CENTER FOR SCIENCE, TECHNOLOGY, AND ENVIRONMENTAL POLICY

Community Shared Solar in Minnesota

Learning from the First 300 Megawatts

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Abstract

Community shared solar is an emerging approach to deploying solar energy that promises to expand the market for solar by allowing a group of electricity customers without roof space or access to capital to own, finance, or lease a share of an offsite, centralized solar facility. Community solar programs are being developed across the country, and as of March, 2018, Minnesota had the country's largest set of programs, with over 300 MW-AC installed. In this paper, we analyze the economic and political factors driving the emergence of Minnesota's 33 community solar programs, and investigate the opportunities and barriers faced in developing community solar in different utility territories. We draw contrasts between Minnesota's programs to illustrate the heterogeneity in approaches to designing community solar programs in terms of accessibility, affordability, subscriber acquisition, utility benefits, and subscriber agency. Our study takes a mixed methods approach: we conduct six in-depth case studies of Minnesota community solar programs, relying on a combination of informal interviews and primary source analysis; we conduct 12 semi-structured interviews with utility managers overseeing different community solar programs in the states; and we collect and analyze contracts of nearly 100 community solar subscription offers across the 31 utilities with a detailed cash flow analysis. We conclude with reflections on the Minnesota experience for reforming program and policy development in the state and lessons for the other 34 states developing community solar programs.

Acknowledgements

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1. Introduction

Transitioning the energy system to meet environmental, security, and economic goals will require the mobilization of resources at a scale unprecedented in the energy sector. The public policies implemented by international, national, and subnational governments will be central determinants of which sub-populations bear the costs and benefits associated with the energy transition. Due to the complexity of sociotechnical energy systems, it is not straightforward how costs and benefits accrue and how risks are shared across different populations. While this complexity has the potential for unintended side effects, it also creates opportunities for policy experimentation, learning, and reorientation toward multiple, contemporary societal objectives. Of key interest in this project are the distributional shifts across subpopulations of the energy transition in terms of costs, benefits, and risks.

The distributional impacts of the status quo orientation of energy systems have been studied in a number of ways, such as analysis of the regional distribution of climate change impacts (Hsiang et al., 2017). Other work has looked prospectively at the distributional impact of climate mitigation policies, such as a carbon tax, finding that without complementary measures, most carbon policies are regressive (Grainger and Kolstad, 2010). More recent work has quantified the distributional impacts of some clean energy policies (Borenstein, 2017; Borenstein and Davis, 2016), finding that in many existing programs, benefiting from programs that incentivize clean energy technology adoption requires existing power (wealth, access to credit, capital ownership, etc.), which may reinforce existing inequalities.

Fairness in who bears the costs and risks, and who receives the benefits, in the energy transition is a critical determinant of the institutional feasibility and speed of the clean energy transition. Perceptions of fairness will vary by actors (electric utilities, customers, regulating bodies, etc.), by geographic region, and by the relative priority of competing objectives (e.g. short-term vs. long-term costs and benefits, avoiding climate impacts, shifting energy burdens for customers of different income levels, or reduced local air pollution “hotspots”).

The complexity of how perceptions of fairness are constructed in the implementation of energy policies is often illustrated by the debate concerning the deployment of distributed energy resources (DERs) on the electric grid. These debates have often focused on rooftop solar adopters who, because of rate design and current utility practices and policy (most importantly the federal Public Utility Regulatory Policies Act and state-level net-metering policies), arguably receive benefits from using the electric grid without contributing a sustainable share for their use. But DERs also produce many non-monetized and uncompensated benefits (e.g. reduced transmission costs and increased grid resilience), which can in some circumstances and time frames outweigh lost utility revenue and impacts of “cross-subsidization” and “cost-shifting.”

New data and studies in different contexts identify cross-subsidization in either direction, including lowering the cost-shift that occurs as customers overpay on their cost-of-service (Barbose et al., 2016). Across the nation, regulators are moving in a variety of directions on rate design to address these issues, generally toward a net-billing system, which allows self-supply and adjusts DER export rates, while also increasing utility fixed charges to collect more of the fixed costs of operating the electric grid (Proudlove et al., 2018). Setting aside the issue of implicit cross-subsidies, most forms of DERs are still subsidized through direct policies (e.g. the federal investment tax credit for solar). If these direct subsidies are only accessible to certain subpopulations (e.g. the wealthy), other policies that incentivize solar (e.g. third-party leasing that allows customers to lease from third-party developers) may have an overall regressive impact. Further layers of complexity compound analysis: clean energy subsidies induce technology learning-by-doing, which can lower costs dynamically and negate the need for subsidies over longer time horizons. DER deployment can also create public or quasi-public goods, such as reduced air pollution, reduced climate impacts, increased grid resilience, and decreased line losses.

In this context, community shared solar (CSS) has emerged as a new form of clean energy deployment with the potential to proactively promote fairness in the clean energy transition, allowing a group of electricity customers without roof space or access to capital to own, finance, or lease a share of an offsite, centralized solar facility. The importance of community solar may be in its potential to overcome the institutional and political challenges raised by other forms of distributed energy generation. But this potential may be difficult to realize given the fragmentation of the energy system and its complex legacy of multiple, overlapping policies. In this report, we explore the potential of CSS and the multitude of ways these programs have been developed in Minnesota, where CSS is being explored as a pathway toward a fairer and sustainable energy system.

1.1. Community Solar

In the context of transitioning the energy system to avoid the worst impacts of climate change, deploying solar energy is seen as a key strategy (IEA, 2016). Photovoltaic solar energy is a modular technology to supply electricity and can be deployed on the scale of a single household to scale sufficient to power over one thousand households. Deploying solar at different scales implies different economics but also different politics (Fairchild and Weinrub, 2017). CSS is emerging as a possible middle-ground between the economies-of-scale gained in utility-scale solar, while encouraging access and affordability to those without roof space, financial ability, or the general means to invest in rooftop modules (Chan et al., 2017).

While specific design characteristics of CSS programs vary, they typically contain contract details such as varying subscription sizes, lifetime subscription values, sign-up fees, REC treatment, siting and scale, usage participation limit, capacity participation limit, production guarantees, minimum terms, program length, subscription transfers, and what to do with the unsubscribed energy (Chwastyk and Sterling, 2015). Flexibility within these domains creates uncertainty about objective outcomes, pace, and scale of solar development, and the characteristics of subscribers.

Much like other DERs, CSS can be modular and work at different scales and locations, typically from tens of kilowatts to tens of megawatts, ranging from behind-the-meter to transmission-tied production. Like other DERs, it too can pose a threat to traditional electric utility business models when it allows distributed, non-utility ownership in a utility's exclusive territory. But CSS can also uniquely maintain traditional utility-customer relationships, feeding into an outlet for partnership between third-party developers, subscribers, and utilities (Chwastyk and Sterling, 2015; Funkhouser et al., 2015).

CSS projects vary significantly in their scale and scope, and are generally supported for their potential to increase the rate of solar deployment, and as a model that can make solar more affordable and accessible (Chwastyk and Sterling, 2015; NREL, 2014). Furthermore, community solar programs enable customers to reap the benefits of solar without having to install rooftop solar, a possibility which is limited to only 20% of ratepayers (MnSEIA, 2014). Many customers are barred from participating in the rooftop solar market due to prohibitive upfront costs and by nature of living in rental units or multifamily complexes. By reducing these barriers, CSS can make solar energy accessible to a broader population, including low income households, and potentially double the market for residential and commercial solar (Feldman et al., 2015; NREL, 2014). Additionally, CSS projects aggregate electricity demand and financial risk over many customers, and therefore can take advantage of scale economies while creating greater flexibility in project siting and enabling opportunities for community-level mobilization of resources for a greater set of social purposes (McConnell et al., 2016).

By this token, CSS programs have enough flexibility to address equity issues and provide an inclusive framework for subscription and ownership that rooftop- and utility-scale solar business models traditionally lack. Program design characteristics such as fixed solar rates, shared investment returns, or per unit bill credits can be weighted to reduce barriers to entry, such as subscription cost and electricity rates, that tend to preclude low- to moderate-income electricity users from CSS (Funkhouser et al., 2015; Stanton and Kline, 2016).

Given its potential, it is not surprising that increasing amounts of public resources at the federal and state level are being directed toward community solar program development (US DOE, 2016). Some utilities, notably electric cooperatives and municipal utilities, explored community solar in the late 2000s. However, as of early 2018, 18 states had legislated its existence as scores of individual utilities continued to voluntarily build their own programs.

Minnesota has a robust mix of CSS programs spread across the state. Minnesota’s set of CSS programs, led by the program legislated toward Xcel Energy in 2013, have currently deployed 300 megawatts (MW) as of March, 2018, the most CSS of any state in the United States (Roselund, 2018). While the Xcel program has received the most attention, Minnesota’s municipal and cooperative utilities, along with individual developers and at least one additional investor-owned utility, have developed their own unique CSS programs featuring a wide array of financing structures, subscription offers and terms, and governance models.

In a state and federal policy environment teetering on direct carbon-reduction policies, Minnesota’s community solar programs offer a first glimpse into how policy adoption by states, utilities, and consumers can balance costs and benefits and overall risk of new renewable energy developments. In this sense, Minnesota provides a useful “policy laboratory” to learn from experience in implementing community solar policies.

In this report, we survey the CSS landscape in Minnesota across investor-owned, cooperative, and municipal utilities, noting heterogeneity in program design and outcomes. We adopt a comparative framework to identify insights from across this landscape for future CSS programs.

In Section 2, we trace the history of electricity policy in Minnesota to contextualize the emergence of CSS and survey the landscape of current CSS projects. In Section 3, we describe our mix-methods approach of combining six case studies, 12 semi-structured interviews, and detailed financial analysis of nearly 100 CSS subscription offers. In Section 4, we synthesize the general literature and our key findings on the opportunities and barriers to CSS development from the perspective of utilities, project developers, and potential subscribers. In Section 5, we delve into the design of our specific CSS case study programs and specific contracts to understand the heterogeneity in subscriber benefits and implications for accessibility, affordability, subscription rates, utility benefits, and subscriber agency. In Section 6, we discuss key policy implications, and Section 7 concludes.

2. Community Solar in the Minnesota Landscape

Minnesota's, and subsequently the nation's, largest community solar program was passed as article 10 of the 2013 Omnibus jobs, economic development, housing, commerce, and energy bill, and applied only to Xcel Energy, the state's largest investor-owned utility. However, actual steel-in-the-ground CSS development in the state was preceded by several voluntary cooperative and municipal utility projects, and has since been followed by almost 30 voluntary developer-led, cooperative, and municipal utility programs. As municipal and cooperative utilities together serve more than 35 percent of Minnesotans' electricity, and as CSS straddles the line between traditional and forward-looking utility structures, the differences in CSS deployment within the investor-owned, municipal, and cooperative utility service areas in Minnesota offers an array of ownership schemes, reimbursement rate rationales, and utility motivations. Comparative analysis between these utility programs and their collective history lends insights into the array of available options available in CSS, and how to most equitably and efficiently deploy solar.

2.1. History of Electricity and Renewable Energy in Minnesota

Each state has a unique history of electrification giving way to a set of historical circumstances shaping the current energy system. Minnesota is no exception. With a single large metro area (the Twin Cities) and a vast, more rural, greater state, Minnesota has a complex economic and political structure. In total, today there are 125 municipal utilities, 45 electric cooperatives, and three investor-owned utilities in Minnesota (Legislative Energy Commission, 2016). They emerge from long, complex, and diverging histories that shape their current actions, particularly as they engage with a new socio-technical system: community shared solar. This history provides important context for understanding energy policy in Minnesota. Appendix A provides a high-level overview to set the context for the remainder of the report's exploration of CSS in the state.

2.2. History of Community Solar in Minnesota

Minnesota's largest community solar garden (CSG) program was signed into law in 2013 by Governor Dayton as a part of an omnibus job, economic development, housing, commerce, and energy bill (HF 729). A confluence of factors opened up a policy window for energy advocates. First was an unexpected political victory for Democratic Farmer and Labor (DFL) party candidates resulting in DFL control of the state house and senate, and governor's office (Scheck, 2012). Second, a trip taken by Minnesota politicians to Germany allowed them to learn about Germany's solar feed-in tariff up-close (Dubos, 2015). Lastly, was the development of Colorado's community solar program, which impacted the IOU shared by Colorado and Minnesota, Xcel Energy (Richardson, 2017).

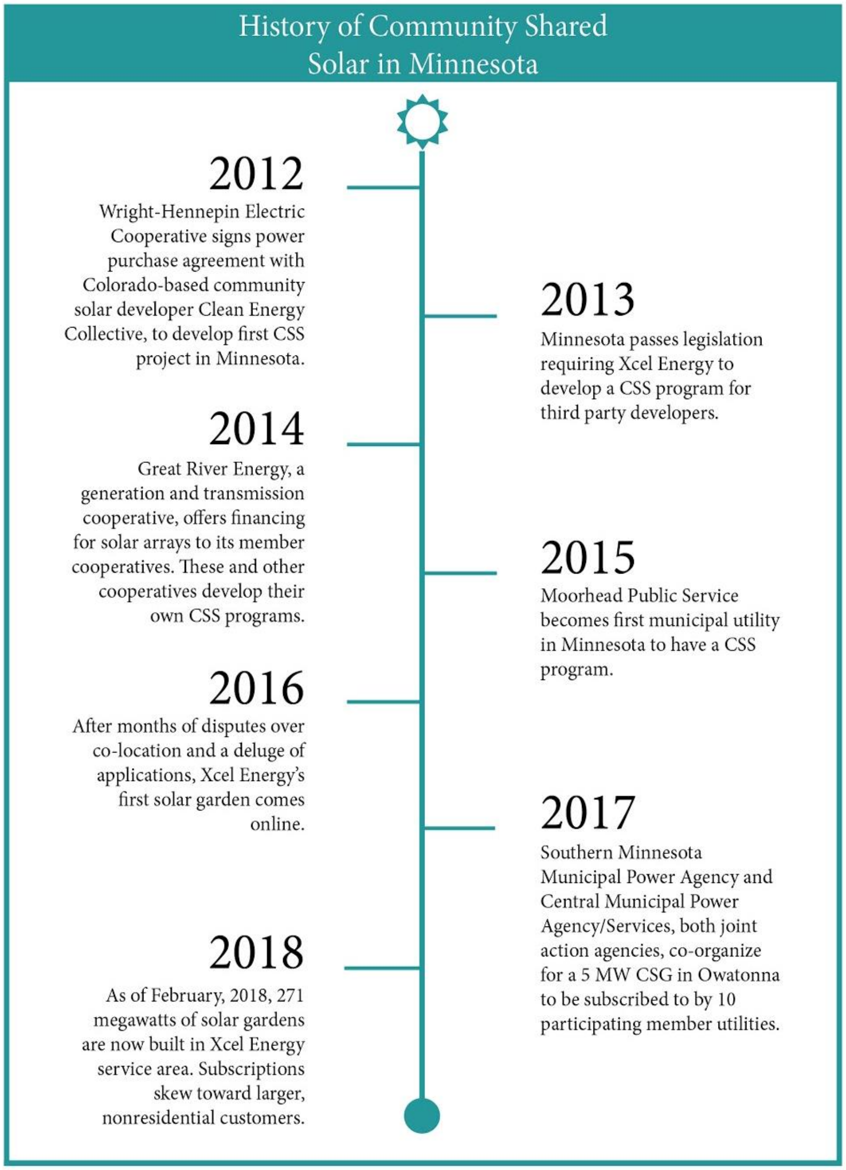

Figure 1. Timeline of Community Solar Program Development in Minnesota

Most solar development in the nation comes from legislatively-mandated CSS programs such as Xcel Energy's. But beside megawattage, Xcel Energy's CSS program origin in 2013 also charts the beginning for 32 other programs in the state, led by distribution utilities such as Moorhead Public Service or Wright-Hennepin Electric Cooperative experimenting with ownership and subscription offers, by power suppliers such as Great River Energy or Southern Minnesota Municipal Power Agency that were willing to finance and aggregate demand, and also a number of community groups, developers, and cities. Today, CSS development in Minnesota continues to evolve in design and intent as groups of electricity purveyors and users learn from others' nascent experiences.

DFL politicians sought to enact an alternative energy-friendly agenda before the end of the legislative session. Along with community solar, the omnibus bill created a renewable portfolio standard (RPS) for the state, and a "Made in Minnesota" solar incentive for solar modules manufactured in state. Though the RPS applied to all utilities in Minnesota, all community solar provisions applied solely to Xcel Energy. The omnibus bill passed 73-59 with strong DFL support but with a number of Republicans voting in favor as well (MN House of Representatives, 2014).

Overall, the CSG program was intended to expand access to solar energy, catalyze solar deployment in Minnesota, create solar jobs, and bring solar energy to communities to create green voters. It also allowed third-party solar developers to build larger installations within Xcel Energy's service area. As signed by the governor, Xcel's plans for a community solar program had to meet the following requirements (Mahoney, 2013):

- Nameplate capacity of no more than 1 MW
- Project must be located in Xcel territory
- Subscribers must be located in co-adjacent counties to subscribed garden
- A credit must be applied to the bill of the subscribing customer making the project financeable
- A "value of solar" tariff for subscriber reimbursement will be studied and considered
- At least five subscribers per project
- No subscriber can own more than 40% interest in a CSG
- Can subscribe to a maximum of 120% of average annual electricity demand

Though the legislation laid out the basic parameters for a community solar garden program, the Minnesota Public Utilities Commission (PUC) was charged with implementing the program, approving Xcel's application, approving tariffs, and arbitrating disputes. All proceedings are available in docket no. 13-867 of the PUC.

The program faced a series of iterative challenges brought to the PUC since enacted. First, when the queue for Xcel's program first opened, they received a large influx of applications for community solar gardens ranging from tens of kW to tens of MW. Xcel filed a complaint with the PUC arguing that the program was straying from its original intent and was not meant to produce "utility scale solar." Though the law limited the size of gardens to 1 MW, developers were "co-locating" multiple 1 MW gardens on the same site to capture better economies-of-scale. The PUC capped the size of co-located gardens at 5 MW for those applications already in the queue, and 1 MW for all future applications. Xcel and many small solar developers supported this decision, while the state's larger developers did not. The 1 MW limitation is seen as one of the reasons applications to join Xcel's program have slowed in recent years (Minnesota Public Utilities Commission, 2015a).

Second, the Commission had to arbitrate an engineering and interconnection dispute between third-party developers and Xcel Energy. Developers complained that Xcel's process was too slow, increasing interconnection and engineering feasibility costs, and review times. SunShare argued that Xcel had inaccurate cost estimates and unjustified fees, and potentially limited developer ability to price solar equitably. Eventually an independent engineering firm was hired to intervene in the engineering and interconnection process and criticized Xcel Energy's cost estimates, interconnection processes, and cooperation with SunShare (Hughlett, 2016a; Trabish, 2016a). These and other project-level disputes continue today.

Third, the PUC was legislatively mandated to design a subscriber credit to capture the value of placing solar energy onto the grid. The process was highly contentious, and an appropriate methodology needed to be agreed upon before the Value of Solar (VOS) bill credit tariff could be enacted. Therefore, in order to get the program off of the ground, the PUC established an interim bill credit rate for subscribers known as the applicable retail rate (ARR). Subscribers also received an extra amount per kWh on top of the ARR for Renewable Energy Credits (REC) sold to Xcel so that they could be retired against the new RPS. The ARR was set between $0.14033 and $0.1503 cents per kWh for residential customers depending on the size of the CSG, with a guaranteed annual escalation. The ARR bill credit is smaller for commercial and industrial subscribers (Eleff, 2016).

The finalized VOS tariff calculation replaced the ARR for all CSG projects applying after January 1, 2017, with earlier applications and existing projects continuing to receive the ARR. VOS approximates the social marginal value of distributed solar power, including avoided fuel costs, construction costs, environmental health benefits, etc. After receiving proposed methodologies and comments for how to calculate VOS, the rate was set at $0.1033 per kWh with a 25 year levelized cost of $0.1280 per kWh (Xcel Energy, 2016). Though designed to capture all the benefits of placing solar on the grid, the lower rate squeezed profits for developers and operators who were already under economic pressure from the 1 MW colocation cap.

Most recently in late 2017 and early 2018, the PUC asked the Minnesota Department of Commerce to make a recommendation on appropriate VOS bill credit adders for eight different possible categories, including adders for residential and low-income residential subscribers. The request was motivated for two primary reasons. The first being the reduced incentive for developers under the VOS rate to pursue residential subscribers since, unlike the ARR, the VOS bill credit rate did not give preferential treatment to residential subscribers (Mackenzie, 2017). The second being increased evidence that the program was not serving primarily residential subscribers. State Senator John Marty submitted for public comment to the PUC with a memo he received highlighting that the main beneficiaries of the program were large corporate and institutional ratepayers (Krause and Staples, 2015). These observations were later confirmed when in October of 2017, Xcel released information on the allocation of subscriptions and total program capacity. "Residential" subscribers were only receiving 9% of the 165 MW of CSS online at the time, while "Business" ratepayers were receiving 91% (Hedlund, 2017). Figure 3 displays updated figures for residential and non-residential subscribers and subscribed capacity through March, 2018.

