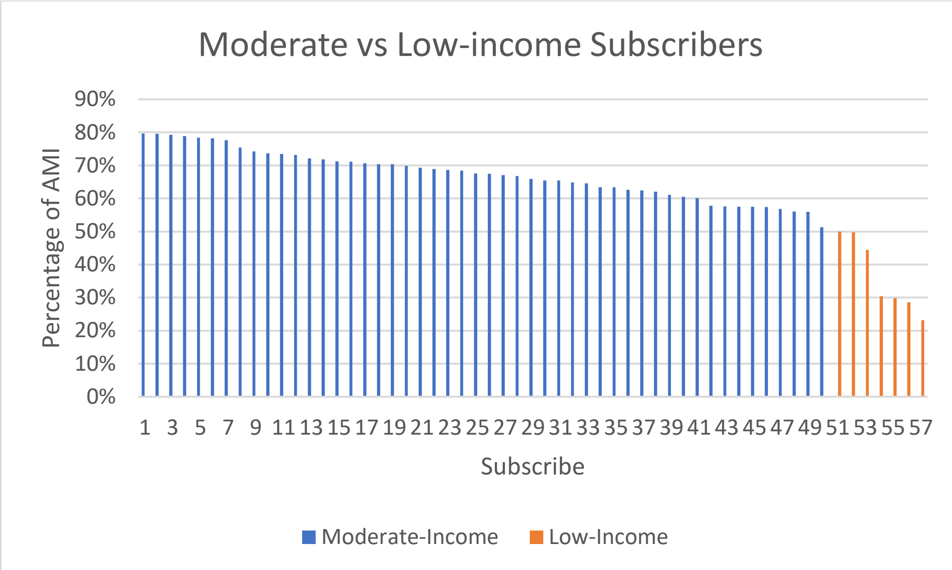

Figure 10 - Graph depicting moderate vs low-income subscriber makeup of sample data. Created by the author.

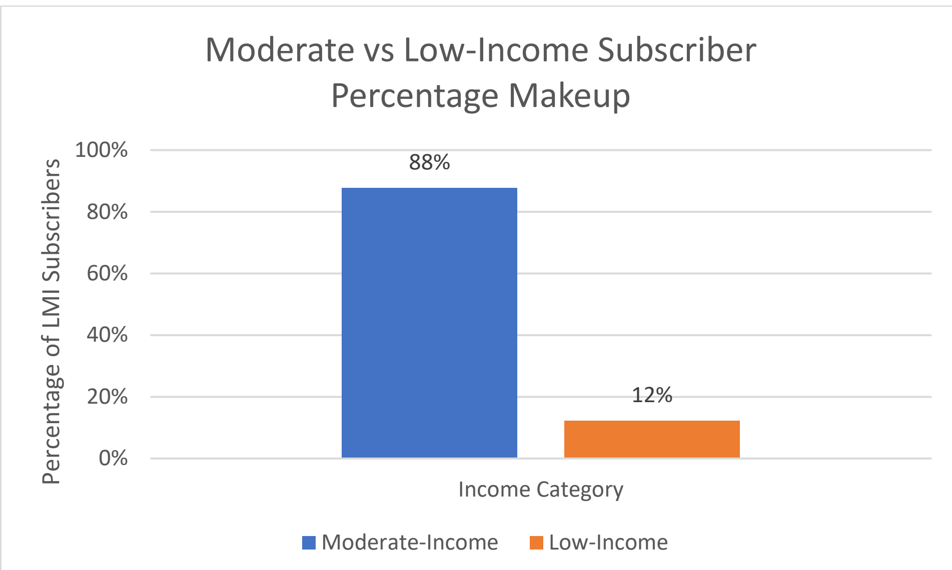

Figure 11 - Graph depicting moderate vs low-income subscriber percentage makeup of sample data. Created by the author.

Finally, using the model with the various inputs to calculate financial impacts on CSG stakeholders, the cash flows for all CSG participants were calculated for years 2015 to 2020 taking into account the different CSG tariffs (before and after the implementation of the VOS that happened in 2017, which credits CSG subscribers based on a calculated value of solar instead of a prescribed rate by the PUC).