In March, 2017 the Minnesota Department of Commerce recommended that the Commission adopt a residential adder to be phased out over three years. Xcel Energy and the Office of the Attorney General, who supported a carve-out, were opposed to any adders; while many developers commented in support. The proposed residential adder would start at $0.025 per kWh, and decline over the next two years to $0.005 per kWh (Mackenzie, 2017). Xcel must conduct two final analyses on the impacts of a residential adder by February, 2018 (Minnesota Public Utilities Commission, 2017).

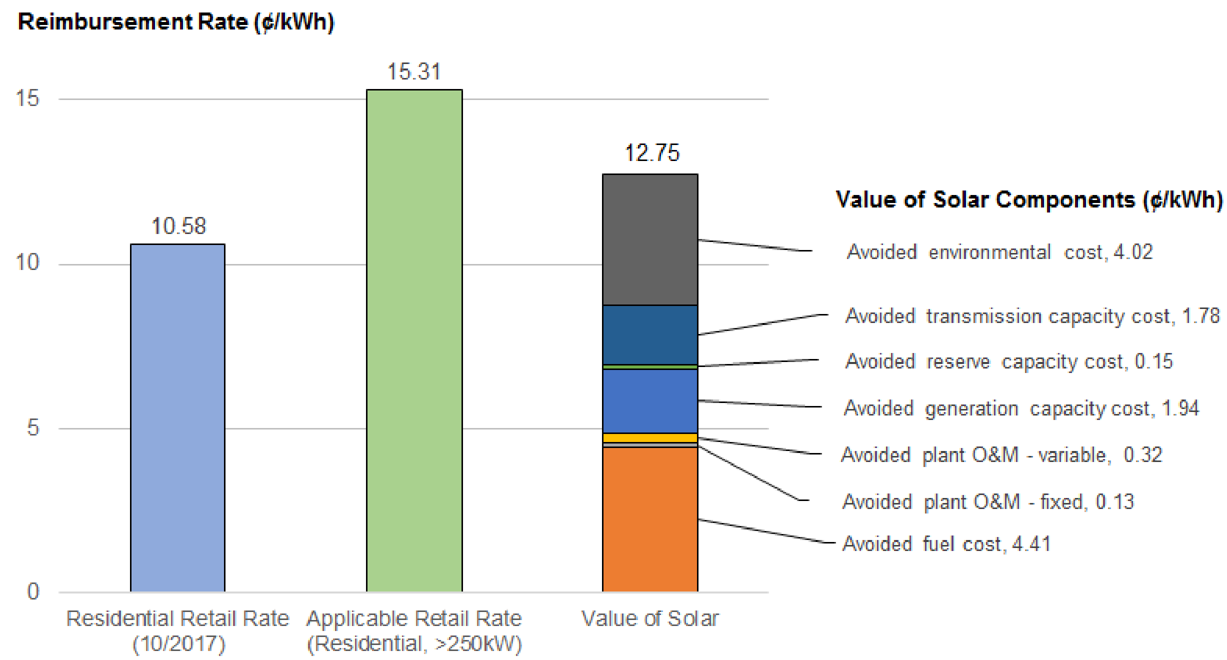

Figure 2. Comparison of Reimbursement Schemes Relevant to Xcel's Community Solar Rewards Program

The first column shows the residential rate beginning in October, 2017, for summer electricity consumption for residential customers of Xcel energy (Xcel Energy, 2017a), which is comparable to the reimbursement that electricity customers would receive under a net metering program (as is typical in municipal and cooperative utility CSS programs in Minnesota). The Applicable Retail Rate (ARR) is pegged to the retail electricity rate and was the basis for the tariffs of first two years of the Community Solar Rewards program. The ARR varies based on the type of customer (residential, small general service, and large general service) and the size of the solar garden (above or below 250kW). The second column shows the ARR for residential subscribers selling renewable energy credits plus energy from a garden greater than 250 kW. Because the ARR is pegged to the retail rate, this rate could also be assumed to grow by around 2 to 3% per year (Xcel Energy, 2017b). The Value of Solar (VOS) is based on a formula approved by the Public Utilities Commission with data provided by Xcel Energy. The components of the VOS are shown in column three in terms of 25-year present values. In calculating present values, each component is given its own escalation rate, and economic costs and environmental costs are discounted at different rates (economic costs are discounted at the weighted cost of capital, 6.42% in 2016), and environmental costs are discounted at 5.39% (Xcel Energy, 2016)).

In spite of the many roadblocks and program changes during and after implementation of Xcel's community solar program, it is still the largest program in the United States in terms of deployed solar capacity. As of March, 2018, the program boasted 300 MW of community solar with an additional 577 MW of active applications in the queue in the (White, 2018); see also Figure 7. There are concerns that success in the number of MW deployed has not equaled success on other goals for the program. Interested parties have highlighted problems such as: a credit limit screening process to subscribe, overrepresentation of large commercial and institutional subscribers (low access for residents and LMI subscribers), lengthy contracts, and concerns of cross-subsidization from non-subscribers to subscribers. The March, 2018, Xcel compliance filing showed 10% of program capacity is allocated to residential subscribers despite residential subscribers equaling 92% of total unique subscribers (White, 2018); see Figure 3.

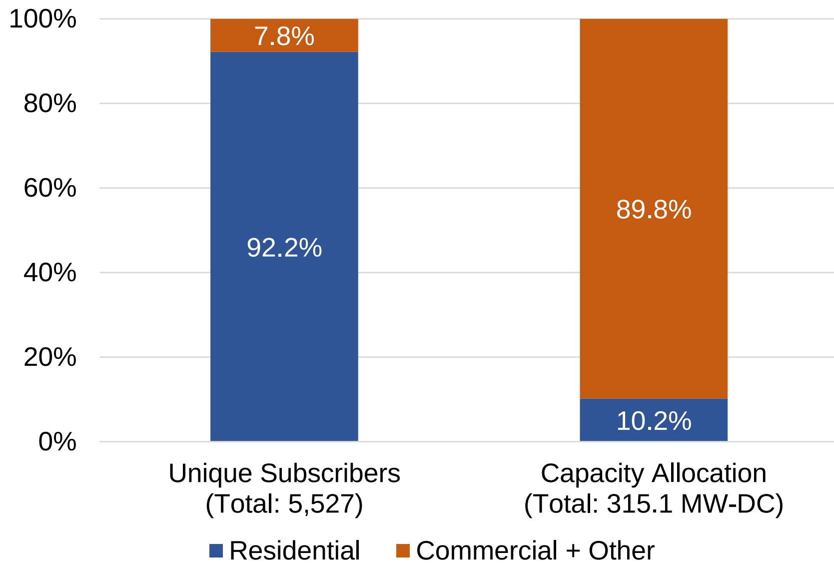

Figure 3. Residential Share of Subscriptions and Capacity in Xcel's Community Solar
When written and passed into law, the Xcel Energy community solar program was intended for Minnesotan Main Streets, subscribing neighbors, utilizing local resources, and creating a new paradigm in solar development. Quickly, though, that vision succumbed to some economic realities of solar development: it was easier to build 5 and then 1 MW solar gardens; easier to acquire large electricity users than residents; and easier for tax equity financiers to bank on single businesses or governments versus hundreds of residents. The result: thousands of residential subscribers that subscribed to only 12% of program capacity, while the remaining megawattage tended toward large institutional users. (Xcel Compliance Filing 13-867, March 2018) (White, 2018)

2.3. Municipal, Cooperative, and Minnesota Power-Led Programs

While Xcel Energy and developers were working within new policy frameworks to develop community solar, municipal and cooperative utilities in the state had already developed their own. Outside Minnesota, the first utilities to develop community solar were publicly-owned. The municipal utility in Ellensburg, Washington, claims to have installed the first community solar project in the nation in 2006, and other cooperative and municipal utilities across the United States followed suit (SEIA, 2016).

Wright-Hennepin Electric Cooperative was the first cooperative or municipal utility in Minnesota to build a community solar array. In 2012, the utility signed a power purchase agreement with Colorado-based Clean Energy Collective (CEC). CEC had prior experience developing CSS in Colorado with other electric cooperatives. This first project was notable as the first community-owned solar array in the nation to feature energy storage (Abbey and Ross, 2013), a lead-acid battery from Silent Power (Australian Energy Storage Database, 2013), allowing the utility to offset peak demand prices from its generation and transmission utilities.

Wright-Hennepin's first community solar array came online in 2013, just as the solar garden legislation affecting Xcel Energy was passed. Although municipal and cooperative utilities gained exemption from the legislation and its solar mandates, increasing member and utility interest in renewable energy in the state, and planning for new technologies, brought early CSS development to these other utilities.

After Wright-Hennepin's project, Connexus Energy, Lake Region Electric Cooperative, and Tri-County Electric Cooperative (now MiEnergy Cooperative) sought financial assistance for community solar arrays from the National Renewables Cooperative Organization (NRCO), a legal and financial coordinating partner between electric cooperative financier National Rural Utilities Cooperative Finance Corporation (CFC), and insurer Federated Rural Electric Insurance Exchange (Federated). At 245 kW, Connexus' project became the largest community solar project in Minnesota at the time in 2014.

In 2014, as these arrays were coming online, Great River Energy (GRE) worked with the National Rural Electric Cooperative Association (NRECA), CFC, Federated, and a cohort of fifteen other electric cooperatives under a federal grant (US DOE, 2014) to deploy solar more cost effectively. GRE, a generation and transmission cooperative supplying energy to twenty-eight distribution cooperatives in Minnesota and Wisconsin, began to work with CoBank, a cooperatively-owned bank, to offer leases to 20 kW solar arrays to member cooperatives. Each member cooperative had the option to install additional solar modules at an incremental cost, to turn their utility-owned array into a community solar array. Five of the nineteen cooperatives under GRE by 2015 had opted for community solar.

Municipal community solar programs officially started in 2015, with Moorhead Public Service's "Capture the Sun" program. The utility had early experience in community energy development, having pioneered its own community wind program in 1999 (Reed et al., 2000), allowing hundreds within its membership to pay the additional cost of supporting two wind turbines. Its program subsidized the cost of panels from a municipal renewable energy incentive fund that previously languished.

In proposing its CSS program in 2015, Minnesota Power nearly fell under the auspice of the CSS regulation for Xcel Energy, which might have authorized uncapped third-party community solar garden development into its territory (MN Public Utilities Commission Docket 15-825). Minnesota Power tried to avoid this mandate while farming its own renewable energy credits to meet the state's small-scale solar standard. The MN PUC made Minnesota Power calculate its own VOS for the project. As a majority of Minnesota Power's sales go to large industrial consumers, and without its own ability to meet small-scale solar development demands set forth by the 2013 legislation, Minnesota Power successfully argued a policy like Xcel's would affect it differently. Its CSS program is currently online, after approval from the MN PUC in 2017. (See Appendix C)

In 2016, both Southern Minnesota Municipal Power Agency (SMMPA) and Central Minnesota Power Agency/Services (CMPAS) issued requests-for-proposals for their own solar arrays, responding to increasing customer and utility interest in solar. In 2017, the two joint action agencies signed a power purchase agreement with Coronal Development Services, a subsidiary of Panasonic North America, for a 5 MW array to be subscribed by customers of its 10-participating member municipal utilities.

During Xcel Energy's CSS program development at the MN PUC, municipal and cooperative utilities largely paid no apparent attention to Docket No. 13-867, with the state's electric cooperative lobbying organization, Minnesota Rural Electric Association (MREA) participating in the docket only two times in four years. While the second time was to defend a member cooperative's territory in 2016 from infringement by an Xcel Energy-interconnected community solar garden, the first instance of participation in late 2014 touches on community solar. MREA participated in the VOS calculation docket because of, the organization said in late 2014, its "concerns over Minnesota's current net metering laws and [its] interest in developing Community Solar projects within our service territories" (Johnson, 2014). CSS wasn't just CSS to these and other utilities: it was renewable energy, distributed generation, and the socio-technical pathways they enjoined.

By late 2017, as most municipal and cooperative utilities in Minnesota continue to evaluate the costs and values of distributed generation on their grids, 29 such utilities have developed or are participating in a form of CSS, with even more considering projects into 2018.

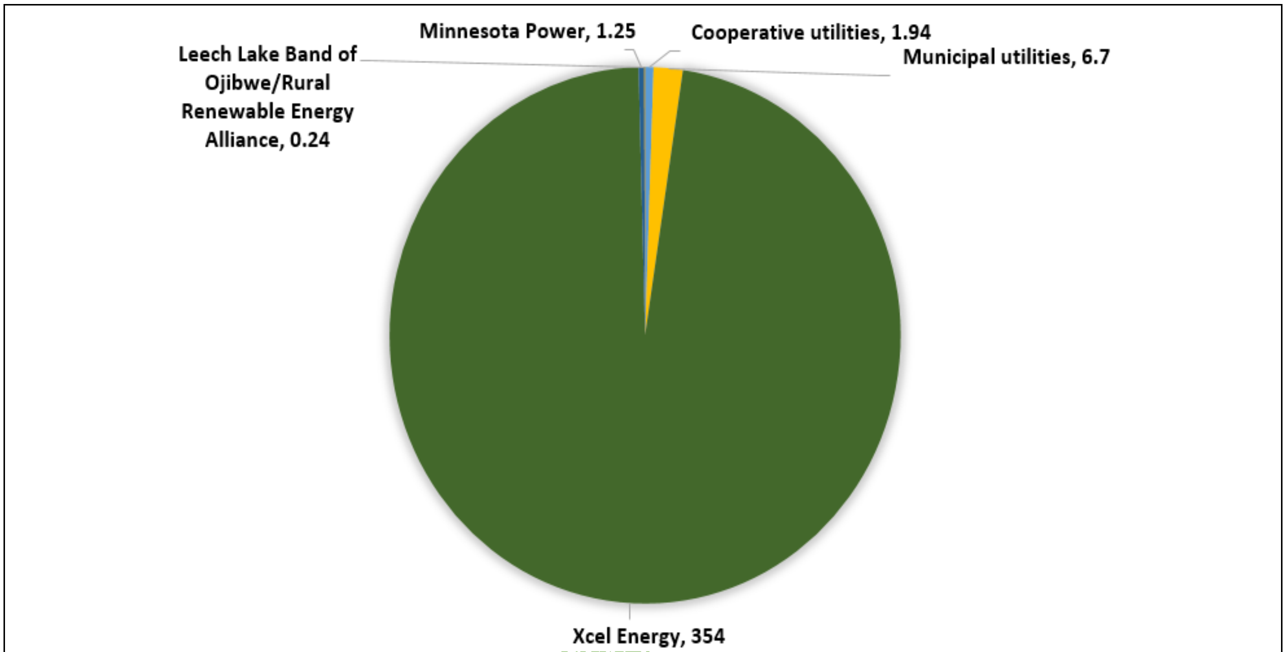

Figure 4. Shares of Minnesota's Community Solar Programs in MW-DC
Totals compiled from PUC dockets, utility news and newsletters, and other governmental materials. Note: Xcel Energy and Minnesota Power's CSG megawattage (reported further in the maps below as 271 and 1.04 MW-AC, respectively) is converted to MW-DC. Leech Lake's wattage is also commonly reported in AC, at 200 kW-AC. For the purposes of comparison with all programs, we used a 1.2 DC-to-AC ratio. (MN Department of Commerce, 2018)

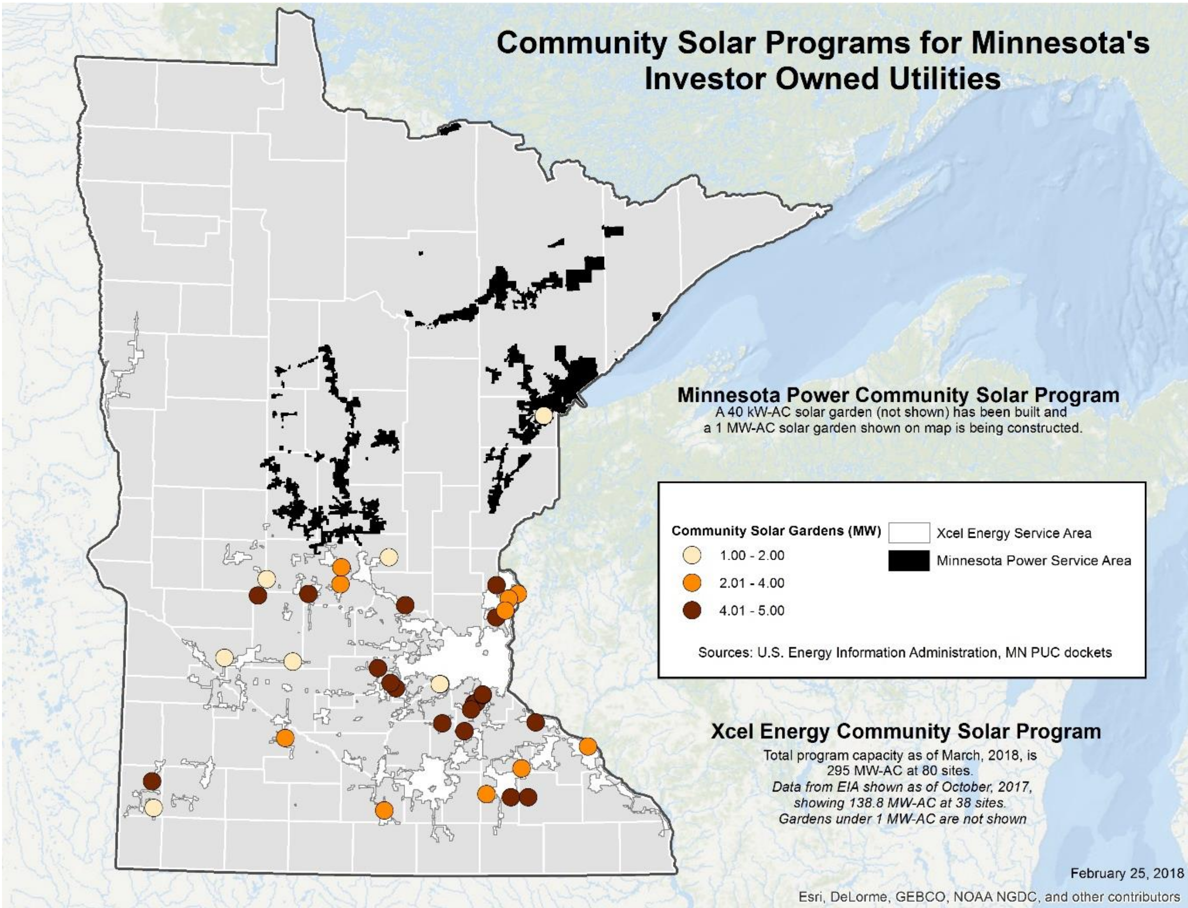

Figure 5. Map of Xcel Energy and Minnesota Power's Community Solar Projects

After an initial rocky start, marked by developer-utility feuds and settlements at the Minnesota Public Utilities Commission, the Xcel Energy community solar program rapidly increased solar deployment in Minnesota. By February, 2018, CSS had eclipsed even the amount of utility-owned or -contracted solar in the state, subscribing thousands of customers, mostly large electricity users and not the residents the program was originally intended for. Spatially, as seen above, these mostly 1 to 5 MW solar gardens circle the Twin Cities on cheaper agricultural land. At the time when Xcel Energy's program was being decided, Minnesota Power (whose territory is marked in black above) applied for its own garden program: its 1.04 MW are now built and open for subscription.

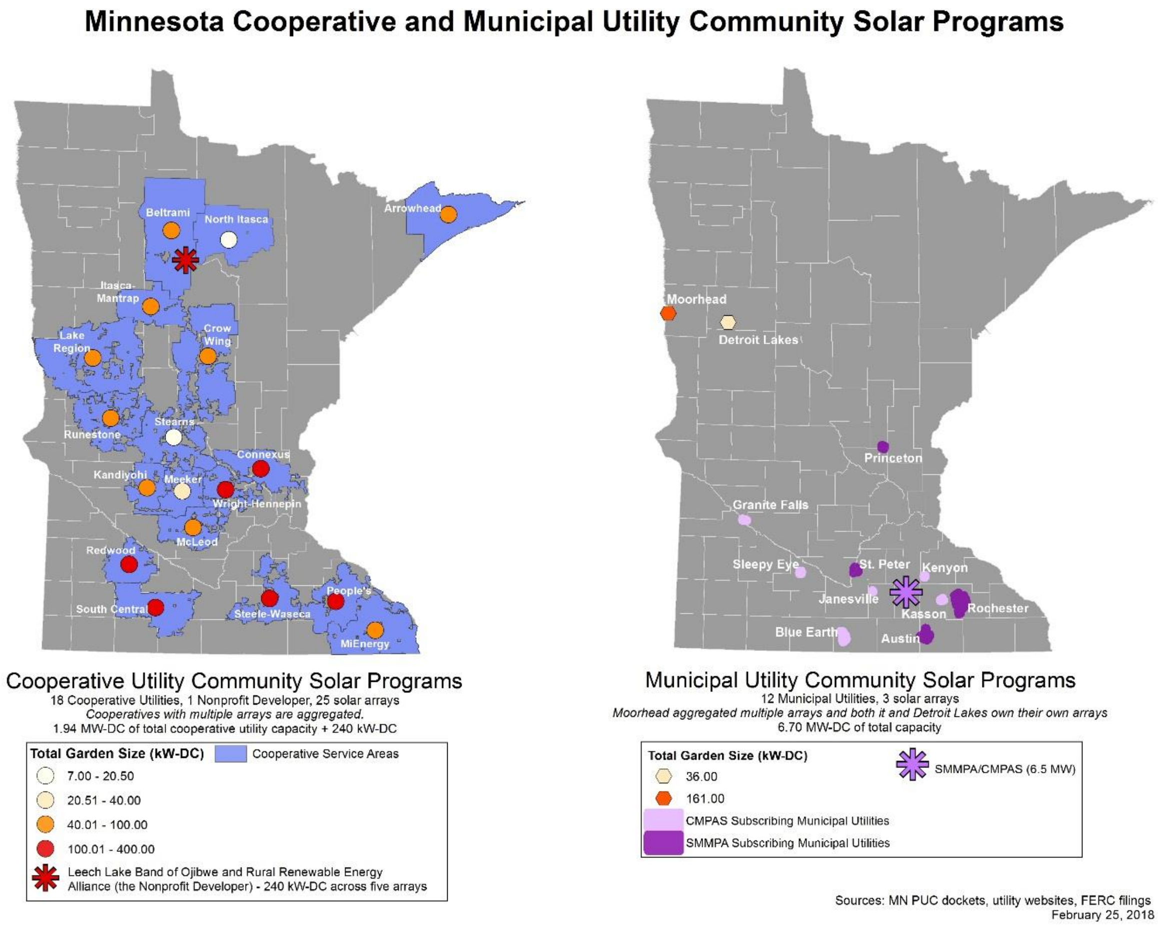

Figure 6. Maps of Minnesota's Cooperative and Municipal Community Solar Projects

Taken with Figure 4, it is apparent that Xcel Energy's mandated program spawned much more solar by megawatt. Yet as the program was rolled out from 2013 on, more than two dozen cooperative and municipal programs began, along with Minnesota Power's and one nonprofit developer-led program. The result is less by megawatt than Xcel Energy's developer-led program, but greater by service area, business model, and intent. Note that arrays from Leech Lake Band of Ojibwe/Rural Renewable Energy Alliance and Southern Minnesota Municipal Power Agency (SMMPA)/Central Municipal Power Agency and Services (CMPAS) are asterisked. The former, donating net metering revenue into the local energy assistance program, and the latter, a utility-scale array into which member utilities buy in for respective community solar shares, are unique, even among the great diversity of CSS in Minnesota today.

3. Methods

Many variables make utilities unique. These include geographic size, number and composition of members or customers, and contractual or market-based wholesale electricity rates. While this data is highly quantitative, qualitative data can significantly shape the character and vision of utilities, ultimately affecting whether CSS is offered by a utility and, if so, influencing CSS program design. The nature of the utility landscape, therefore, led us to take a mixed-methods approach by combining literature review, comparative case studies, semi-structured interviews, and a financial analysis. Together, these four areas of research were used to establish a more comprehensive sample of the CSS programs across utilities, with a current understanding of CSS literature given throughout the forthcoming sections.

3.1. Case Studies

We selected six examples of CSS for in-depth case studies. Cases were selected to give a comprehensive sample of the different forms of community solar programs in municipal, cooperative, and investor-owned utilities. We selected Wright-Hennepin Electric Cooperative because their CSS offerings were among the first and became among the most diverse. Minnesota Power was selected as an investor-owned utility that, though much smaller than Xcel Energy, offers an example of voluntary CSS design from a state regulated utility. Beltrami and Stearns Electric Cooperatives were chosen because of their more distinct natures as electric cooperatives, with fewer customers per mile of line and unique customer class composition than an average investor-owned utility in the United States. Rochester Public Utilities, as the largest municipal utility in Minnesota, might be considered an outlier, but its participation in a joint CSS project with its joint action agency was distinct. The Leech Lake Band of Ojibwe's low income-dedicated array, developed by the Rural Renewable Energy Alliance, was chosen because its focus and funding is unique among Minnesotan and national CSS projects. Cooperative Energy Futures, the only developer in our study (and also another of the cooperatives), was chosen because it actively developed CSS with residential subscribers in mind, compared to the majority of developers who pursued only large electricity consumers.

3.2. Semi-Structured Interviews

Semi-structured interviews provided an opportunity for us to gain a better understanding of utilities' perspectives of CSS programs. We sought to speak to staff of utilities with existing CSS programs to answer questions around five main research objectives in municipal and cooperative utilities:

- How do stakeholders view CSS and understand how they think about cost and benefits distribution?
- Analyze the decision-making processes in CSS program design
- Identify CSS subscriber characteristics, motivations, and barriers to subscribing
- Identify how utilities learn about successful CSS program design, implementation, and differences across utility size and type
- Gain insight into utility financing options/models for CSS projects

These research objectives are the basis for our interview protocol, and guided our analytical framework around the effectiveness of Minnesota's CSS program design models.

We mapped all municipal and cooperative utilities in Minnesota who had incorporated CSS programs by October of 2017. We first began outreach to the utilities using convenience sampling where existing relationships with utilities existed. We then contacted additional utilities with CSS programs by phone and email to participate in an interview. Interviews were conducted by two Graduate Research Assistants, individually, at the utility offices, public spaces, and by phone call if meeting face-to-face was not possible. Each graduate research assistant completed the Collaborative Institutional Training Initiative (CITI) Program Social/Behavioral or Humanist Research Investigators and Key Personnel course prior to performing interviews. Interviewees signed consent forms before participating. Interviewee positions included general managers, energy advisors, energy services managers, and member services managers, typically the point of contact or an influential stakeholder for the CSS program of the utility. All 12 interviews were recorded, with the signed consent of the interviewee, and transcribed. Nvivo software was used to organize and analyze the qualitative data. The interview data was stored on the encrypted University of Minnesota network and transcripts were renamed to separate identifiable information from audio files. Qualitative data from these interviews are used throughout this analysis to provide reinforcement from a utility perspective.

3.3. Financial Analysis

In our financial analysis we determined the subscription benefits for a given CSS program or project for each contract offer. Basic program characteristics were gathered from publicly available contracts, newsletters, press releases, and utility websites. We analyze contract information from seventeen electric cooperatives, developers from Xcel Energy's program and Minnesota Power's utility-led program, and twelve municipal utilities across the state. Data includes capacity of the shared solar array, payment type, payment and contract length, year energized, minimum subscription size, additional fees, and the type of bill credit applied to a subscriber's account. Specific financial assumptions are included in Appendix I.

Except for a few utilities, customers are given a production credit reimbursement based on the utility specific net metering rate multiplied by the number of kilowatt hours produced from the subscriber's share of a CSS array. For our analysis, we assumed, except where noted, that all contracts were subscribed by residential customers. Rates were collected from the Minnesota Public Utilities Commission's 17-09 and 17-11 docket filings, and from publicly available announcements, for rates available in the year 2017.

4. Opportunities and Barriers to Solar Garden Development

CSS design models in Minnesota have significantly evolved since first beginning in the early 2010s, both as a response to state mandates and to bottom-up demand for CSS. Each of the utility or developer-led programs have their own specific opportunities and barriers for development stemming from their different regulatory and legal structures, political positions, financial constraints, inter- and intra-organizational dynamics, and unique social and cultural conditions. In this section, we explore the factors underlying the incentives and barriers faced by utilities, project developers, and potential subscribers across Minnesota's utility landscape.

4.1. What is the Incentive/Barrier Structure for Utilities?

In this section, we explore the sources of difference in utility approaches to CSS development in Minnesota. Minnesota's utility landscape, introduced in Section 2, divides the state into more than a hundred service territories that have emerged from different regulatory, legal, and political circumstances that shape energy decisions generally, and CSS decisions specifically. The different structures also create unique financing constraints for potential CSS development in different utility territories. Further, the organizational structure of utilities, particularly that of cooperative utilities and their generation and transmission partners and of municipal utilities and their joint action agency partners, is a critical consideration of distribution utilities in deploying distributed energy resources and CSS. Finally, the dynamics within a utility, particularly how it collects and acts on new information, is a key factor in approaching CSS development.

4.1.1. Utility Regulatory, Legal, and Political Factors

Xcel Energy's legislatively mandated program is by far Minnesota's largest CSS program, comprising the vast majority of CSS development in the state (see Figure 4). As an investor-owned utility in a vertically integrated state, the Minnesota PUC maintains primary regulatory authority over Xcel Energy. Oversight and regulation takes many different forms, covering rate regulation, cost recovery, capacity planning, among other functions. Operating in a vertically-integrated state means Xcel faces greater exposure to legislative change. As described in Section 2.2, Xcel's CSS program is unique in Minnesota, as it is the only program to have emerged from legislation that mandated its creation. While this legislation was passed with bipartisan support, it required Xcel to take actions it wouldn't have otherwise. Across the United States, as of early 2018, 18 states and the District of Columbia have also pursued legislation to mandate CSS programs, and overall, these programs are the largest in the country (Stanton and Kline, 2016) – although Xcel's CSS program in Minnesota is the largest overall.

Regulation by the Commission has equally significant implications for the implementation of Xcel's CSS program. As already mentioned above, the state PUC Arbitrated critical decisions that effected the pace of growth of the program. The most notable decisions, the co-location revision in late 2015 and the replacement of the Applicable Retail Rate tariff to the Value of Solar tariff in late 2016, created visible shifts in project applications under Xcel's program. Figure 7 displays project proposals in Xcel's program over time, noting the timing of key regulatory changes.

The regulatory uncertainty in the first few years of the Xcel program perhaps reflect the novelty of CSS programs nationally. Xcel's program quickly became the largest in the country before the PUC took a set of actions to deliberately slow the pace of growth. Yet the PUC is a quasi-regulatory, quasi-political body, and Xcel, project developers, and consumer and environmental groups are not passive actors with respect to shaping the PUC's decisions making (Trabish, 2015a). The implementation of Xcel's CSS program has continued to unfold in the public view, with many critical decisions negotiated by various interest groups in front of the PUC (see MN PUC Docket 13-867 and Figure 7).

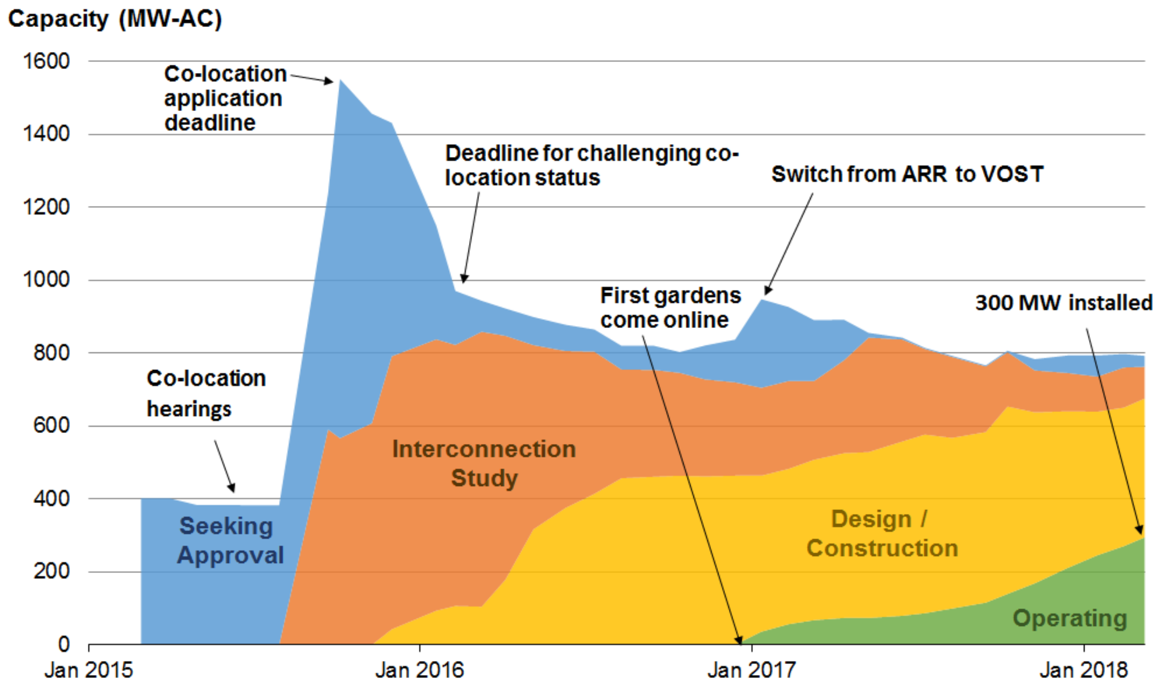

Figure 7. Timeline of CSS Project Proposals and Development in Xcel Energy
Community solar projects in Xcel Energy's program were rapidly proposed through the end of 2015. A decision by the Minnesota Public Utilities Commission, effective in late 2015, limited the "co-location" of multiple (up to 5) projects that met the 1 MW cap established in the 2013 enabling legislation. Following the co-location decision, applications to the program dramatically declined while development of previously proposed projects continued. Meanwhile, deliberations for revising the reimbursement rate for CSS projects commenced, creating uncertainty for the financial viability of new projects. At the end of 2016, a new tariff scheme to reimburse energy generated by CSS projects at the so-called "Value of Solar" was established, creating more financial certainty and an uptick in new project proposals.

Minnesota's two other investor-owned utilities, Minnesota Power and Otter Tail Power Company, due to their smaller size, have not faced the same intensity of regulatory and legislative oversight as Xcel Energy, despite also falling under the PUC jurisdiction. For example, Minnesota Power, was not included in the 2013 legislation that mandated Xcel's community solar program. Instead, Minnesota Power's program was initiated by the utility voluntarily and has faced some scrutiny by the PUC to date. Otter Tail Power has not developed a CSS program.

Unlike Minnesota's investor-owned utilities, the state's municipal and cooperative utilities are excluded from regulation by the PUC and thus face significantly different regulatory, legal, and political constraints. Municipal utilities are responsible to local governments and the citizenry of the municipalities they serve. Cooperative utilities are owned by their customers, so-called "member-owners," and are governed by a locally selected board[1]. Both municipal and

[1] Only one electric cooperative in Minnesota, Dakota Electric, is rate-regulated by the state Public Utilities Commission.

cooperative utilities are locally regulated by utilities commissions and city councils or boards of directors, respectively, leading to some flexibility in crafting their own regulations and program designs that investor-owned utilities traditionally lack. Without investor shareholders and facing less state-level oversight, these utilities face very different operating constraints and generally hold more "agnostic" views toward distributed solar. And because municipal and cooperative utilities are controlled locally they may be more sensitive toward rate impacts and conditions of "fairness" amongst their membership. (Shenot, 2016)

> *If you're looking to policy…the most important thing is that we're able to do this without state mandates. We like that we are actually self-regulated… So, going through a process to do this is very simple… You know, we're not doing it because we're mandated, or making decisions that aren't wise.*
>
> **Interviewee (94246)**

> *We did [community solar] fundamentally to try to anticipate some things… We didn't do this because of a regulatory measure. We did this because we wanted to just sort of get ahead … We hear all about, 'Well, solar is dropping in cost. I mean, this can do things.' We wanted to get ahead of that.*
>
> **Interviewee (71999)**

4.1.2. Utility Financial Factors

Because investor-owned utilities in Minnesota are regulated by the state public utilities commission, and because they depend on cost-of-service regulation for profits, CSS can reduce a utility's revenue in at least two ways: 1) directly reducing sales to end customers who now meet some of their electricity demand through a CSS contract, and 2) reducing the need for new generation and transmission infrastructure, thus compromising a utility's primary means of developing new revenue streams. In many ways, these concerns mirror the often-discussed concerns of revenue erosion due to distributed generation more broadly (e.g., Blackburn et al., 2014; Satchwell et al., 2015). But CSS has put a spotlight on the issue in Minnesota due to the rapid growth of the Xcel program led by third-party developers.

Municipal and cooperative utilities are typically much smaller and not-for-profit, and often go through a third party (for-profit) developer and financier to construct and finance their solar garden. These utilities often do not possess the technical knowledge or staff capacity necessary to complete the construction of a CSS array. Additionally, third-party financing is necessary to capture financial incentives such as investment tax credits and accelerated depreciation. Additionally, smaller utilities often do not have the capacity to navigate the legal and financial complexity of contractual agreements. Once developed, municipal and cooperative utilities have some discretion in creating subscription contract offers but must take into account the risk appetite and other requirements of their partners on the CSS project. These constraints can affect the attractiveness of these offers to potential subscribers and may make projects financially unattractive.

We did end up using a financial model that brought in a for-profit partner that could utilize those [tax incentives]. Then they put up part of the capital, which helped bring down the cost.

Interviewee (75575)

It was [name of partner] that fronted the construction costs. The[y] had ownership of it. They're able to take advantage of the tax credits, the incentives, and so on. And then there's a flip. I think it's a seven-year or a ten-year, where the depreciation has run out, and tax credits have run out, and then the ownership comes back to [utility name].

Interviewee (27730)

Utilities must also incur additional costs in customer outreach, education, billing system upgrades, and engineering studies that can act as a barrier for CSS development. The magnitude of these costs varies significantly between utilities, and all utilities must decide how those costs will be borne across all customers in addition to debt service and operations and maintenance obligations that they must pay to upkeep their grids (Shenot, 2016). Interview results aligned consistently with these barriers. The importance of billing software was mentioned in 7 out of 12 interviews.

At that point in time it was the traditional community solar model. We partnered with [third party name] because we didn't have the experience, we didn't have the wherewithal, the know-how to develop one ourselves. There was a third party that had that and could offer it. So we partnered with them.

Interviewee (75346)

Municipal utilities often provide multiple services to a town, including water, wastewater, gas, and steam. They provide funds in the form of payments-in-lieu-of-taxes (PILOT) to the city's general fund, alleviating some pressures from property taxes, but perhaps generating anxieties over declining revenues (Grimley, 2016). A CSS project can contribute to this, but generally these projects are quite small relative to other services.

Despite the nonprofit status of cooperative and municipal utilities, they too may feel financial pressures of customer sales defection due to increased rooftop solar adoption. While investor-owned utilities may resist distributed generation because it erodes shareholder value, in the absence of shareholders, municipal and cooperative utilities may be more concerned about the cross-subsidization of household-level generation sold at the retail rate. In these conditions, embracing CSS could reduce these financial risks by enabling projects at greater scale and with subscription schemes that minimize cross-subsidization (Shenot, 2016). It may also lead utilities to design CSS programs that profit off subscribers. See also Section 5.2.

As stewards of their customers or member-owners, many utilities are concerned about cross-subsidization and cost-shifting in regard to distributed solar. CSS can exacerbate or mitigate those concerns. In 2014, the Minnesota Rural Electric Association acknowledged its nascent CSS programs were “structured in a way that allows the cooperative to recover the fixed costs required to serve the enrolled members and avoiding unnecessary and unfair cost-shifting to other members” (Johnson, 2014). The organization was further concerned that the mandate in Xcel Energy’s program-to “reasonably allow for the creation, financing, and accessibility of community solar gardens,” would end up exaggerating the calculated value of solar in areas of avoided generation, transmission, and distribution costs, while “distort[ing] prices and expectations regarding community solar elsewhere in the state.”

As of 2015, co-ops and municipal utilities are allowed to charge a fee to distributed generators, but the PUC began reviewing complaints that the fees from some cooperatives were discriminatory and over-recovering lost revenue. The review would end in late 2017, when a state law change that exempted cooperative and municipal utilities from rate regulation from the PUC by the year’s end. Ending their review, the PUC found that the fees were based on lost revenue projections, not actual cost-of-service studies, and had to be re-performed under revised assumptions. This review has not yet been conducted for co-op and municipal utilities’ CSS programs.