Tariff ($/kWh)(i)	0.12000
Retail Rate(ii)	0.12
CSG Production (kWh/year)(iii)	1330990.00
Average electricity usage (kWh)(iv)	10972.00
Subscription (0.5%) (kWh)(v)	6654.95
Ratepayer Increase ($)(vi)	36.00

Table 1 – Inputs to the financial impact model shown in Table 2. (i) CSG tariff – variable input; (ii) average retail rate of electricity in Minnesota; (iii) Based on a 1 megawatt project using NREL's PVWatts tool with Rochester, MN location; (iv) the average annual electricity consumption for a U.S. residential utility customer in 2018 from the US Energy Information Administration; (v) model assumption of 0.5% subscription for a customer (0.005×CSG Production); (vi) Average increase per year in utility payments in MN due to CSG program implementation.

Stakeholder	2015 (tariff = $0.15033/kWh)	2017 (tariff = $0.1033/kWh)	2018 (tariff = $0.1006/kWh)	2019 (tariff = $0.0904/kWh)	2020 before compromise (tariff = $0.25/kWh)	2020 after compromise (tariff = 0.0940/kWh)
Developer revenue(i)	$ 180,078.95	$ 123,742.14	$ 120,507.83	$ 108,289.35	$ 299,472.75	$ 112,620.92
Cost to Utillity(ii)	$ 200,087.73	$ 137,491.27	$ 133,897.59	$ 120,321.50	$ 332,747.50	$ 125,134.36
Subscriber utility bill per year(iii)	$ 1,252.60	$ 1,283.89	$ 1,285.69	$ 1,292.48	$ 1,186.27	$ 1,290.07
Non-Subscribing Ratepayer bill per year(iv)	$ 1,352.64	$ 1,352.64	$ 1,352.64	$ 1,352.64	$ 1,352.64	$ 1,352.64
Non-subscribing Ratepayer premium(v)	8%	5%	5%	5%	14%	5%

Table 2 - Financial impact of CSG on all its stakeholders from 2015 to 2020. Calculations for each stakeholder: (i) 10% discounted tariff ×CSG production; (ii) Tariff ×CSG production; (iii) (Average electricity usage per household ×retail rate of electricity)-(subscription ×tariff)+(0.9×tariff ×subscription)+CSG cost to ratepayers; (iv) (Average electricity usage per household ×retail rate of electricity)+CSG cost to ratepayers; (v) (Non-subscribing Ratepayer bill per year/Subscriber utility bill per year) – 1.

Table 2 shows that non-subscribing ratepayers pay at least 5% more in utility bills per year than subscribers, regardless of their income level. It is also shown that the cost to utility has increased since 2018, even after the VOS compromise. The analysis of these figures supports the opposition from utilities and LMI ratepayer advocates. While the cost to Xcel keeps going up (which means the cost of CSG programs passed onto ratepayers could increase, as well), the revenue for developers keeps shrinking. This coincides with the slowing rate of CSG project installations depicted in Figure 5.

5. Conclusion

Before conducting my analysis for this MP, my hypothesis was that a credit score check of potential subscribers largely excludes LMI ratepayers from CSG programs. However, the analysis of the sample data I obtained from a developer showed that even with a credit score check, at least 30% of subscribers are LMI ratepayers. Compared to other states' LMI subscriber requirement, 30% is much higher. Unfortunately, a deeper dive of the LMI subscription base showed that the low-income ratepayers are disproportionately underserved, while the majority of LMI subscribers fall under the moderate-income category. It is especially important to address the limited inclusion of low-income ratepayers in the energy transition, in this case CSG programs, because of their high energy burden. Furthermore, analysis has shown that CSG programs result in net electricity bill savings for subscribers; therefore, it is important to provide these cost-saving opportunities to relieve them of the energy burden as much as possible through programs like CSG.

This can be achieved through multiple ways. The first approach operates under the assumption that the system of credit score checking stays in place. First, more resources should go towards marketing CSG programs to low-income ratepayers. It could simply be the case that low-income ratepayers are not aware of the programs; therefore, missing their chance to save on their bills.

Second, LMI ratepayers should be given more resources to strengthen their credit scores. Since a credit check is one of the first barriers to becoming a subscriber and developers are not privy to income information, ensuring a high credit score will give them a higher probability of being approved as a subscriber. Providing better education about credit scores and bill payment relief programs could help improve credit scores.