> *As a not-for-profit cooperative, some of the incentives are tax incentives (and) accelerated depreciation; which have very little value to the cooperative. So trying to study the financial models…to figure out how to make this the most affordable you can for your membership, that took a lot of research.*
>
> **Interviewee (75575)**

4.1.3. Utility Inter-Organizational Factors

In Xcel’s CSS program, nearly all projects have been proposed and developed by third parties. These third parties have their own set of inter-organizational relationships with equipment suppliers, installation companies, and financiers, many of which mirror the relationships of more traditional solar developers (see Section 4.2). These developers do not necessarily require close inter-organizational relationships with Xcel, as the law and regulation of the program sets the terms of how third-party developed projects are connected to the grid and compensated. Nevertheless, there has been some controversy with regards to Xcel’s management of the interconnection process for CSS projects (MN PUC Docket 13-867). While Xcel Energy’s program allows it to own and build its own solar garden, it has declined to do so until its recent low-income solar garden pilot project was approved by the PUC (Passer, 2018).

Unlike vertically-integrated utilities, who own power plants down to the distribution transformers, electric cooperatives and municipal utilities function as distribution-only utilities, sparsely owning generation, and instead contracting for energy with larger generation and transmission cooperatives or joint action agencies. As discussed in Section 2, many cooperative and municipal utility CSS projects were borne from relationships with their power suppliers and even other distribution utilities. As stated in section 4.1.2, other players important to the development of these voluntary programs are the financiers providing the capital to build the CSS array. These loans can go directly to the distribution utility, or to the G&T. The result is a network of actors working together to create a CSS project. Table 1 outlines a few examples of the nature of these contractual relationships, and the variety of actors involved. These financing arrangements used to develop CSS projects is revealing of the diversity of approaches that can be taken to finance voluntary CSS programs.

Table 1. Summary of Cooperative and Municipal Community Solar Financing Methods

As non-taxable entities, consumer-owned utilities have to engage on CSS projects with for-profit entities to take advantage of savings from the accelerated depreciation and the investment tax credit. Exactly who that happens with is telling. SMMPA chose the for-profit Coronal Development Services, LLC, from Virginia, to create a project shared among multiple member utilities of it another joint action agency. On the other hand, most cooperatives used familiar insurance or banking organizations to finance their single utility developments, often in tandem with self-financing. Beltrami Electric Cooperative, for instance, wouldn't build their CSS project until 50% of it was upfront subscribed.

Procurement Type	Integrating Organization/Financier	Financing Type	Utility Project Examples
Shared between utilities	Coronal Development Services, LLC	Power purchase agreement	Southern Minnesota Municipal Power Agency. Central Municipal Power Agency/Services was an offtaker to SMMPA's PPA.
Single utility use	Clean Energy Collective	Power purchase agreement	Wright Hennepin Co-op
	Great River Energy - CoBank and Farm Credit Leasing	Lease-to-own	Kandiyohi Co-op, Wright-Hennepin Co-op, South Central Electric Association, Steele-Waseca Co-op, others
	National Renewable Energy Cooperative	Power purchase agreement	MiEnergy Co-op, Lake Region Co-op, Connexus Energy, Beltrami Co-op, others
	None	Self-financed	Detroit Lakes Public Utilities, Moorhead Public Service

Municipal and cooperative utilities typically do not own generation assets and instead contract with joint action agencies and generation and transmission utilities that sell power to multiple municipal and cooperative utilities (see Section 4.1.3). Distributed energy resources are shifting these relationships slowly, as generation, particularly from solar, occurs "behind the meter" of municipal and cooperative utility wholesale power procurement. The CSS projects in Moorhead and Detroit Lakes exemplify municipal-utility-led distributed generation outside of the traditional contracting arrangements with joint action agencies. And similarly, the 25 CSS projects in 18 cooperative utility territories diverge from the typical means of procuring power from generation and transmission utilities that cooperatives typically use. This form of arrangement, particularly in light of the potential scale of CSS projects relative to rooftop solar, raises new questions about the long-term contracts municipal and cooperative utilities sign for wholesale power. CSS programs have opened the door to larger developments that could erode the profitability of generation assets and if scaled significantly, would put pressure on parties on both sides of these contracts to renegotiate terms. So far, the legality of potentially renegotiating these contracts due to increased distributed energy generation from CSS projects has not been explored in Minnesota.

Often, cooperative and municipal utilities must work these arrangements within the confines of their power supply contracts. Great River Energy (GRE), like many generation and transmission utilities and joint action agencies that supply power to their member distribution utilities, used all-requirements contracts with many of its members. These contracts ensure that the electric cooperatives purchase all of their energy from GRE for decades into the future, locking low financing rates for the utility as a whole.

GRE allowed a 5% self-supply provision in its contracts to specifically help accommodate community solar and other distributed technologies into its members' service areas. Many solar gardens were the first generation capacity owned by distribution cooperatives in Minnesota. Other generation and transmission utilities have made or expanded their self-supply options within their contracts for solar garden programs (Overgaard, 2017). Cooperative and municipal utilities without all-requirements contracts may hold multiple contracts -- some fixed, some for peaking energy only – that create more unique barriers to deployment. One example is Basin Electric's 150 kW size limit on distribution utility ownership of solar arrays on its peaking contracts (Basin Electric, 2014). As one magazine put it, "what is unfolding in a variety of ways is an effort to maintain the G&T contractual structure that has served electric cooperatives for more than a half-century while providing G&T member systems with the means and ability to acquire local power resources that their members increasingly favor." (Gibson, 2017)

In Minnesota, there are still legacy power plants in many cities, remnants from the early and middle 1900s when power was generated onsite. Today, because of those existing capacities, many municipal utilities have flexibility in their generating contracts leftover from the space created by their local power. Still others (such as SMMPA or Minnesota Municipal Power Agency [MMPA]) have all-requirements contracts that allow members to only buy from the joint action agency. In light of its two largest member utilities (Austin and Rochester), the agency has moved toward a project-based contract, meaning that member utilities now participate in new generation voluntarily rather than obligatorily (Minnesota Municipal Utilities Association, 2018). CMPAS was the first in the state to follow this project-based contract, giving its members more flexibility in determining their generating resources.

In 2017, the joint action agencies SMMPA and CMPAS signed a power purchase agreement a 5 MW array to be subscribed by customers of its 10 participating member municipal utilities. To capture the greatest economies-of-scale, these joint action agencies worked within the current bounds of their wholesale power contracts and secured a power purchase agreement wherein only portions of the array are rented out to member municipal utilities, allowing these distribution utilities to offer shorter term contracts and "dabble" in the financial and physical structures of solar, as opposed to committing to a long-term relationship with NRCO or CoBank, in the cooperatives' cases.

While traditional relationships are reinforced, it seems that municipal and cooperative utilities as a whole in Minnesota still show some hesitation in working with developers, especially on CSS projects. Generally, benefits for working with third parties include access to experience with CSS projects, billing software, programmatic efficiencies, and cost-effectiveness, while potential barriers include a lack of price transparency, a departure from traditional utility-customer relationships, and general knowledge asymmetries (Romano et al., 2016). Many municipal and cooperative utilities face these common challenges.

Two utilities that we interviewed were able to construct the CSS projects on their own with the guidance of third-party vendors. This allowed for some isolation of outside costs.

> *We installed it. We've got our own line crew. We've got our own electrician[s] on staff. We installed it with the guidance of the vendors. I think we probably taught the vendors as much as they taught us on the installation, so I think it was worthwhile. Once we got ready to go and got the equipment in the door, it went pretty smooth. It went really smooth.*
>
> **Interviewee (91537)**

4.1.4. Utility Intra-Organizational Factors and Learning

There is an educational benefit for utilities engaging in a CSS project. For experienced utilities, it offers an opportunity to test locational values and match to peak demand on the grid (Stanton and Kline, 2016). For less-experienced utilities, it offers lessons in operations and testing new technologies such as advanced inverters or different panel manufacturers. Utilities consistently mentioned education for the utility as a benefit of the CSS project (9 out of 12). It can provide a mechanism for building brand loyalty and customer satisfaction for utilities in general. It provides a testing ground for new rate and financing ideas. It also offers an opportunity to build organizational capacity to work with customers and third parties in investing in grid modernization.

Even for an experienced utility, benefits from similar learning experiences. Through the implementation of its CSS program, Xcel Energy experienced a learning curve in accommodating for new interconnection and billing standards (Hughlett, 2016b). Lessons learned from one can be reflected in the program of another utility. In fact, lessons from Xcel's program have been found in program designs replicated in cooperatives across the state and served as a model in an environment where there were few local examples. One utility mentioned adopting designs from Xcel's program directly.

> *It was basically modeled after Xcel's [Solar Rewards] program... Xcel's the big guy. They have all the research*
>
> **Interviewee (56122)**

Other utilities sought expertise in CSS program design from other municipal and cooperative utilities as they became established. 11 out of the 12 interviews included information about utilities seeking best practices in program sizing, pricing, and contract design from other cooperative and municipal utilities with existing programs. Still others used resources from Clean Energy Resource Teams (CERTs), the U.S. National Renewable Energy Laboratory (NREL), the Electric Power Research Institute (EPRI), and NRECA in the early stages of their program design.

> *We took a look at some of the best practices from coops that dipped their toes in this already, different scenarios that they had come up with – like if a house sells or if, they want to transfer the subscription to another member, those types of things, and then we also took a look at the language and information that NREL had available.*
> **Interviewee (62852)**

> *We looked at how many panels the other co-ops were doing, looked at their size, and we knew that we were actually overbuilding.*
> **Interviewee (83141)**

4.2. What is the Incentive/Barrier Structure for Developers?

Developers of CSS projects face distinct incentives and barriers in considering entering CSS programs. CSS programs, having only begun in Minnesota in 2012, are still relatively new, and lack the scale, modularity, and standardization that have driven down costs in more mature solar segments (primarily rooftop and utility-scale solar).

4.2.1. Developer Regulatory, Legal, Political Factors

Policy and regulatory context are key determinants of where and what type of solar projects are developed (Trabish, 2017). In community solar, the enabling legislation and subsequent regulation of CSS programs shape many of the key determinants of project viability. Xcel's program in Minnesota has been successful relative to other legislatively mandated programs in other states in terms of attracting capital and solar developers to invest in Minnesota.

In Xcel Energy's program, most CSS developments have been in the 1 – 5MW range, which has created a new niche for solar developers, distinct from the utility-scale, commercial and industrial-scale (C&I), and residential-scale markets. While developers of C&I solar (and to a lesser extent, utility-scale solar) regularly develop projects of this scale, these developments almost always have a single off-taker, simplifying electricity sales and reducing customer acquisition and management costs. CSS projects, while requiring much of the same physical infrastructure as C&I or smaller utility-scale solar, are more complex in how electricity is sold due to the participation of multiple subscribers, each with their own risk profiles to blend and manage (see Section 4.2.2 for more detail).

The requirements in the Xcel program to have at least five subscribers per project, with additional restrictions on the size of each subscription, create additional complexity. However, this complexity has been managed by many developers who have worked just within the constraints of the legislative requirements to fill subscriptions with the minimum number of large institutional subscribers. By targeting these larger electricity customers, the impact of individual subscribers defaulting on their subscription contracts is minimized. But this approach that minimizes financial risk also results in much less residential participation in CSS projects in Xcel territory (see Figure 4).

Within the constraints of the Xcel program's legislation, there has been some innovation and new business model development. Cooperative Energy Futures (CEF) has developed a unique (to Minnesota) model of developing CSS projects with large residential subscription rates and dedicated strategies for attracting low-income residential subscribers. Their approach to achieving high residential subscription rates is grounded in their organizational structure as a cooperative with all CSS subscribers also shareholders in the company. CEF's subscription terms are some of the most subscriber-friendly in the state, due in part to the use of anchor subscribers that assume a relatively large capacity of a CSS project to lower overall project risk. See Appendix H for more detail on CEF.

In Xcel Energy's program, administratively-determined rules by the state PUC have led to some conflict between developers and the utility, as detailed in Section 2.2. While informal working groups and growth in Xcel Energy's internal management capacity have helped smooth over the CSS queue, tensions remain between large and small developers in the state, and between the utility and developers of all sizes.

Xcel's CSS program is unique to Minnesota in that it has opened the door for third-party developers to build solar projects in the state. Save on a case-by-case basis (Jossi, 2017a) outside of Xcel's CSS program, third party-owned, developer-led solar is not explicitly allowed in Minnesota. Outside of Xcel's territory, unclear third-party solar ownership rules have largely left CSS development to the utilities. Solar developers work with utilities in these territories within the rules for net-metered distributed generation, behind-the-meter generation or demand response assets, and PURPA-qualified generation. But the bounds of these policies are being contested and the long-term prospect of large non-utility ownership remains an open question in Minnesota.

The 40-kW limit for net-metered distributed generation in municipal and cooperative territories (and one megawatt in Xcel Energy's territory) indirectly creates opportunities for some economies-of-scale for developers, but generally, it does not allow for CSS by itself. However, by building up to that limit and creating a behind-the-meter donation agreement for the proceeds of their five 40 kW solar arrays to the Leech Lake Band of Ojibwe, the Rural Renewable Energy Alliance created a workaround within current state rules. This is believed to be the only developer-led CSS project working outside Xcel Energy's service area or the bounds of a utility-led program in Minnesota.

4.2.2. Developer Financial Factors

Developing a CSS project involves financial arrangements that are distinct from other forms of solar development. But many of the principles that drive solar development for other applications apply to CSS development as well. Namely, CSS developers must balance the upfront financial costs of a project against anticipated revenue with a suitable risk profile that meets the participation constraints of financial investors. Financial policies at the federal and state level are critical for opening solar markets. NREL reviews the array of federal and state financial policies and their effect on CSS prospects. (Cook and Shah, 2018; Coughlin et al., 2011)

Relative to rooftop development, CSS projects are larger and therefore typically require larger financial partners – typically those more experienced in C&I and utility-scale development with large tax equity appetites. Relative to C&I and utility-scale solar development, CSS projects involve multiple subscribers, which can create or reduce additional financial risk, depending on the management of those risk profiles.

Third-party ownership, the prevalent model in the Xcel program, incurs additional soft costs related to the financing of solar development and customer acquisition that are important factors in the economics of CSS development. In 2012, NREL estimated that soft costs associated with third-party ownership added, on average, 18% to the total price of commercial-scale solar projects, noting that third-party ownership also confers potential benefits (Feldman et al., 2013). Soft costs can easily outstrip hard costs in solar development, especially in the emerging CSS market. An NRRI report contends that the existing "compliance regulations and soft costs" make the deployment of solar more complex and expensive (Stanton and Kline, 2016). Issues such as compliance for building, electrical, and fire safety codes, insurance company treatment, local siting and zoning issues, and tax treatment exist at all levels of government.

Finally, one of the most critical determinants of the feasibility of financing CSS projects is the CSS specific tariff rates. In Xcel's program, opportunities for innovation and new partnership formation were opened up by the tariff regime established by the PUC, particularly under the Applicable Retail Rate reimbursement scheme which was set significantly higher than retail electricity rates for all energy customers (see Figure 2).

4.2.3. Developer Inter-Organizational Factors

The inter-organizational factors shaping CSS development in Minnesota in some ways bring national tensions between electricity customers, solar developers, and utilities to Minnesota.

In Xcel's territory, some of the national tensions around third party solar development are being replicated in the CSS program. One notable manifestation has been through disputes in the interconnection process for new CSS projects, which have also arisen in other states (Varnado, 2009). Some observers of the program have argued that the barriers to interconnection in Xcel Energy's CSS program have had as much to do with technical functionality and financial feasibility as with political power dynamics. Solar developers, such as Novel Energy Solutions, have blamed Xcel for the delays in project execution and have claimed that Xcel's rates to connect to the grid are higher than anticipated. In response, Xcel has agreed to work on lowering the cost for interconnection, but also argues that part of the delays in interconnection have been due to developer issues in obtaining financing and permits (Hughlett, 2016b). Joseph Goodman, a manager at the Rocky Mountain Institute, has said that without certainty on the cost and time required by utilities for interconnection reviews and for permitting, developers may lose financial backing by being unable to put investors' money to work on schedule, creating a “chicken-and-egg” dynamic for developers to manager their relationships with utilities and financiers (Trabish, 2016b).

Generally, developers have improved the quality of their program applications to Xcel’s CSS program as familiarity with working with Xcel’s procedures has grown. Still, there is limited knowledge of open capacity where interconnection would in theory be more desired on Xcel Energy’s grid. And even if they developers were allowed to develop openly in municipal and cooperative territories, it is unclear if these utilities have current distribution planning practices and staff capacity to allow for considerable CSS expansion (EPRI, 2017).

Developers must often weigh larger social and political considerations against CSS project viability. The industry can tend to favor larger, more sophisticated developers with longstanding financial or construction-based relationships. To mitigate these costs and foster long-term revenues, developers seek to grow interpersonal relationships with recurring groups of similar installers (EPRI, 2017). From a marketing standpoint, it may also make sense for a project to be visibly accessible to its customers so that they can connect to it more readily, but that can also put a larger financial burden on the overall project cost (Capage, 2015). For utilities acting as developers, they often they have to interface with local units of utilities, which can have their own sometimes-conflicting priorities.

> *The initial problem was finding the site for (Community Solar)... The problem with the site is that it’s kind of way out on the edge of town and nobody can really see it. We tried to get some other sites that were a little bit more visible but we got some pushback from the city on that ‘cause they said, ‘Nah, we want to use that for apartments or something later.’*
>
> **Interviewee (56122)**

Additionally, CSS is rarely the only business for some developers. Some developers are active at multiple scales: utility, C&I, rooftop, and CSS. At each scale, developers interface with different community groups, customers, and regulatory bodies. How these efforts are portioned and prioritized, especially as policies change, remains unclear. Most third-party developers are for-profit by nature. This includes a majority of the Xcel Energy CSS project sites and select cooperative and municipal utility community solar developers. Non-profit developers such as Rural Renewable Energy Alliance exist, and because municipal and cooperative utilities sometimes act as developers, they are also non-profit entities, by definition.

In municipal and cooperative utilities, relationships with developers are often nascent, developed through requests-for-proposals, institutional relationships with the power supplier, or through informal industry connections. From interviews, word-of-mouth matters heavily here: tales of botched third-party sold distributed generators spread through utilities.

> *I got a call from the manufacturer that they were having liquidity problems. I don't know that that means bankruptcy, but it meant they were going out of business. Which then meant I could still get the product from them, but there would be no warranty because the entity didn't exist... How can we purchase a product that isn't going to have a warranty?... do we want to switch to a different manufacturer? A different product? Is there extended warranties or something we can purchase from a third party, like you do when you buy a car?*
>
> **Interviewee (75575)**

> *And when you're dealing with these smaller-scale developments, managing those costs, managing contractors and vendors in a marketplace that is the wild, wild, west, I would say of companies coming and going, going out of business. That, I think, was probably the biggest challenge for most that participated was just finding a reputable partner and getting a project developed, understanding how it's going to perform, because performance numbers which you get quoted and what you actually realize sometimes can be quite different.*
>
> **Interviewee (75346)**

4.2.4. Developer Intra-Organizational Factors

No two developers are the same. Generally, they exist on a spectrum, from small local providers that typically only handle construction and development, to national integrated providers that have in-house financing. As described below, as of 2016, developers can be placed in roughly four categories (according to the Community Solar Value Project) (Romano et al., 2016):

- **National Providers.** These players are active in multiple states and in most cases provide services along the value chain, from turnkey packages to a la carte customizations.
- **Emerging National Providers.** These include large national solar companies that have made announcements about entering the community solar sector, yet have released little confirmation of their progress. Some of these providers may become market leaders, but it is too soon to know.
- **Local Service Providers.** These companies are likely to play an increasingly important role in the development of community solar programs. They include engineering, procurement and construction (EPC) firms, specialty service consultants (from market-researchers to legal advisors and IT specialists), high-profile local installers, and others. They typically work with national providers and collaborate with utilities and other local stakeholders in putting projects together. They compete best on projects that emphasize local economic impacts and bring complementary utility skills and resources to the table.

- **Specialty Service Providers.** These national players provide community solar program consulting (e.g. 3Degrees provides program design, marketing and implementation expertise and Navigant focuses on policy research, program design, and solar economics), or they focus on certain customer segments (e.g. Grid Alternatives focuses on low income community solar and Tendril focuses on customer acquisition and engagement).

Table 2. Community Solar Third-Party Players
Adapted from Community Solar Value Projects (Romano et al., 2016), which notes "this reflects a market assessment as of late-summer 2016. Listings of companies are representative, and not all-inclusive."

National Providers	Emerging National Providers*	Local Service Providers	Specialty Service Providers
• Clean Energy Collective • SunShare • Nexamp • Ecoplexus • SoCore Energy • Community Energy Solar • Bluewave Capital • Ethical Electric	• SolarCity • SunPower • First Solar • Borrego Solar • NextEra Energy • REC Solar • NRG	• Solar EPC firms • Financiers • Lawyers • Marketers	• Grid Alternatives • 3Derees • Tendril • Project Economics • Ampion • Navigant • Smart Electric Power Alliance

* Limited project-development documentation available from these companies to date; some have significant commitments.