Third, states should analyze if requiring non-investor owned utilities like electric cooperatives and municipal utilities to build and operate more CSG programs could be economic and beneficial to rate-payers. As the analysis of current CSG programs and MN's 25 poorest neighborhoods showed, only 40% of them have a CSG project near them. Even if they can be a subscriber because they live in the same utility territory as a CSG project, they will not reap the grid benefits from having a solar distributed generation facility close to them. Many of the poor neighborhoods are in or near rural communities where Xcel does not serve, and many of the non-Xcel utilities do not have the resources to implement and support big CSG programs. If incentives are created to encourage development in those areas, more opportunities to serve poor communities could be created and the benefits of CSG could outweigh its costs.

The second approach for more LMI inclusion is under the assumption that the credit score checking system retires. First, the MN government could make legislative changes to require a certain percentage of LMI households in CSG programs like Colorado and New York did. A verification method should be developed to ensure inclusion while protecting their privacy. If the verification burden falls to the ratepayers themselves, it may deter them from signing up because of the hassle. On the other hand, if the burden falls to the administrators, a program that deals with sensitive personal information could create costs and complications. To minimize this, lawmakers should work closely with the LIHEAP and other assistance program agencies to develop a simple and secure process. Finally, to minimize default risk to the developers, information on payment history could be provided.

It is true that CSG programs have a higher cost to the utilities and ratepayers than utility-scale projects. However, because it gives a net bill savings to subscribers, it is important to market this program to LMI subscribers. Instead of passing bills and amendments to restrict the program or disincentivize development, the effort should go towards recruiting more LMI ratepayers. Additionally, more deployment of CSGs means MN will be closer to achieving their RES and give grid benefits. More CSG projects also means that there will be more subscription opportunities available for LMI ratepayers.

Finally, MN should finalize and commit to a VOS calculation and its resulting VOS tariff. The new compromised tariffs are not encouraging rapid new developments and the uncertainty in tariffs is also driving developers away. Furthermore, ignoring the resulting VOS tariffs doesn't properly incentivize developers for the benefits they add to the grid and the environment. As willing consumers and providers of an essential commodity, both parties should take responsibilities for the externalities. This entails paying for grid modernization and infrastructure updates, as well as climate change mitigation. For most consumers, a $36 addition to their yearly bill to pay for these projects will go unnoticed. However, the LMI households' energy burdens are further aggravated, which should be offset by various programs, such as CSG as mentioned above. This will ensure higher LMI participation in the energy transition and a more just environment for all ratepayers.

Other states that are creating and implementing CSG programs should learn from MN's history and actions. This would help create a more inclusive and equitable program for all ratepayers in the energy transition.

As the energy community continues this discussion around energy burden and environmental justice, a few questions remain. After weighing the pros and cons of CSG projects, can one conclude that they are a cost-efficient way of reducing greenhouse gases? Can deployment of the CSG model reach utility-scale levels to a) provide benefits to more ratepayers; and b) reduce fixed costs? What solutions are there to reduce or eliminate the cost of CSG programs to ratepayers? Answers to these questions must be carefully thought out and formulated to ensure there is enough public and legislative support for CSG programs in the future. CSG programs are a tool for states to meet their RESs/RPSs and to distribute its costs and benefits in a more equitable manner. They are also a tool to speed up the energy transition towards a more sustainable future.

Appendix A

Glossary

1. US – United States of America
2. RPS – Renewable portfolio standards
3. CSG – Community solar garden
4. MN – Minnesota
5. LMI – Low-to-moderate Income
6. PV – Photovoltaic
7. PPA – Power purchase agreement
8. ITC – Investment tax credit
9. EPC – Engineering, procurement, and construction
10. RES – Renewable energy standards
11. PUC – Public utilities commission
12. VOS – Value of solar
13. AMI – Area median income

Appendix B

25 poorest cities in MN and their CSG availability analyzed by comparing zipcodes and city names to PUC data on CSG locations