In Minnesota, many active developers build projects at different scales. They swing between distributed generation, CSS, and utility-scale offerings. Geronimo, in addition to developing numerous community solar projects, also developed the 100-megawatt scattered site Aurora Solar project (Geronimo Energy, 2018). CSS developers Cooperative Energy Futures also works in residential solar. Innovative Power Systems and Novel Energy Solutions both also work with schools and commercial projects. NextEra Energy, working through a subsidiary, constructs solar in Minnesota and helps to finance other projects (NextEra Energy Resources, LLC, 2018); the holding company also owns the largest investor-owned utility in Florida, Florida Power & Light. Each developer may have different CSS projects and offerings based on current conditions in other solar market segments, national financial outlooks, its own business mission, and internal business structure.

4.3. What is the Incentive/Barrier Structure for Subscribers?

Community shared solar is a new offering to electricity customers; and therefore, a common characteristic of all CSS subscribers is that they are relatively new to these programs and none have held a contract through its full lifetime. Therefore, the incentives and barriers for CSS subscribers include the same factors that shape any new technology adoption decision (Rogers). Yet there are a number of additional specific considerations that shape how potential CSS subscribers approach the decision to subscribe.

4.3.1. Subscriber Regulatory, Legal, Political Factors

Consumer protection, in the case of Xcel Energy's CSS program, has been a concern (x). According to the state's Attorney General, cost-savings claims and contract details can leave many project subscriptions unvetted. Given the up to 25-year length of the contract, many consumers can be left with an obligation to pay a fee to break a CSS subscription contract if they move. Laws vary for consumer protection education across states: Minnesota has disclosure requirements for contracts, and the state Department of Commerce provides resources to potential subscribers (Chace and Hausman, 2017).

According to this study's analysis of contracts (see Section 5.2), CSS contract terms vary from utility to utility and developer to developer, in the amount of energy usage allowed to be covered by a CSS subscription, the payment needed to break a contract, contract length, and treatment of the renewable energy credit (REC).

REC retirement can also create confusion. Specifically, in Xcel Energy's service area, developers were incentivized by mandated two- or three-cent per kilowatt-hour payments for renewable energy credits (RECs) to sell their CSS RECs to Xcel for the utility's own solar standard. Other municipal and cooperative utilities either give RECs from the CSS projects to their power supplier (such as Basin Electric), give them to the consumer, or hold onto them as a utility. Legally, cities or individuals claiming renewable energy goals through CSS subscriptions may have trouble representing their actions, due to REC ownership conflicts (Hoffman and High-Pippert, 2015).

An additional complication is the potential conflict of multiple related green power options. For example, Xcel offers the WindSource and Renewable*Connect program to its customers that allows customers to support the development of renewable energy. In these programs, RECs are retired on the behalf of participants (unlike Xcel's CSS program where Xcel typically maintains the RECs) and may better meet the needs of some institutional electricity customers with sustainability goals. But for residential customers, the distinctions between these other Xcel offerings and the CSS program are complex and could potentially erode participation in the either program, although empirical evidence is limited.

4.3.2. Subscriber Financial Factors

CSS programs, largely in Xcel Energy's service area, often require credit checks and may pass through some of the risk of future rate increases to subscribers in the form of uncertain subscription payment escalators (Bovarnick and Johnson, 2017). There are also a number of payment options and contract terms that accompany any CSS contract that complicate straightforward financial comparison. In this way, among any of Minnesota's CSS programs, it becomes difficult for a potential subscriber to understand the scope and potential of the subscription, the justification for the cost, and the payback period. Tools like the Clean Energy Resource Teams' Community Solar Subscription Comparison Tool have been developed to help potential subscribers understand the financial implications of their contract offers (Clean Energy Resource Teams, 2018).

Given the range of contracts in Minnesota (which we explore in Section 5.2), there is considerable variation in the terms and competitiveness of the terms. Different contracts shift costs and risk onto or away from subscribers, but the complexity of contracts may make direct comparisons challenging. Further, depending on the terms of a contract, especially requirements for upfront payments, low- and medium-income (LMI) subscribers without access to finance may be excluded from CSS programs, even those programs offering contracts with positive lifetime savings. Minnesota still lacks coherent policy measures to assist LMI households in participating in CSS programs, which leads to a lack of participation or access to the financial benefits that a CSS subscription could potentially offer.

> *There's been some residential interest in [CSS] from people who thought that, effectively, they'd be able to make money off of this… this is not a money-making proposition at all; this is not a financial investment; don't think of it that way, and actually, for most of those people, I think that they lost interest in it after we told them that.*
>
> **Interviewee (71999)**

Some CSS programs and developers have designed subscription contract models to overcome the financial barriers posed by high upfront costs. One route to overcome the upfront costs is to offer a pay-as-you-go (PAYG) structure that allows for little-to-no upfront cost and a fixed rate for energy purchased every month. Minnesota Power does this with a fixed $0.1115/kWh rate which will eventually cross over with the retail rate that customers are reimbursed at. Another example is CEF's contract: rates increase annually for the first few years and then freeze, creating almost-guaranteed savings for the duration of the 25-year contract (Cooperative Energy Futures, 2016). Another financial option to eliminate upfront cost is a monthly payment plan, such as Minnesota Power's monthly subscription fee of $15.62 for one kW block. Pay-as-you-go and loan-lease structures require less upfront capital and may broaden participation in CSS programs to customers seeking initial benefit, which may include LMI customers.

For many of the initial institutional subscribers to Xcel's CSS projects, the value to the subscriber is positive, and may in fact be quite lucrative, even in the first year of the subscription contract. For example, through a competitive RFP, the University of Minnesota (UMN) subscribed to 2 MW of community solar in 2016 with anticipated savings of $800,000 over 25 years (net present value at 5% discount rate: ~$475,000) no upfront costs or debt or capital invested in the project (UMN Board of Regents Facilities, Planning, & Operations Committee, 2016). In late 2017, UMN agreed to subscribe to an additional 22.5 MW of community solar development with anticipated lifetime savings of $35.7 million over 25 years (net present value at 5% discount rate: ~$21.4 million)[2]. In total, UMN's CSS subscriptions will equal

[2] In general, CSS subscriptions with large institutional subscribers in Minnesota Xcel's program are not disclosed publicly. As a public institution, some specifics of the University of Minnesota's subscription terms are public. Given the University's competitive process to solicit CSS subscription offers, the University's subscription contract provides a unique window into the financial terms of these contracts, which may be indicative of these contracts more generally. Large, non-residential CSS subscriptions have driven the majority of development in the state.

approximately 14% of the University's annual electricity consumption (Butler, 2017; Jossi, 2017b; UMN, 2017).

4.3.3. Subscriber Social and Cultural Factors

Although Minnesota has developed the largest set of community solar programs in the nation, one of the most important remaining barriers facing all programs nationally stems from a lack of public awareness (Carey, 2017). Generic educational outreach mechanisms typically include a survey or chain message to find the target audience for educational opportunity, followed by in person sessions with additional information. Newsletters also offer additional opportunity for educational outreach, but are limited by brevity. Education serves an extremely important role in customer acquisition and support. Educating potential subscribers on the specifics of community solar increased interest levels among residential subscribers from 14% to 47%, and among commercial subscribers from 19% to 52%, in a recent SEPA study (Szaro, 2017).

Municipal and cooperative utilities have sometimes reported incongruence between surveyed interest and realized subscriptions (NREL, 2016). Additionally, it has been found that many CSS programs do not provide adequate room in their project timelines for public education and customer acquisition (Morse, 2016). Often initial demand is not indicative of actual conversion to subscriptions.

> *Now, the challenge in that is a small group can make a lot of noise... not realizing that the equipment to harvest this free energy is expensive. So a lot of the interest that people have is driven by a belief that somehow it will be cheap. And when the reality is no, I actually pay a premium for locally-produced renewable energy, rather than it being a discount from the standard base load price, that's a real education curve for most of them. And then that really strong interest that's out there fades right away when they realize it's not going to be free or low-cost.*
>
> **Interviewee (75575)**

> *If I were to do it over again, because we had a list of people who were interested, and we sent them special letters once the project was all done. And one of them signed up out of 150 people. So that's where surveys really don't show what's happening. You need to get people to sign up and pay $500.00 down or something like that if you really want to get people locked in.*
>
> **Interviewee (94246)**

Different developers and utilities recruit subscribers through different social and institutional channels, such as through churches and coworkers (Hoffman and High-Pippert, 2015). Communication paths include media and public relations campaigns, meetings and workshops, exhibitions, mail, or email, all facilitating networks of personal, cultural, and institutional trust (Hoffman and High-Pippert, 2015). Developers partnering with community groups has also been a fruitful strategy for building higher residential subscription rates, as modeled by CEF's many partnerships in the communities where it develops projects (see Table 6 in Appendix H). Cities may get involved, too: Cologne, Minnesota, worked to enroll their citizens as subscribers. For its part, the City of Minneapolis created a request-for-proposals in which it requires workforce hiring practices and savings for low-income subscribers specifically living in Minneapolis (Finance & Property Services, 2017).

5. Community Shared Solar Program Design Features

In the previous section, we looked at the general literature on CSS, with a focus on Minnesota's experience, coupled with our interviewee's impressions of their own CSS projects and the state's CSS landscape. Next, case studies were utilized to delve deeper into CSS in Minnesota required more in-depth review within case studies.

With the case study selections, our analysis focused on parallels across heterogeneous program features, elements of cross-subsidization within CSS programs, program design characteristics, and implications of available contracts. Due to the brevity of CSS existence, emerging parameters are chosen for evaluation of basic issues: Are programs accomplishing what they were intended to? What program incentives drive decisions? How does policy and precedent expose itself in program design?

Utilizing contracts from across the state, drawing from general literature, and using interview feedback, we produced evaluative measures for cross-program and cross-project evaluation, based on the following parameters. We defined these criteria as the following:

- **5.1 Accessibility**: Are contracts flexible, with variable lengths, and are multiple payment offerings available for the same CSS project?
- **5.2 Affordability**: Does the program offer loan or leases (LL) or pay-as-you-go (PAYG) subscriptions that offer potential savings upfront or over the life of the (sometimes assumed) contract? Does it offer half-panel subscriptions, if upfront payments (PUF)? What's the lifetime net present value per watt (NPV/watt) of the subscription?
- **5.3 Subscriber Acquisition**: How fully subscribed is the program and how did the program attempt to acquire its subscribers, if at all?
- **5.4 Utility and Developer Motivations**: Does the utility identify motivations or services from the CSS project that benefit the utility or developer themselves?
- **5.5 Subscriber Agency**: Is there room for more CSS development and/or does the program appear to be part of a larger transition to renewable energy that engages the customer or member-owner?

The following sections will attempt to qualify these criteria. For this, we examined 99 CSS program contract offers from more than 30 projects spread across Minnesota, from developers in Xcel Energy's program, to each additional municipal and cooperative program. Those utilities or developers included as case studies were included because their contracts were publicly available. Five additional contracts were removed because of incomplete or unverified information, or additional products or services offered in the contract. We created cash flow analyses for each project, using assumptions outlined in Section 3.3. We also tracked contract terms.

Combined with analysis of individual utility documents posted online and outlined in Appendices B-H through the body of Section 5, we completed our assessment below in Table 3, supporting general ideas where noted, otherwise specific to the utility or developer.

The programs described in Table 3 are utility-led (Beltrami, Minnesota Power, Rochester, Wright-Hennepin, and Stearns) and developer-led (Leech Lake and Cooperative Energy Futures). Across all utilities and developers engaging with CSS in Minnesota, of whom our subset is only a fraction, CSS touches on a number of policy, economic, and social issues, beside energy issues alone. Rochester's CSS contracts, for example, are extended only to the life of their wholesale power contract with Southern Minnesota Municipal Power Agency. Wright-Hennepin appears to be the only utility in our sample experimenting with values of solar on the grid, both social and economic. Some programs, such as Beltrami's and Stearns, are still unsubscribed after years of availability in their service areas. Cooperative Energy Futures, with Rochester, might be the only entities here that actively recruited subscribers beyond newsletter and website updates. These anecdotes indicate an expanding focus of CSS, perhaps applicable to other fields of customer engagement, cost sharing, and wider electric grid dynamics.

Table 3. Program Design Features in Seven Community Solar Programs.

Program	5.1 Accessibility	5.2 Affordability	5.3 Subscriber Acquisition	5.4 Utility and Developer Motivations	5.5 Subscriber Agency
Beltrami Electric Co \]”operative	Pay-up-front $1295 for a full-panel or $647.50 for a half-panel; 12, 24, 36 month loan-lease financing also available for a 20-year contract; pay-as-you-go; may sell or donate shares, utility may repurchase shares	No upfront savings; half-panel subscription option; negative NPV/watt for PUF, PAYG, and LL subscription options	Small initial group of members, newsletter, website, social media; 60% subscribed, as of August, 2017	Member interest in renewable energy, preempt legislation, and learn from new technology and finance models	Program originated due to member-owners' stated demand, but has only slowly attracted subscribers
Minnesota Power	Pay-up-front $2132.15/kW for a 25-year contract; flat monthly fee for loan-lease financing; pay-as-you-go; may sell or donate shares, utility may repurchase shares	No upfront savings; payback within contract time-frame for PUF, PAYG. No payback for LL	Website, social media; No overall subscription rate found - 331 people on solar interest list, as of February 25, 2018	State solar mandate and customer interest in renewable energy	Launched program under MPUC oversight, forced into remediation to open the program to competition, and residential, low-income, and minority participation
Rochester Public Utilities	Pay-up-front $650 (no financing) for 12-year contract; loan-lease available to pay back $660 over a year; may sell or donate shares, utility cannot repurchase shares	No upfront savings; negative NPV/watt for both PUF and LL options	Website, newsletter, social media, city magazine, radio, television, additional 4kW array built at HQ for visibility; No recent subscription rate found	Customer interest and meeting city renewable energy goals	Significant advertising by utility to promote community solar, but little buy-in. SMMPA
Leech Lake Band of Ojibwe	No direct payment by subscriber; enrolled through local energy assistance program	Upfront savings in the form of energy assistance	Low income energy assistance needs identified, Developer working in partnership with entity; 100% subscribed	Reducing energy cost burden and expanding low-income access to renewable energy	Driven by impact investors, state grant and RREAL donations
Wright-Hennepin Cooperative Electric Association	Pay-up-front $869 (no financing) for 20+-year contract, Pay-as-you-go, May sell or donate shares, utility cannot repurchase shares	Upfront savings for select PAYG options. Wide range of affordability and subscription type	Interested members, website, newsletter, social media; 100% subscribed across 4 projects	Member interest, research and development, peak savings, business model innovation; works without cross-subsidization, preempt third party developers	First community solar in the state. Wright-Hennepin Electric Co-op initiated solar development, in conjunction with a small group of subscribers; part of larger utility push on solar energy
Stearns Electric Association	Pay-up-front $1235 (24-month financing available) for 20-year contract, No pay-as-you-go, May sell or donate shares for free on the first transfer; utility may repurchase shares only if subscriber leaves the service territory	No upfront savings. PUF and LL subscription options; negative NPV/watt, no payback over length of contract	Small initial group of members, website, newsletter, social media 68% subscribed, as of November, 2017	Member interest in solar, works without cross-subsidization, learning from small-scale for future projects	Not clear how the program originated
Xcel Energy: Cooperative Energy Futures	Pay-up-front; pay-as-you-go that flattens after several years; 25-year contracts; contracts transferable with a fee; no credit score checks, unlike other Xcel Energy-based CSS developers	Upfront savings, positive NPV/watt over contract life	Organization and member demand, partnerships, website, social media; some projects completed subscribed, others still in the process of acquisition as they are developed	Job creation, reduced fossil fuel usage, reduced bills for low-income members, return excess revenue to future efficiency or solar projects for members	For-profit cooperative focused on energy efficiency; uses geography, faith, or culture to attract subscribers to a project; prioritizes low-income individuals and renters, uses anchor tenants to back up defaulting subscribers

5.1. Accessibility

The costs of CSS development for project developers can be de-risked through member payments. Those payments, however, can become less accessible with high upfront costs, long contract durations, or overly restrictive policies. In creating the CSS project, utilities and developers may deter the very subscribers they first sought to enroll, walking in and out of risk.

The critical question for accessibility is how flexible those payment options are for the utility customer or member. Financing up-front payments and offering options to transfer community solar subscriptions were the primary tools used by our case studies, with pay-as-you-go options providing an alternative in a subset. Options to sell or transfer a subscription to community solar offered another degree of accessibility. Given its status as somewhat of an outlier, Leech Lake will be reviewed separately because its model is uniquely subsidized by grants and donations.

Across Minnesota's CSS programs, subscription contracts generally follow the following forms of payment models available to subscribers:

- The pay up-front model: where the subscriber is required to pay a one-time lump sum for subscribing to a garden.
- The pay-as-you-go model: In this model the co-op charges a subscription tariff for every kWh of energy produced by the subscriber's portion of the array. For a couple of contracts, the co-ops also charge a pay-as-you-go escalator which is a steady percentage increase in the payment to be made by the subscriber year on year.
- The loan-lease model: In this model the subscriber makes a fixed monthly payment to the co-op as a fee for subscription. The payment duration for the loan-lease model can either be lasting for a couple of years or can even extend upto the lifetime of the contract. The loan-lease option for certain contracts also charges a fixed interest on the monthly payment to the subscribers.

While up-front payments decrease the utility's risk in making the project, they reduce program accessibility by establishing a financial hurdle that subscribers must overcome. Up-front payment options are offered by five utilities in our case studies. Costs varied from $650 for 42 kWh/month over twelve years in Rochester, to $2132.15 up front for 1 kW over 25 years in Minnesota Power. Cooperative Energy Futures also offered an upfront payment option.

The loan-lease financing options available were available with Minnesota Power (to pay a fixed rate of $15.62/month for the 25-year duration of their contract (Minnesota Power, 2018)), Stearns (with a $200 down-payment to finance this plan at 5% interest over 24 months) and Beltrami (with 12-, 24-, and 36-month financing options at 6% interest). Beltrami is also the only utility to lower the barrier to entry by offering an up-front payment of $647.50 for a half-panel, half of their $1295 for a full-panel subscription (Beltrami Electric Cooperative, 2016). Lower up-front costs may make it easier for low-income customers to subscribe to a CSS program.

PAYG financing options are offered by Minnesota Power, Beltrami, and Cooperative Energy Futures. Minnesota Power allows members to pay a flat rate of $0.1155/kWh. Beltrami offered an additional $0.05/kWh adder for theirs. Cooperative Energy Futures' main offering was PAYG, creating savings upfront. These PAYG options reduce the initial hurdle of subscribing to community solar, but may result in a larger net cost to the subscriber than an up-front payment (Section 5.2).

Contract length is another marker of accessibility in community solar. Contract lengths range from 5 to 25 years in our total contract sample, from 12 to 25 years in our case studies, with a special exception for Leech Lake Band of Ojibwe, whose subscribers are chosen annually. Some community solar programs offered multiple contract length options that allowed subscribers to choose the right balance of commitment to the program and long-term financial benefit. Shorter contracts may appeal to a larger number of ratepayers, since retirement, changing business expenses, or unforeseen incidents may limit the time a subscriber is willing to commit. Most case-study utilities have twenty-year contracts. Minnesota Power's CSS program requires a 25-year commitment, while Rochester's program is planned for only twelve years, when its relationship with SMMPA may end.

All five utility-based CSS and the one developer-based CSS project allow subscribers to transfer or sell their shares in the program, with variation in whether the utility can buy out the subscription. In Beltrami and Minnesota Power, members may transfer their shares to another address in the Beltrami service area, but the utility reserves the right to buy back shares at a prorated value (Beltrami Electric Cooperative, 2017a). Stearns' program likewise allows members to transfer their shares to other ratepayers, but buyout only occurs when the member moves outside the territory (Stearns Electric Association, 2016). In contrast, the Rochester and Wright-Hennepin programs allow a ratepayer to transfer their subscription to another qualified ratepayer within the utility territory, but provide no option for utility buyout. Allowing subscribers to transfer ownership of their solar subscription to another ratepayer reduces the risk for subscribers who may move outside the utility area, by allowing them avenues for repayment of their initial investment in the policy. Prorated utility buyout options guarantee a minimum return on investment for the subscriber.

Cooperative Energy Futures allows for transfer with a nominal fee, and unlike other Xcel Energy-based developers, does not check its subscribers' credit scores. Other cooperative and municipal CSS projects are not known to pose credit checks on potential subscribers.

Leech Lake's solar arrays are an outlier because its program was sponsored by government and philanthropic funds. This 200kW community solar program sells power to tribal buildings and utilities, and uses the revenue generated to fund payments for low-income households on the Leech Lake reservation (Louwagie, 2017). Providing free power may be an optimal outcome for accessibility, but it still depends on how the local energy assistance unit determines eligibility. These circumstances are rare in Minnesota but are growing across the country by initiatives from non-profit third party developers and state funds. Additionally, there is no transfer clause because the recipients of the electricity generated is reset annually. Who gets to receive energy assistance is reanalyzed each year on the criteria of income, family size, and electrical consumption.

A more accessible community solar program increases the potential population that can support and benefit from the garden. While high initial costs can be a hurdle for subscribers, PAYG options and the option to transfer shares to other ratepayers allow users to more easily join or leave the program. Each of these options had benefits and trade-offs which will be addressed in later sections.

5.2. Affordability

It's important to understand the meaning of "affordable," as its definition will vary between subscribers, developers, and utilities. Furthermore, long-term affordability differs from short-term affordability. Subscribers may see long term affordability as an investment bearing higher returns than other options. These subscribers often have higher upfront capital to deposit on high cost contracts. With short-term affordability, subscribers may use it as a means of participating under capital constraints and as less burdensome for financial budgeting. Depending on the explicit or implicit discount rate used by subscribers, short-term options may be more expensive over the length of the contract than options with higher upfront costs.

This is the case for Minnesota Power, for instance, where an upfront cost of $2,132.15 contrasts with a fixed rate of $15.65/month which adds up to $4686 over the lifetime of the program (2). Yet one offer may be more "affordable" than the other, depending on the subscriber. Equity concerns arise from this disparity in affordable options. Short-term affordability is thought to be better for lower-income individuals while long-term affordability is primarily for higher-income individuals.

Our criteria included a few dimensions, for these reasons. Utility- and developer-led community solar gardens offer a variety of payment options across Minnesota, as discussed in Section 5.1. Additionally, some projects offer savings upfront, an indicator of short-term affordability and an incentive for many subscribers. Other programs trim the upfront cost of panels by offering half-panel subscriptions. For long-term affordability, we used NPV per watt of subscription, whose methodology was described in Section 3.3. Results are summarized in Table 4 below.

Table 4. Affordability Metrics in Seven Community Solar Programs

Program	PUF, PAYG, LL Options?	Savings Upfront?	Full Panel or Half Panel Options?	NPVs ($/W at 5% discount, 2.5% rate increase, 15% capacity factor)
Beltrami Electric Cooperative	6 LL options, 1 PAYG option, 2 PUF options	No	Both	-$1.03 PUF -$0.98 LL1 -$1.00 LL2 -$1.01 LL3 -$0.98 PAYG
Minnesota Power	PUF, PAYG, LL	No. Positive cash flow starting in year 11 for PAYG contract offer	Full panel only	-$0.423 LL +$0.249 PAYG +$0.087 PUF
Rochester Public Utilities	PUF, LL	N/A	Full panel only	-$0.49 LL -$0.55 PUF
Leech Lake Band of Ojibwe	Energy assistance, via net metering	Yes	N/A	N/A
Wright-Hennepin Cooperative Electric Association	PUF for first two CSS; PUF, LL, and PAYG all for last two CSS	Yes, on the third and fourth CSS projects on their PAYG options	Full panel only	1st CSS: -$1.35 PUF 2nd CSS: Unknown 3rd CSS: -$2.14 PUF -$0.41/$0.08 PAYG 4th CSS: -$2.42 PUF -$0.36/$0.08 PAYG
Stearns Electric Association	PUF, LL	No	Full panel only	-$1.18 LL -$1.23 PUF
Xcel Energy: Cooperative Energy Futures	PUF, PAYG	Yes	Full panel only	$0.90 PUF $0.61 PAYG $0.47 PAYG

Beltrami offers options for pay-up-front, loan lease, and pay-as-you-go contracts. It is the only utility evaluated to offer a half-panel subscription. In spite of this, its affordability is low. Its best option is a NPV of -$0.98 per watt, for both PAYG and LL. NPV only varies $0.05 across all contract options. No contracts have a payback period.

Minnesota Power shows a large variation in contract incentives between PUF, LL, and PAYG. PUF and PAYG contract options show a positive NPV to subscriber $0.25 and $0.09, respectively. The LL contract has a NPV of $-0.42. Payback periods for these options are 14 years and 11 years, respectively. The deviation between LL and both PAYG and PUF shows severe subscriber loss in the monthly lease option, exactly $0.67 less than the PUF option. Typically it would be expected to see the LL option as less lucrative for the subscriber than the PUF option, because the utility/developer cannot utilize upfront capital and instead must gain back the investment potential with higher monthly billings. The motives for this contract offering are unknown, but it reveals clear subscriber cross-subsidization between options, not just between participating and nonparticipating customers. In other words, LL subscribers might be paying more to reduce the cost for PUF and PAYG subscribers.

Rochester Public Utilities offers both a PUF and a LL option for subscribers. Both contracts project negative NPV's of -$0.49 and -$0.20, respectively. Again, similar to Minnesota Power, the LL option is much less desirable than the PUF option.

Leech Lake Band of Ojibwe's solar arrays are an outlier amongst the other case studies. Its options offer upfront benefits to its subscribers immediately.

Wright-Hennepin offered an array of payment options to subscribers. There is a wide range of NPV, spanning $2.50 per watt, the spread of which is between PUF and PAYG payment options in the last CSS project. Only two options across all CSS projects present a positive NPV and both of these are PAYG. Both of these options have immediate payback. This again tells a story of a wide range of affordability and accessibility across project sites and contract options. Wright Hennepin was amongst the first CSS programs in the state, so it's possible that its framework for addressing equity and cost of development has evolved over the years.

Stearns Electric offers a LL and PUF option, Both contracts project negative NPV's of -$1.18 -$1.23, respectively. In this instance, the LL option may be more desirable than the PUF option, but neither have any payback period over the length of the contract.

Cooperative Energy Futures is a non-profit co-op within Xcel Energy territory. They offer a PUF and PAYG option, both of which provide positive NPVs. The PAYG option provides immediate payback to subscribers. The PUF option offers the greatest NPV per watt to subscribers ($0.90 versus $0.61 and $0.47).

This evaluation presents several possible interpretations:

- IOU's and developers may be able to offer more lucrative contracts to their subscribers than municipal or cooperative utilities; IOU's may do this for reasons of policy mandate and/or equity concerns
- PAYG options are offered mostly by IOU's; PAYG options have the highest ratio of positive NPV
- PAYG options may correlate with favorable NPV, but may correlate with other variables as well, such as utility type, subscriber landscape, and objective
- Utilities may see a tradeoff between making a subscription more affordable vs. making a subscription more heavily cross-subsidized to its other customers.

Across all our contract samples, a wide array of NPV per watt is shown. Below, in Figure X, we break down the contracts by payment type and utility offering them.

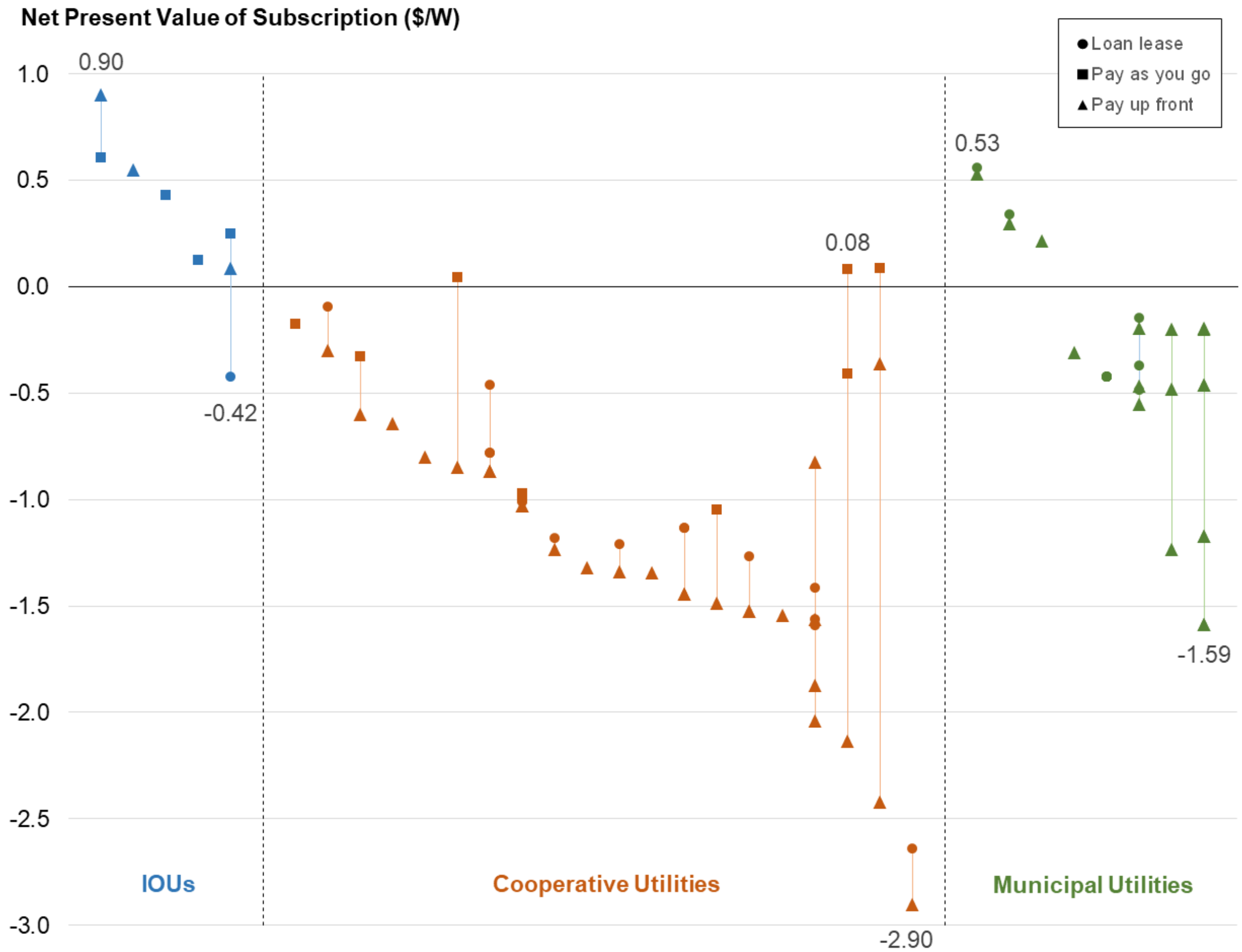

Figure 8. Net Present Value of Residential Community Solar Subscription Contracts
Comparison of community shared solar subscription contracts by net present value to subscribers, organized by type of utility (5% discount rate, 2.5% annual rate increase, see Appendix I for alternate discount rates and rate escalations). Developers offering multiple contracts within the same utility territory are stacked vertically and denoted by the contract type (loan/lease, pay-as-you-go, and pay-up-front). See Appendix I for sensitivity analysis with different discount rates and rate increases.

Benefits, discounted 5% annually over the life of the contract, show considerable difference given higher or lower discount rates. Typical contract lengths are either 20 or 25 years, but some municipal utilities offer more flexible arrangements as low as 5, 10, or 15 years. Additionally, when a contract offers absolute flexibility in contract length, the net present value is calculated with the assumption that they would continue with the program for 20 years. A detailed description of the subscriber net present value calculation and standard assumptions are found in Appendix I.

5.3. Subscriber Acquisition

This section takes a closer look at subscriber acquisition tactics used by utilities to develop, market, and subscribe customers to the CSS programs. A variety of payment options, cost structures, and contract lengths can play a role in subscription rates at utilities. The prevailing electricity rate at the utility must also be considered by the customer and it plays a role in subscription feasibility. Utilities may seek varying levels of customer subscription before projects move forward, so subscription rates are of paramount importance. Unfilled subscriptions can create the potential for non-subscribers to bear costs of the project. In all, education is a key component of any subscriber acquisition program.

Minnesota cooperative and municipal utilities have experienced significantly different subscription rates among CSS programs despite often similar outreach tactics and surveying before project construction. Three out of the seven cases are fully subscribed to all of the CSS capacity offered, achieving full subscription before construction. Other utilities have significant available capacity remaining. Member surveys, in some cases, overestimated demand. Several other utility contacts in our formal interviews mentioned how CSS had been received with widespread support, but many who were interested ended up not subscribing.

All utilities analyzed in our case studies utilized existing channels of communication to promote CSS programs with their customers. Some of these popular methods include newsletters, mailings, social media, and website content. Other, lesser-used methods to attract subscribers included advertisements on radio, television as well as other print media including newspapers and magazines. Word-of-mouth advertising from subscribers, to some extent, seemed to be present in all utilities. All utilities appeared to refrain from door-to-door, individually-targeted promotion of the CSS projects, with only the developer Cooperative Energy Futures engaging in this more-directed outreach.

Beltrami Electric Cooperative, as with many utilities, sought to achieve a committed base of subscribers before the project would be built. Member interest, not necessarily acquisition strategies, drove the initial conversation in CSS and led to further consideration by the utility.

The Cooperative's goal was to achieve a 50 percent subscription rate before construction. Marketing and outreach included the monthly newsletter and website. Initial subscriptions filled quickly but the 50 percent threshold wasn't reached until after two years, in 2017. This pushed back the original goal of starting the project before freeze-up in late 2016. By late 2017, roughly 60 percent of the panels had been subscribed to (Beltrami Electric Cooperative, 2017b).

Minnesota Power hosts a 40 kilowatt array in Duluth and a 1 megawatt array in Wrenshall have a waiting list of 331 customers (MN Power, 2018). The University of Minnesota, Duluth, subscribed to a 100 kW block of the CSS project (Business North, 2017). Minnesota Power appears to have advertised this opportunity to join the solar garden program through their website and social media.

Rochester Public Utilities (RPU) serves more than 50,000 electric customers and has pledged to attain 100% electricity usage from renewables by 2031 (Walton, 2015). This goal played an integral role in the CSS project for the utility.

Beginning in June 2017, RPU announced a marketing campaign to promote the CSS opportunity. Extensive marketing through the municipal magazine, utility newsletter, website, social media, and even radio and television ads were used to promote the project and attract subscribers. A small 4kW solar array was built at the headquarters in Rochester to further promote the CSS program. These efforts, however, produced limited results for this 3MW project. As of October 2017, the CSS project was 2-3% subscribed. A firm deadline of December 31st, 2017 closed the opportunity for additional subscriptions to the project.

The Leech Lake Band of Ojibwe hosts the first integration of community solar with an energy assistance program to facilitate customer outreach, education, and enrollment in the United States. The 200 kW project, with five 40 kW arrays, is expected to produce about 235 megawatt hours per year. The project, geared at supplementing energy assistance funding for low-income households, provides roughly 100 additional households with energy assistance (Louwagie, 2017). Because the Leech Lake Band of Ojibwe did not function as a utility, but now obtains financial benefits to be distributed, 100 percent of the CSS project's generation is subscribed to and realized by recipients of energy assistance at the Leech Lake Band of Ojibwe Reservation. This pool of recipients was identified before project construction.

Wright-Hennepin Electric Cooperative Association has completed four CSS projects - all of which are fully subscribed. A waiting list currently exists for additional construction. Member interest drove conversation which led to the utility constructing the first CSS array in the state in 2013. Organizations have taken a strong interest in the programs and have played an integral role in subscribing to additional projects alongside residential subscribers. As with most utilities, the CSS program was advertised in a monthly newsletter and the website.

Stearns Electric Association began offering a 20.5kW CSS array in 2015 to its 25,000 members. The member newsletter, website, and social media were all utilized to promote subscriptions. By the time the project energized in June 2015, 14 subscriptions had been sold (Petrie, 2015). After almost three years however, the project, with 50 panels, has yet to be fully subscribed.

Cooperative Energy Futures (CEF) has 7 gardens in Minnesota, two of which are fully subscribed (Cooperative Energy Futures, 2018). CEF takes a unique approach to acquiring subscribers to CSS projects. Anyone who wants to join may become a member. Members who subscribe retain democratic control of the CSS projects. The projects are identified and created through partnerships with community leaders and local organizations. Community teams plan solar garden projects to be launched. Once a level of interest is reached, new gardens are created. Currently, five CSS projects are open for subscriptions. Among our case study examples, CEF may well be the only entity that has taken an active role in subscriber recruitment, employing other nonprofits, faith-based organizations, and cooperatives to recruit subscribers across Xcel Energy's service area.

5.4. Utility and Developer Motivations

The utility-as-developer or developer of the CSS project can receive some benefit from its completion, be it social, economic, technological, political, or otherwise. Their motivations for completing the community solar garden can vary widely. In this section, we track the apparent outcomes to each utility or developer in its community solar project(s). (See sections 4.1 and 4.2 for more generalized benefits across utilities and developers.)

Beltrami Electric Cooperative wrote their community solar "is a result of the cooperative member-owners expressing desire to have a local renewable energy option and their willingness to support the project." It was also better that it was member-determined rather than regulatory or legislatively mandated (Beltrami Electric Cooperative, 2017b). The utility seems to express an appreciation in satisfying a segment of customer demand for renewable energy while giving its members a hassle-free option for them. The utility also identified benefits from learning about new technology and finance (Beltrami Electric Cooperative, 2017b).

Minnesota Power initially framed the program as a way to satisfy member demand for solar while also fulfilling its own state mandates for renewable energy credits from small solar. The utility also cited its visibility for customers and emissions-free energy as other benefits (x).

Rochester Public Utilities is the main vehicle for its city's goal of 100 percent renewable energy by 2030. Its community solar program helps satisfy its and its customers' renewable energy goals, while working on a CSS solution within the confines of its contractual relationship with SMMPA (Rochester Public Utilities, 2017a). Currently, because of its power supply contract with SMMPA, private CSS projects are "uneconomical"; its current CSS may offer a transition offer to future projects when its contract ends in 2030 (EPRI, 2017).

The Leech Lake Band of Ojibwe is more unique in its benefits: the focus is to expand access within the tribe's energy assistance program and to provide job training opportunities to Leech Lake Tribal College students. Approximately 100 people per year benefit from the additional finances created by the CSS project. The Rural Renewable Energy Alliance, as a nonprofit and a developer, has used this project to argue for additional equity-focused projects regionally and nationally. Meanwhile, there are no stated active benefits to the utility, but it might be surmised that instead of the more well-off members taking advantage of solar energy benefits, this project offers the reverse for the utility: an actively progressive economic distribution of benefits from solar energy.

Wright-Hennepin Electric Cooperative Association has four different CSS projects and iterative benefits with each (and more if one includes its solar projects with the City of Rockford and its utility-scale array, Dickenson Solar). All projects are managed, some owned, through WH Solar, Wright Hennepin's subsidiary company that was spawned in response to consumer demand for solar and to pre-empt potential third party development in their service area (Trabish, 2015b). The projects were intended as a way to bring solar into the mainstream for member-owners while making it work in harmony with the Wright-Hennepin grid (Nikula, 2014). Additional utility benefits include revenue building, lack of cross-subsidization, project risk mitigation (since members sign up for rates before the project is built, legislative preemption, utility-level learning, and maintaining traditional utility-customer relationship. Additional project-level benefits include:

- The first project was solar-plus-storage, giving Wright-Hennepin the ability to offset its demand charges from its power suppliers. It was also an opportunity to work with a national developer, Clean Energy Collective.
- The second project was the first owned solely by WH Solar, offering a learning experience for the utility on business models. No tax credit was captured for the project.

- The third and fourth projects both offered multiple contract types and expanded to 150 kilowatts in scale, testing new business structures in the process.

Stearns Electric Association has stated that its benefit derives from giving its members a hassle-free, more accessible option for solar (Petrie, 2015). The cooperative started with a small array, apparently planning to learn from the experience for potential future CSS projects. The money-down pays for fixed costs of infrastructure and additional lost revenue, lowering concerns of cross-subsidization between member-owners for the utility.

Cooperative Energy Futures, the only developer in the case study, gains value by providing value to its member-owners (Cooperative Energy Futures, 2018). Profits are reinvested in renewable energy or energy efficiency projects, or given back to members as patronage. Other greater social benefits include jobs, reduced fossil fuel usage, and reduced bills for low-income members. The cooperative developers support other cooperatives, as well.

5.5. Subscriber Agency

The development of community solar as a portion of the renewable energy portfolio varies among utilities. In some cases, it originated to satisfy member demand; in others, it is part of a deliberate push towards greater renewable usage; and still in others, it is part of mandated requirements.

Wright-Hennepin is credited with the first community solar garden in the state. Its four current gardens (totaling 370 kW) are fully subscribed, with reservations available for to-be-announced future projects. Projects are expected to pay for themselves on a 20-year time horizon. The first program was announced in the December 2011 newsletter, with an informational meeting the following July (Wright-Hennepin Cooperative Electric Association, 2012, 2011). Once the first 40kW system went online, another 30 kW system went online within a year.

Stakeholder involvement in the design of a community solar program does not necessarily imply a fully-subscribed program. **Beltrami Electric's program** "is a result of the cooperative member-owners expressing desire to have a local renewable energy option and their willingness to support the project" (Beltrami Electric Cooperative, 2017c). Although the utility began the energization process in 2015, by November 2017 only 55% of their array had subscriptions. The slow pace of member adoption meant that in spite of early member interest, there were no plans to expand this community solar program.