Rank	Zipcode	Zip Name	County	Adjusted Gross Income	Median Household Income	CSG in area
1	55454	Minneapolis	Hennepin	$25,860	$18,053	Yes
2	55455	Minneapolis	Hennepin	$28,040	$19,615	Yes
3	55130	St. Paul	Ramsey	$29,910	$41,814	Yes
4	55411	Minneapolis	Hennepin	$31,020	$35,203	Yes
5	55605	Grand Portage	Cook	$31,120	$44,190	No
6	56626	Bena	Cass	$32,810	$29,420	No
7	55805	Duluth	Saint Louis	$34,870	$27,946	No
8	55103	St. Paul	Ramsey	$35,620	$39,534	Yes
9	56633	Cass Lake	Cass	$36,430	$33,589	No
10	56681	Squaw Lake	Itasca	$36,600	$25,000	No
11	55806	Duluth	Saint Louis	$36,930	$30,795	No
12	55106	St. Paul	Ramsey	$37,080	$47,338	Yes
13	56440	Clarissa	Todd	$37,300	$35,960	No
14	55404	Minneapolis	Hennepin	$37,420	$27,309	Yes
15	56566	Naytahwaush	Mahnomen	$37,430	$32,499	No
16	56270	Morton	Renville	$37,510	$49,312	No
17	56759	Strathcona	Roseau	$38,380	$40,710	No
18	55785	Swatara	Aitkin	$38,740	$39,600	No
19	55412	Minneapolis	Hennepin	$38,800	$50,444	Yes
20	56350	McGrath	Aitkin	$38,830	$36,654	No
21	56384	Upsala	Morrison	$39,190	$42,328	No
22	56387	Waite Park	Stearns	$39,240	$43,920	Yes
23	56219	Browns Valley	Traverse	$39,360	$32,212	No
24	55430	Minneapolis	Hennepin	$39,470	$53,723	Yes
25	56437	Bertha	Todd	$39,580	$33,279	No

25 wealthiest cities in MN and their CSG availability analyzed by comparing zipcodes and city names to PUC data on CSG locations

Rank	Zipcode	Zip Name	County	Adjusted Gross Income	Median Household Income	CSG in area
1	55402	Minneapolis	Hennepin	$651,720	$56,057	Yes
2	55391	Wayzata	Hennepin	$345,180	$105,928	No
3	55424	Minneapolis	Hennepin	$312,940	$119,747	Yes
4	55356	Long Lake	Hennepin	$237,750	$97,682	No
5	55331	Excelsior	Hennepin	$221,060	$116,772	No
6	55439	Minneapolis	Hennepin	$220,150	$119,079	Yes
7	55436	Minneapolis	Hennepin	$219,870	$94,145	Yes
8	55340	Hamel	Hennepin	$192,720	$105,687	No
9	55347	Eden Prairie	Hennepin	$160,000	$127,763	Yes
10	55127	St. Paul	Ramsey	$155,890	$94,617	Yes
11	55415	Minneapolis	Hennepin	$147,930	$35,928	Yes
12	55359	Maple Plain	Hennepin	$147,360	$93,665	No
13	55401	Minneapolis	Hennepin	$142,680	$63,107	Yes
14	55001	Afton	Washington	$139,120	$117,502	Yes
15	55410	Minneapolis	Hennepin	$138,080	$86,538	Yes
16	55446	Plymouth	Hennepin	$134,940	$133,826	Yes
17	55115	St. Paul	Washington	$134,790	$89,938	Yes
18	55386	Victoria	Carver	$130,390	$116,027	No
19	55042	Lake Elmo	Washington	$129,600	$103,943	Yes
20	55317	Chanhassen	Carver	$128,290	$116,019	No
21	55043	Lakeland	Washington	$126,360	$85,183	No
22	55129	St. Paul	Washington	$125,890	$131,494	Yes
23	55311	Osseo	Hennepin	$122,170	$125,773	Yes
24	55364	Mound	Hennepin	$121,110	$87,822	No
25	55902	Rochester	Olmsted	$120,040	$80,623	No

Appendix C

Sourced from the MN PUC's Annual Distributed Generation Reports

City	Zip Code
Cottage Grove	55016
Eagan	55121
Eagle Lake	56024
St.Paul	55101
Woodbury	55125
Montevideo	56265
Winsted	55395
Scandia	55047
Big Lake	55309
Brooten	56316
Buffalo Lake	55314
Byron	55920
Center City	55002
Clara City	56222
Claremont	55924
Clear Lake	55319
Cleveland	56017
Cold Spring	56320
Corcoran	55340
Courtland	56021
Edgerton	56128
Farmington	55024
Foley	56329
Freeport	56331
Glenwood	56334
Goodhue	55027
Granite Falls	56241
Hadley	56151
Hector	55342
Janesville	56048
Kasota	56050
Kasson	55944
Kenyon	55946
Lake Lillian	56253
Lester Prairie	55354
Lindstrom	55045
Mankato	56001
Mapleton	56065