Likewise, **Rochester Public Utilities** used bill inserts, and TV and radio ads to promote their program since it launched in July 2017, but estimated that as of October 2017 their system had subscriptions for just 2-3% of its 3MW capacity (Rochester Public Utilities, 2017b). Rochester intends to supply 100% of their power from renewables by 2031, coinciding with the end of its contract with SMMPA, and its program is linked to this initiative. There are no clear answers yet about how community solar will persist past this time.

The two utilities in this paper with rates regulated by the MPUC, Xcel Energy and Minnesota Power, followed different paths to their community solar programs. Xcel's community solar was mandated by an omnibus bill (HF 729) in 2013, which established prices favorable to the private development of solar gardens, which currently boast over five thousand subscribers. Xcel's appeals to the MPUC to adjudicate the details of the legislation delayed the launch of the first 1MW array until late 2016 (see Section 2).

Cooperative Energy Futures, acting as a developer in Xcel's community solar program, builds solar gardens designed with an emphasis on low- to moderate-income individuals and renters, with anchor tenants framed as a backdrop in case subscribers fall behind on payments (Konewko, 2015). They prefer to foster community support and subscription to their programs through geography, faith, or culture, but will fill a garden with unaffiliated subscribers if needed.

In contrast, **Minnesota Power** filed a request to the MPUC asking permission to launch a community solar garden, and was approved. As part of its approval process, MPUC initiated a separate comment period calling for reactions regarding "What actions, if any, the Commission should take to encourage residential, low-income, and minority participation in [the] proposal?" (Minnesota Public Utilities Commission, 2015b). The Northland Coalition commented that the program was "community" in name only and had been driven exclusively by the utility, questioning whether it fell within the letter and spirit of the 2013 law authorizing community solar for investor-owned utilities (Minnesota Public Utilities Commission, 2016).

The motivations that launched the **Stearns Electric Association** community solar garden were not clear from our research. A 2015 interview indicated that their preference was to "[start] small with just 50 panels," and increase the scope if demand warranted additional panels (Petrie, 2015). Subscriptions for the 21kW array are slowly increasing, with nearly 70% subscribed as of November 2017.

The Leech Lake Band of Ojibwe community solar array was organized by RREAL and the Ojibwe tribal council, with unknown input from members. The households that will benefit from the revenue from the system will vary from year to year based on income, family size, and electrical consumption, so the stakeholders may have limited options to govern their own participation. Future community solar programs aligned with this model will require additional funding from philanthropists and government grants.

6. Discussion

Minnesota's early experience with CSS offers potential lessons for reforming the state's programs and implementing programs in other states.

For many utilities, community solar projects appear to be one-offs. Some never got off the ground. Some projects are still unsubscribed after a year or two. But other utilities are expanding the solar gardens as they sell out. All are using lessons from CSS, in some way, to inform their thinking about the types of projects they will engage in in the future.

The tumultuous rollout of Xcel Energy's CSS program, while initially stalling development, also caused much change in the utility and across Minnesota's electric grid, reflecting the political process and spillover effects that many IOUs across the country engage with. But with its CSS program, Xcel Energy, in particular as the largest and most historically prominent electric utility in the state, has had to change. It had to begin to reform its interconnection process, the way it releases information about its grid, and its traditional role with all customers and low-income customers, especially. Combined with the unexpected involvement of out-of-state developers and financiers, and multiple rounds of re-negotiation under the auspices of the PUC, Xcel Energy's CSS program reflect the increasing complexity of policy implementation in the context of politically powerful incumbents when national attention is given to policies For political and economic realities of solar development and utility involvement, the large majority of activity under Xcel's program has been directed toward serving commercial entities, rather than residential customers. While the rules of the program and subsequent reforms have continued to largely support commercial subscribers, this has not precluded room for innovation. Cooperative Energy Futures, operating in Xcel's territory, has developed innovative CSS programs that serve relatively high fractions of residential and low-income subscribers. It is unknown the extent to which other developers besides residentially-oriented Sunshare are involved with smaller CSS subscribers.

Outside of the IOUs, in municipal and cooperative utilities, the range of experience with CSS indicates uneven progress and a lack of established, universal best practices. Some of this unevenness reflects the very different circumstances that many municipal and cooperative utilities face. But some of these differences reflect ongoing deliberation about the role of the utility as distributed energy expands into greater Minnesota. At least a few of the cooperatives have built lost revenue into their community solar subscription offerings, while others have begun to incorporate into their pricing structures the long-term and social values of distributed, renewable energy deployment. In these pricing structures -- whether they are upfront or pay-as-you-go, their price relative to project cost, and their term lengths -- CSS offers a glimpse into how these utilities believe they will end up in the next 20 years when their CSS projects are fully depreciated and perhaps uninstalled. That few utilities currently support low-income solar deployment in the state, and that only developers in Xcel's territory and one in RREAL in northern Minnesota are, says more about the relative path dependence of any utility's mission to serve all customers equally than it does about actual customer needs and potential to create a more equitable energy system.

Even among these distribution municipal and cooperative utilities who, as unofficial distribution service operators, largely unbundled from generation and transmission assets, are primed to engage with customers, CSS has come mostly from the top-down, mostly, within the confines of requirements contracts or traditional business relationships from cooperative banks or third-party renewable developers. And even here, there are still spots of bottom-up development: from customers who pressure the utilities to create a CSS or offer additional projects, from utility managers and boards who actively market and acquire customers, and from developers (such as the Rural Renewable Energy Alliance with the Leech Lake Band of Ojibwe) who create new models within the confines of current practices and regulations.

Even though they are by-and-large unregulated, Minnesota's community solar programs outside of Xcel Energy, offer the lesson that policy cannot be crafted to simultaneously fit every utility but also that policy can predict changes among those in the same business or physical space. Instead of having to follow an encompassing regulation, utilities, their financiers, and their consumers will simultaneously craft their own implicit policy, subject to present power constraints and visions of the future, in response to regulation they believe is forthcoming or other developments in the field within the state.

This introduces ideas of sequencing policy, learning-by-doing, and spatial theories of technology diffusion that could apply for future grid modernization and carbon reduction policies. Here, effects from policies are not evaluated by stated effects, but by the kinds of experiences they afford to individual utilities to have and innovate from.

Electric cooperatives and municipal utilities are too numerous in Minnesota to sum up their operations, but it is certain that CSS isn't prevalent among the utilities, with more than 30 programs among 160-plus utilities in the state, and among those transitioning to customer-based power approaches within CSS, these utilities' CSS programs are either undersubscribed or hitting a wall after initial projects go completely subscribed. This may correspond to a parallel observation from our semi-structured interviews that many utilities didn't expend as many resources in customer acquisition and management, as the third-party developers in Xcel Energy or other investor-owned utilities' service areas.

The uncertain limits to distributed generation, combined with the apparent limit in the number of customers willing to sign up for a long-term price that results in certain front-end or uncertain back-end savings, leaves CSS in the state in a moment of transition.

6.1. Room for Growth and Innovation

> *And that's where I think we're probably going if we do more solar. It'll be something bigger, with batteries, and a little bit more flexible for customers.*
>
> **Interviewee (56122)**

What is next for community solar? Community solar among Minnesota's consumer-owned utilities was, and remains, an initial point of entry beginning into distributed energy deployment. Of the 125 municipal and the 45 distribution cooperative utilities active in providing electricity in Minnesota, few had experience with distributed energy technologies. Instead, their generation and transmission cooperatives and joint action agencies, alongside more national networks of cooperative and third-party providers, supported much of the deployment in the state. Additionally, while CSS was originally thought of as a response to those without access to capital, credit scores, or sunny proprietary space for solar modules, it's unclear whether member-owners or municipal customers who subscribe to CSS in their territories are those who wouldn't have deployed solar on their property anyway in the absence of a CSS program.

Still, innovations arose within CSS to accommodate shifting utility and customer preferences. Seemingly in response to the rising tide of distributed energy, one innovation of the community solar programs was making easier-to-finance offers among the distribution cooperatives for financing and project ownership of solar arrays. Choosing between leases, power purchase agreements, self-financing, and clean renewable energy bonds, the distribution cooperatives were able to utilize familiar networks to scale and access clean energy. Generation and transmission cooperatives opened all-requirements contracts to five-percent self-supply provisions to allow community solar gardens in their territory. While no cooperative is nearing the self-supply limits, the decision may have implications for the future as distribution cooperatives gain experience with distributed energy and CSS.

Another innovation lay in the experimentation in offering multiple products and multiple contract provisions in CSS projects, often drawing from products or offerings the utilities themselves consider granted or commonplace. Steele-Waseca Electric Cooperative and Meeker Cooperative both offered controllable water heaters with a reduced-price solar panel in their community solar array, accounting for future (albeit discounted) electricity sales to the electrified heaters in the solar price, while using the member's water heater to offset cost peak demand rates from the co-op's generation and transmission utilities. Wright-Hennepin's battery storage option in their first community solar array similarly offered a similar benefit to all consumers of the cooperative by displacing peak demand with solar-powered energy.

Likewise, pricing structures and a willingness to try new contract terms with consumers was a strength of many CSS programs. As pay-as-you-go contracts for 20 to 25 years, with either escalating or flat rates, became the norm among third-party developers in Xcel Energy's service area, many cooperatives and municipal utilities tended outside that norm, offering an array of flat-rate contracts, shorter length contracts from five to 10 years, on-bill financing with zero-percent interest, and even using general revenue to buy down the price of solar panels within the solar garden, in Moorhead Public Service's case. The general spread among CSS offerings reflects an even greater spread of motivations, leadership, and rationale among cooperative and municipal boards.

As time passed, community solar pricing options also changed within individual cooperatives, as well as within Xcel Energy's territory. A timeline of change, though explicit to consumers, constructs just how willing utilities-as-developers and developers are willing to compromise on project finance. For instance:

- Early contracts in Xcel Energy's program offered many upfront offers for residential consumers (Grimley, 2015), shifting quickly to pay-as-you-go payments as the CSS market matured toward larger, nonresidential subscribers
- People's Energy Cooperative dropped the price for a panel from $750 down to $712.50 as part of the garden remained unsubscribed (People's Energy Cooperative, 2018)
- South Central Electric Association shifted from $1175 per panel or a flat $0.14/kWh pay-as-you-go (South Central Electric, 2016), to just a $0.13/kWh pay-as-you-go contract
- Wright-Hennepin Cooperative Electric Association shifted from solely upfront payments in its first two gardens to a mix of upfront, flat pay-as-you-go, and a lifetime discounted pay-as-you-go that follows retail rate changes over the contract
- Moorhead Public Service, with its policy of subsidizing the cost of panels to earn customers a shorter payback, shows in each CSS iteration a declining internal subsidy as panel prices have come down (Figure 9 below). Moorhead used this program to respond to customer demand, invoking their mission as municipal utility to buy-down the project costs.

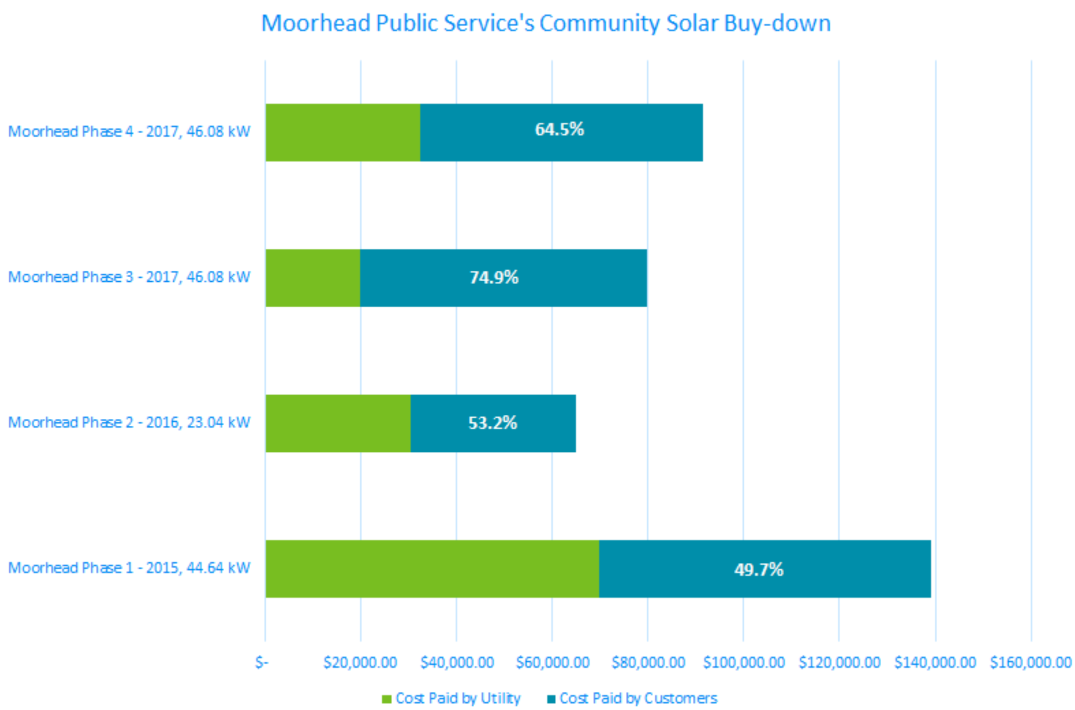

Figure 9. Moorhead Public Service's Community Solar Buy-Down
Share of Moorhead's community solar project's cost paid by the utility and by customers, illustrating a willingness on the part of the utility to offer a subscription contract that shortens the payback period for subscribers by leveraging utility cash. Reproduced from Moorhead's filing in Docket 18-10.

SMMPA and CMPAS' 5 MW community solar array reflects a not-often realized aspect of CSS: many community solar arrays among cooperative and municipal utilities are only partially subscribed, and the unsubscribed portions are almost left to act as utility-scale arrays would, their costs socialized among all the utilities' consumers.

In a way, leveraging and balancing risk through the vertically-connected governances and cooperative finance, these cooperative and municipal utilities in sum have accomplished many of the features of what would make a targeted LMI program successful: as local utilities whose rules are determined, in part, through democratic processes, they are engaged with membership; their contract offerings are diverse, easily transferable, and financeable, at times; and their consumer bases are already, in general, believed to be at a lower-income level than those of the investor-owned utilities.

Yet it is unclear that these municipal and cooperative utilities, or Minnesota Power, have any internal prerogative to actively market, acquire, and sustain low-income subscribers in a way that RREAL does through its local coordinating LIHEAP agency. More broadly, it appears that customer acquisition is not something that these utilities anticipated having to spend much time on, even though many third-party developers report having to spend 200 to 600 dollars per kilowatt-subscribed in recruitment for their community solar arrays (Greco, 2017).

Many initial CSS projects arise from a response to consumer demand, a realization among seemingly hundreds in the state that a utility can respond to individualized preferences. Out of

12 interviews, 10 identified customer interest as a driving force in the construction of the CSS project.

> *It's one thing that we had customers who were wanting it and as a municipal were owned by our customers so we listened and went through with developing a program to meet that need within our customer base. It was a positive experience.*
>
> **Interviewee (39732)**

> *We had been getting I would say steady interest and questions from our members on renewable energy, on solar specifically. A few years back it was more leaning towards wind, but a few, maybe eight to ten years back and now I would say that conversation shifted, you know, in the past five to six years and more is leaning towards solar.*
>
> **Interviewee (62854)**

> *A lot of it was frankly just driven by member inquiries. We had a group of members that were calling and even doing an online petition asking for the option of being able to have locally-produced solar energy. So that was kind of the key driver that got the ball rolling, trying to respond to that member request.*
>
> **Interviewee (75575)**

To date, however, only a few programs have created programs wherein consumer agency drives additional community solar construction. Wright-Hennepin Electric Cooperative, an early adopter of community solar, used CSS as a method of research and development and member development. Additional utility-scale and offtaker-centric arrays offered a compendium of solar options.

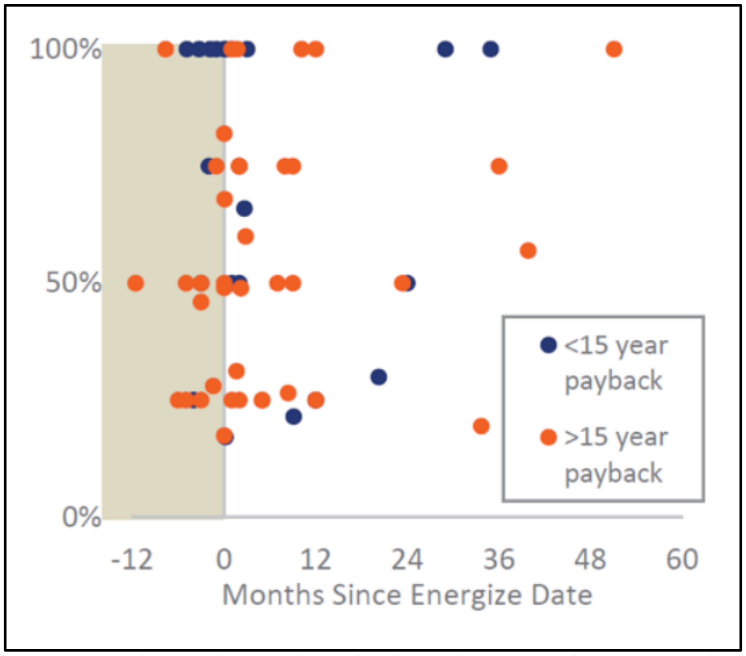

Figure 10. Rates of Community Solar Subscription since Project Energize Date
Reproduced from Smart Electric Power Alliance 2015 Community Solar Survey (NREL, 2016). Rates of subscription can indicate total demand for the project, as well as an willingness on the part of the customer or member-owner base to fund additional projects. The chart above demonstrates that many CSS projects can stall at a certain subscription level, and that payback periods matter.

Whether explicitly or implicitly, other utilities in the state are considering how they might build their solar gardens or at least satisfy customer appetite for renewable energy products and additionality. Some are moving into installing utility-optimized solar on their customer's homes; others are considering more utility-scale solutions to sell with renewable energy credits. It's clear from these early studies that for CSS to occur, at least in Minnesota, both members in the subscription or finance and utilities in the actual deployment are needed in a relative symbiosis of the project, a shift from a more traditional utility-sells/customer-buys mentality. One side may have the idea and agency to begin the product, but it will always be the other who must buy-in to complete it.

Likewise, utilities often face internal and external questions of cross-subsidization on their community solar gardens and distributed generation, in general. Some programs, like Beltrami or Rochester, set contractual boundaries to limit cross-subsidization, either collecting future lost revenue up front in the CSS payments, or pricing the contract such as its payback is extended to the life of the contract. Others, such as Moorhead or Xcel Energy's program, actively subsidize CSS participants. And yet others, whose CSS projects are layered in judgments about future electricity prices and underlying policy or utility motives, create bets and hedges through which the customers and utilities engage in guessing games about the future. In all these CSS projects, in and out of thoughts about what "cross-subsidization" is, utilities, developers, and customers balance each other's' interests, whether they know it or not.

6.2. Knowledge Gaps

Knowledge gaps and questions remain surrounding our research of CSS across Minnesota's utilities. These knowledge gaps range from acquisition costs to perceptions of policy impacts on the industry.

What is the best way to gather member support for community solar? Utilities like Rochester have gone out of their way to rally support, but failed to achieve higher subscription rates after months of advertising. Beltrami delayed breaking ground for two years while gathering 50% member support, but since launching its array, subscriptions have stalled at nearly 60% of capacity. Still other utilities and developers have benefited from anchor tenants financing their systems, but the mechanism of recruiting these tenants bears further research. From our research, most municipal and cooperative utilities have not been tracking their subscriber acquisition costs, giving rise to further questions: What are the average subscriber acquisition costs for utilities? What type of marketing has worked best for different utilities, and potential reasons why? And finally, for utilities that tie a product with their CSS program, what is the difference in utility customers' desire for production?

For community solar garden programs launched by the utility in the absence of prior subscriber support, research could be conducted to find the original force motivating the new program. Was it a reduction in the cost of renewables, a belief that adding community solar on the utility's own terms was preferable to having it forced by legislation, or some other factor? Interviews with utilities have indicated that each of these answers provides partial motivation for their programs, but more detailed analysis is warranted.

Questions remain surrounding how much upfront savings PAYG models attract LMI subscribers, and what measures, if any, are required to make up-front PAYG models more successful among LMI populations, as stated in Section 6.1 most Minnesota cooperative and municipal utilities take a top down approach to their program design. Would a more bottom-up program design model be more successful among LMI operations, and what would one look like?

What are the effects of information networks and policy on municipal and cooperative utility subscriptions since they are not heavily regulated at the state or federal levels? During the interview process municipal and cooperative utilities mentioned going to fellow utilities for advice on program design. Who did they connect with to influence their program design, were these connections important, and if so, how could stronger networks improve decision making in this area?