Maynard	56260
Minnesota Lake	56068
Monticello	55362
Montrose	55363
Morgan	56266
Morristown	55052
New Richland	56072
Nicollet	56074
North Branch	55056
Northfield	55057
Norwood Young America	55368
Osakis	56360
Owatonna	55060
Paynesville	56362
Pine Island	55963
Pipestone	56164
Prinsburg	56281
Red Wing	55066
Renville	56284
Richmond	56368
Rosemount	55068
Sartell	56377
Sauk Rapids	56379
Shakopee	55379
Slayton	56172
St. Cloud	56301
St. Joseph	56374
St. Michael	55313
Stacy	55078
Starbuck	56381
Taylor Falls	55084
Taylors Falls	55084
Tracy	56175
Wabasha	55981
Waconia	55387
Waseca	56093
Watertown	55388
Waterville	56096
Waverly	55390
Webster	55088
Wyoming	55092
Zumbro Falls	55991

Zumbrota	55992
Afton	55001
Albany	56307
Altura	55910
Annadale	55302
Annandale	55302
Atwater	56209
Belgrade	56312
Belle Plain	55315
Belle Plaine	56011
Bellechester	55027
Brooklyn Park	55428
Buffalo	55313
Cannon Falls	55009
Chandler	56122
Chisago City	55013
Cokato	55321
Cologne	55322
Danube	56230
Dassel	55325
Dayton	55327
Dodge Center	55927
Dundas	55019
Faribault	55021
Felton	56536
Frontenac	55026
Garvin	56132
Gaylord	55334
Gibbon	55335
Glydon	56547
Good Thunder	56037
Green Isle	55338
Hampton	55031
Hartland	56042
Hayfield	55940
Hugo	55038
Jordan	55352
Kellogg	55945
La Crescent	55947
Lake Wilson	56151
Mantorville	55955
Mazeppa	55956
Melrose	56352

Minnesota City	55959
Minnetrista	55331
Pemberton	56078
Plato	55370
Randolph	55065
Randolph Township	55065
Raymond	56282
Rogers	55374
Rollingstone	55969
Sacred Heart	56285
Sauk Rapid	56379
Silver Lake	55381
St.Michael	55313
St.Peter	56082
St. Paul Park	55071
Stewart	55385
Stillwater	55082
Villard	56385
Waite Park	56387
Avon	56310
Benton Township	55322
Blomkest	56216
Brownton	55312
Clarks Grove	56016
Clearlake	55319
Dakota	55925
Delano	55328
Dennision	55018
Dennison	55018
Eden Prairie	55344
Elko New Market	55020
Fairbault	55021
ForeSt.Lake	55025
Foreston	56330
Glencoe	55336
Glyndon	56547
Greenfield	55357
Grove City	56243
Hamburg	55339
Hastings	55033
Holdingford	56340
Howard Lake	55349
Independence	55328

Kimball	55353
Lafayette	56054
Lake City	55041
Lake Crystal	56055
Lake Elmo	55042
Lent Township	55013
Lino Lakes	55014
Lonsdale	55046
Loretto	55357
Mayer	55360
Meire Grove	56352
Millville	55957
Minneapolis	55401
New Germany	55367
New Prague	56071
Olivia	56277
Osseo	55311
Otisco	56093
Redwood Falls	56283
Rice	56367
Sartel	56303
Sauk Centre	56378
Shevlin	56676
South Haven	55382
Spicer	56288
St. Peter	56082
Town of Denmark	55001
Wakefield Township	56320
Watkins	55389
Willmar	56201
Oakdale	55128
Wanamingo	55983
Winona	55987
St.Joseph	56374
Young America	55394
Franklin	55333
St.Cloud	56301
Tyler	56178
Welch	55089
Fridley	55421
Plymouth	55441
Butterfield	56120
St. Paul	55101

Bloomington	55122
Edina	55343
Hatfield	56128
New Hope	55427
Mendota Heights	55111
Belview	56214
Burnsville	55306
Nerstrand	55053
West St. Paul	55118
St. Louis Park	55416
Maple Grove	55311
Another City	#N/A

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