Similarly, what are the effects of industry maturation on utility deployment? Utilities mentioned barriers with solar panel suppliers going out of business having an effect on their program development. One utility mentioned the new tariff has influenced their consideration of implementation of future programs due to uncertainty from effects of future solar policy.

These knowledge gaps can inform future research moving forward and help to inform future program design thinking. Answering these gaps will help to further inform important variations in CSS projects across the state and help to provide a useful comparative framework.

7. Conclusion

In this report, we offer a look at the collective history of Minnesota's utilities and how policy development and subsequent reaction produced important variations in CSS projects across the state. Understanding how CSS programs are developed in different utility contexts provides a fruitful comparative framework. In IOUs, concerns regarding lost revenue, rate increases, and loss of control of infrastructure planning and ownership dominate. In contrast, municipal and cooperative utilities, without the shareholders of investor-owned utilities, can be said to lack a profit motive, though other incentives for revenue exist (such as payments-in-lieu-of-taxes to general funds, or patronage kept and dispersed by the cooperative or the generation and transmission cooperative). Their sales and revenues are variously increasing and decreasing; likewise, levels of distributed generation and willingness to experiment vary incredibly on their systems. Developers, in each utility context, negotiate the explicit and implicit limits set on them, and subscribers are variously aware of the ongoing energy transition around them and their role.

In Minnesota, CSS has evolved in conjunction with history and other policies. It became both a replacement and complement to net-metered distributed generation, and seems to be evolving once more to diversify the utilities' CSS project- and utility-level risk. Individualized subscriptions hinge on a temporal and spatial shifting of risk, from one generation to the next, from participants to nonparticipants, from the utility to the customer. In future research, we plan to explore how ideas of cross-subsidy come out in contract structures: payback length of contract; retail versus wholesale cost; sizing to load versus outsizing home energy use; having project level costs subsidized by load management or general fund revenue. Against interviews with community solar managers at municipal and cooperative utilities across the state, we ask: how do implicit policies form, what's the role of framing fairness in CSS project development, and what does this mean for other CSS projects and the clean energy transition, in general?

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Appendix A: History of Electricity and Renewable Energy in Minnesota

To first get mechanical power in the 1800s, mills and towns dammed rivers in Minnesota. Dams then turned from mechanical uses to electricity generation. During the late 1800s, municipal utilities were born, fighting with numerous privately-owned utilities for supply of gas and electricity to towns across Minnesota. Often, two or more private or public utilities existed in the same town, building wires on top of each other, waiting on building permit hearings to snatch new customers from each other (Meyer, 1957).

Transmission was built, bringing hydropower 28 miles to St. Paul from Apple Valley, Wisconsin (+). Private utilities gained investors and rapidly bought out their private and public competitors. City-granted franchises to private utilities created patchwork schemes of local regulation. Other states created state utilities commissions as a compromise between the "natural monopoly" of private utilities and their sometimes-corruptive influence on local regulation (+).

Among the fastest-growing investor-owned utility in Minnesota was Consumers Power, of the holding company Northern States Power (NSP), which was incorporated in 1909 (+). NSP was operated by H.M. Byllesby, a utility magnate who owned generating companies across the United States. One of six major utility monopolists at the time (including Samuel Insull and J.P Morgan), he began his career apprenticing for Thomas Edison, then working with the Westinghouse Electric Company a stint with an electric vehicle operation in New York City (+). Other private utilities in Duluth (Duluth Edison Electric) and Fergus Falls (Otter Tail Power) expanded into the Iron Range and more-western prairie towns, respectively. A 1914 Minnesota survey shows that electric plant operation was split 81 to 86 between municipal and private entities (while water, at the time, was almost entirely municipal) (+).

Electricity was quick-coming for concentrated populations, as investor-owned utilities began to build transmission lines between their franchises, connecting larger towns such as Minneapolis, St. Paul, and Mankato. But sporadically, small generators and single distribution lines wove into the countryside, where few investor-owned utilities thought to build. In 1914, Stony Run Light and Power, maybe the first electric cooperative in the nation, strung a power line from the Granite Falls municipal plant, eventually supplying 50 families by 1921 (+). Federal agencies and local farmers tried to incentivize municipal and investor-owned utilities to generate rural power, but found these entities nonresponsive or antagonistic, especially as the Great Depression set in. In 1935, the federal government created the Rural Electrification Administration (REA) to create jobs and provide three percent-interest loans and other financing to spread electric cooperatives around the nation.

Rumors of the government condemning farms for the insolvency of the potential cooperative, or the hard-fought volunteerism conducted for $2 to $5 in per-person upfront fees, at first stunted the growth of electric cooperatives in Minnesota (Severson, 1962). Skeptics stood still, waiting for others to prove value, as county extension agents pestered them for easements to plant utility poles. Members faced additional hurdles, as the REA required fair wholesale power prices and minimum numbers of members per mile of line before it would approve loans. Private utilities expanded their lines where they wouldn't before, seemingly just realizing they were now in competition. And once the cooperative lines were energized and rates were established, new consumers often faced high bills. Despite it all, the cooperatives (often after consolidation of a few smaller co-ops) gained the economies-of-scale in members and sales, the governance, and the loans needed to exist.

The map of service territories experienced more consolidation, more municipalization, more vertical-integration, from the 1930s on, filling most corners of Minnesota with light. With the advent of generation and transmission providers to cooperative and municipal utilities in the 1950s, '60s, and '70s, these true-public utilities now owned their own power. Power plants grew in size, following national trends: among the largest was Sherburne County Generating Station in Becker, three coal-fired units owned by Northern States Power with more than two gigawatts in total capacity when it was finished in construction in 1987. Its third unit was partially owned by the Southern Minnesota Municipal Power Agency (SMMPA), a joint action agency, which owns generation assets to contractually supply some of the larger municipal utilities in the state.

Minnesota remained without a state utility commission and exclusive service territories until 1974 (+). It was one of the latest such regulatory bodies in the nation to come into existence. It regulated investor-owned utilities, while largely exempting cooperative and municipal utilities.

Northern States Power, in total, also built more than one gigawatt of nuclear power plants: one on Prairie Island, next to the Prairie Island Indian Community on the Mississippi River, and the other in Monticello. These plants became the reason for the state's first official renewable energy goals, as the state fretted in 1994 over what how to store nuclear waste in-lieu of a national storage site (+). Ultimately, after much consternation and suing, the state legislature approved 17 dry casks of storage and an additional storage site, with the stipulations that Northern States had to:

- Acquire 425 megawatts of wind power by the end of 2002;
- Acquire an additional 400 megawatts of wind, if the public utilities commission (PUC) found it necessary;
- Acquire 125 megawatts of biomass power;
- Place $500,000 per cask per year into a renewable development fund starting in 1999;
- Increase conservation spending; and
- Provide low-income discounted electricity rates

In 1999, Northern States Power became Xcel Energy, merging with the Public Service Company of Colorado and the Southwestern Service Company. In 2001, the state passed the Minnesota Renewable Energy Objective (REO), requiring electric utilities to make a "good faith effort" to obtain ten percent of their retail sales from eligible renewable energy resources by 2015, with a 0.5 percent carve-out for biomass. Xcel Energy, as the nuclear-owning utility in the state, was the only utility legally mandated to meet the ten percent standard.

After a 2004 law requiring the PUC to determine criteria for tracking utilities' "good faith effort[s]" on building voluntary renewable energy, thus establishing a verification and tracking system for renewable energy in Minnesota, 2007 saw an amendment to the statute, the Next Generation Energy Act (+). It established a firm mandate of a renewable portfolio standard, one of the first such policies that are now adopted in 29 states, Washington DC, and three US territories (+). Specifically, under the 2007 law, all Minnesota utilities providing retail power or selling power to distribution utilities had to acquire 25 percent of their energy from renewable sources by 2025. For all electric utilities "that owned a nuclear generating facility as of January 1, 2007,", the utility (Xcel Energy) had to obtain 30 percent of its retail sales from renewable energy by 2020.

As a result of these and past laws, no new coal or nuclear facilities can be built anymore in Minnesota. The 2007 Next Generation Energy Act also established non-binding goals for greenhouse gas (GHG) emissions reductions for 2015, 2025, and 2050: reductions of 15%, 30%, and 50% below 2005 levels by 2015, 2025, and 2050, respectively. Preliminary data suggests that the 2015 goals was not met (+).

Against the climb toward renewable and carbon-free energy, during the 1990s, several states, mostly those with higher electricity prices in the Northeast and West, moved to restructure their electricity markets (+). Minnesota remained free from the restructuring movement, joining many Midwestern and Southeastern states in keeping their customers from freely selecting their electric service provider. Prior to this restructuring movement, several reforms at the state and federal level have altered the strict monopoly role of utilities in regulated states (and altered relationships between customers and utilities in deregulated states). Notably the federal Public Utility Regulatory Policies Act (PURPA) of 1978 allowed for distributed energy resources and third-party owned generation facilities (qualifying facilities) to supply power, even in regulated states (+). Following PURPA, states have enacted a number of policies seen as critical for supporting or hindering electric generation not owned by monopoly utilities within regulated states, such as net energy metering and third-party ownership.

In Minnesota, state regulation came late for investor-owned utilities, but legislation for these utilities (most notably Xcel Energy) has been among the most progressive in the nation. By contrast, cooperative and municipal utilities largely maintain local self-government, typically by cooperative boards elected by member-owners or city-appointed commissions boards, respectively. Operating rules and policies vary tremendously outside of IOUs in Minnesota, with some non-IOUs seen as favorable to innovative new models to incorporate distributed energy resources, while others have chosen not established supporting policies. Effects of legislation centered on Xcel have been to seen to ripple out to these unregulated utilities, most notably to date in the renewable energy mandates from the state, which elected to include only these utilities generation and transmission suppliers under the mandate.

Appendix B: Beltrami Electric Cooperative

Overview

Beltrami Electric Cooperative (BEC) is a member-owned electric cooperative located in Bemidji, MN. It provides power to over 17,000 member-owners within a 3,000 square mile service area in northern Minnesota across six counties. The cooperative is guided by a board of nine directors elected by membership. BEC purchases electricity from Minnkota Power Cooperative, which is owned by 11 cooperatives. The headquarters for BEC is the site of their community solar array Northern Solar. The Northern Solar project "is a result of the cooperative member-owners expressing desire to have a local renewable energy option and their willingness to support the project" (+).

Stakeholders/Legislation

Northern Solar is available to members in Beltrami, Itasca, Koochiching, Clearwater, Hubbard, and Cass counties. The utility researched opportunities to create the Northern Solar project in-house without a third-party contractor. TenKsolar was contracted as the manufacturer. However, due to manufacturer financial issues, the warranty on the panels or the inverters disappeared after the utility agreed to contract with TenKsolar. The utility purchased additional panels and inverters to control for any damages or faulty future equipment. Footings for ground mounts and installation of the equipment was done by the utility.

Low-Medium-Income Opportunities

Customers are able to sell their subscription to another member or donate shares to another individual within the Beltrami Electric Cooperative service area (+). The contract also gives Beltrami the right to buy back shares. This encourages flexibility and short term adaptability, which favors LMI. However, the vast majority of subscribers are not low or middle income.

Rate Design

Members may purchase half panels or single panels (up to 6) for $1,295 per 450 kWh/yr panel ($647.50 for half panel). An easy pay financing model with 12, 24, or 36 month financing is available for a 6% interest rate. (+) The panel agreements are good for 20 years. Members are credited based on their portion of Northern Solar array production and are only credited if they have kWh usage. BEC projects a net zero cost after 20 years of production. A pay-as-you-go option is also available for subscribers who do not want to lock in a long-term contract. Subscribers are able to specify how many kWh/month they would like to subscribe to per month with a rate adder of $0.0503/kWh. That total is added to the monthly electric bill.

Outcome

60% is subscribed, as of August, 2017 (+).

Future

No plans to expand are in the works as almost half of the panels are still available for subscribers. The utility is interested in members to purchase the remaining panels and would entertain the possibility of removing the 6 panel cap to interested parties.

Conclusion

The Northern Solar project began producing electricity in August, 2017. As of February 25th, 15.3 MWh have been generated. (+)

Appendix C: Minnesota Power

Overview

Minnesota Power requested approval for a community solar program in September 2015 under claim 216B.05 (MPUC). Minnesota Power proposed to sell 25 year subscriptions at 1 kW for 1,040 subscriptions at a site in Wrenshall, Saint Louis County (1MW) and a site on company owned property on Arrowhead Road, in Duluth (40 kW). The proposal suggested U.S. Solar would be contracted to construct the gardens. The subscriptions could be obtained using one of three possible payment options. (+)

- Upfront $2,132.15 for a 1kW subscription
- Fixed monthly subscription fee of $15.62 for 1kW block, totaling $187.44 for one year and $4,686 after 25 years.
- Fixed $.1115/kWh

Subscribers may transfer their subscription to another eligible ratepayer or to Minnesota Power at any time, with 30 days notice (+). Subscribers who paid the up-front payment are reimbursed at a value computed by linear depreciation of their original payment, and other subscribers may unsubscribe at any time.

An caveat thrown into the proposal was a $.002/kWh payment to customers for S-REC which would be retained by Minnesota Power to use for compliance with Minnesota's Solar Energy Standard (stat. 216B.1691) (+) It appears Minnesota Power is motivated to construct this program to meet SES goal, which requires 10% of the 1.5% energy standard be met from pv devices nameplate of less than 20kW (216B.1691). There would be no explicit opportunity for LMI individuals. (+)

Costs would be met through customer subscription, or, if subscriptions are not fully distributed, funds would be recovered from ratepayers, excluding mining, paper mill, wood manufacturing.

Stakeholders

MPUC issued a notice shortly after commenting on Minnesota Power's intentions with this program, specifically asking for comments on the question, "what actions, if any, the Commission should take to encourage residential, low-income, and minority participation in [the] proposal?" (+). Comments followed by the Northland Coalition, which specifically addressed the MPUC about issues it had with Minnesota Power's proposal. Specifically, they were upset community solar was not actually a "community" involved process and was instead directed and controlled entirely by the utility (+). The Northland Coalition suggested benefits of community solar should go to the communities supporting the arrays. SunShare and US Renewable Energy Credit Exchange claim the S-REC credit is "unreasonably small" in light of market values. Fresh Energy suggested Minnesota Power perform a Value of Solar calculation or credit subscribers at their full retail rate. The three issues they detailed to remediate this concern are as follows:

- Fair playing field for all community solar gardens, including non-utility proposals. Ensure a transparent, clear and consistent pathway to solar garden participation
- Fair Pricing and compensation policy for renewable energy production
- Fair accounting for small scale solar

Legislation

In essence, this response claimed Minnesota Power would violate stat. 216B.05 - 1) Does not comply with CSG Statute and 2) Program fails to meet statutory standards of justice and reasonableness.

However, Minnesota Power was still granted their proposal, subject to modification. Minnesota Power was mandated to submit annual report. The utility was granted 3 non-utility solar gardens, up to 1 MW each. The Department concluded Minnesota Power is "not obligated to adhere to all of the requirements" of Stat. 216B.1641 and is free to counter propose, given that rates are just. Thus, the only public utility held accountable to this mandate is Xcel Energy. In absence of stat. 216B.1641, MPUC requests:

- Rate and cost-recovery methods
- Application of program subscriptions toward small-device SES compliance obligations
- Accessibility of solar gardens to outside developers and to customers
- Terms of the proposed customer contract

Rate Design

The MPUC mandated Minnesota Power's $.002/kWh S-REC be redirected to all non-SES exempt ratepayers, instead of subscriptions. MPUC also implemented (upon customer subscription termination) unpaid kWh credit balance be paid at the monthly average amount of the bill credit for the previous twelve months. Subscription price must also be adjusted to reflect competitive prices for Northern Minnesota. Ultimately, Minnesota Power was refused the SES requirement as the 1 MW and 40 kW sites were too large. Final rate designs are as follows: (+)

- Upfront $2,132.15 for a 1kW subscription
- Fixed monthly subscription fee of $15.62 for 1kW block, totaling $187.44 for one year and $4,686 after 25 years.
- Fixed $.1115/kWh

Outcome

There are 331 people on waiting list, as of February 25, 2018 (+) Those exempt from Solar Energy Standard costs (Docket No. E999/CI-13-542) are not eligible. (+)

A clause was added for non-residential. "The cost for a residential customer who typically uses about 750 kilowatt-hours a month and wants to replace their current energy with solar energy will range from about $81 for a customer that chooses a monthly subscription fee to about $95 a month for a customer that chooses a fixed charge per kilowatt-hour. Subscriptions will be offered in 1-kilowatt blocks and customers will be able to choose to purchase enough to cover all or a portion of their monthly electricity needs" (+).

In recent filings, Minnesota Power projects a bulk of REC strategy will be met with banked SREC and then slowly replaced by utility over the next 10 years (+). It's very unclear where those SRECs are banked from.

Appendix D: Rochester Public Utilities SolarChoice Program

Overview

The city of Rochester pledged to attain 100% renewable energy by 2031 (+). In order to help reach this goal, Rochester Public Utilities (RPU) is partnering with their parent joint-action agency, the Southern Minnesota Municipal Power Agency (SMMPA), to construct a 3 MW Community Solar Garden (CSG) in Princeton, MN. While this is about 135 miles away from Rochester, Princeton Utilities is a fellow member of SMMPA. Construction will be started as soon as RPU attains a 25% subscription rate. Until then, a recently built (July, 2017) 5 MW SMMPA CSG in Owatonna will be used.

Stakeholders/Legislation

RPU is installing a small 4 kW solar array at their headquarters to promote the CSG program. The power from the "billboard" solar array will be sold to SMMPA. The solar installer MC Power is giving a discount on the "billboard" array (RPU gets it at the price rate of a utility scale array), but the discount is invalidated if they don't meet the aforementioned subscription goal by the deadline.

Low-Medium-Income Opportunities

Currently there are no specific opportunities for LMI customers.

Rate Design

Subscriptions to the CSG are sold at $650 per panel, with maximum caps based on one's minimum electric bill. 1 panel corresponds to roughly 42 kWh/month. The application deadline was December 31, 2017. Participating customers would be reimbursed for their share of the power produced every month for 12 years (until 2030) via a kWh credit (same as retail rate) on their electric bill. The program is available to all RPU customers, with the first phase being residential. No contract mechanism allows customers to sell their subscriptions back to RPU, though they may transfer them to other RPU customers. (+)

Outcome

The program was announced to customers via a marketing campaign in June 2017, including utility bill inserts, TV, and radio ads. At the June RPU board meeting, several customers spoke out in favor of the CSG project. Several public info sessions were held over the summer, attracting hundreds of people. Six customers had signed up by end of June, and 12 by the end of July. At the August meeting however, there was pressure from a customer on RPU senior employees to help move the project along by signing up for subscriptions, "because people are not getting the message." As of October 2017, the garden was between 2-3% subscribed. (+)

Future

The program began on January 1, 2018, and construction will probably begin on the Princeton, MN solar garden around that time. After the 12-year program ends in 2030, which is around the time RPU plans on going 100% renewable, they might plan on separating from SMMPA, so the future of community solar in Rochester is uncertain after that time.

Appendix E: Leech Lake Band of Ojibwe Community Solar

Overview

The first integration of community solar with an energy assistance program to facilitate customer outreach, education, and enrollment in the United States was completed on the Leech Lake Band of Ojibwe Reservation in August 2017. The 200 kW project, with five 40 kW arrays, is expected to produce about 235 megawatt hours per year. (+)

Stakeholders

The Rural Renewable Energy Alliance (RREAL) developed, designed, and built this project at a cost of $887,000 with funding provided from a state-issued grant of $490,000 and the remaining funds coming from the following foundations: (+)

- The Minnesota Environmental and Natural Resources Trust Fund
- The Initiative Foundation
- The Bush Foundation
- The Headwaters Foundation
- The McKnight Foundation
- The Carolyn Foundation
- Shakopee Mdewakanton Sioux Community

Through a partnership with the Leech Lake Band of Ojibwe, the 200kW solar array built by RREAL will create revenue to supplement existing energy assistance financing. The additional revenue is expected to provide assistance to 100 additional homes (+).

Low-Medium-Income Opportunities

Last year, Leech Lake Energy Assistance helped pay off the energy bills of nearly 1,000 households in Beltrami, Cass, Hubbard, and Itasca Counties. The solar installations will power "an additional 100 homes" (+). As a result, participating customers will see a reduction in their utility bills, which will decrease their need for energy assistance support. This community solar structure targets low-income households specifically.

Rate Design

All of the $887,000 initial capital and labor cost was funded through a $490,000 state grant and donations from foundations. The reservation expects to generate $23,500 annually in revenue from the project. Some of the electricity is sold directly to tribal buildings and the rest is sold to local utilities through net metering. These revenues will be distributed to up to 100 households on the Leech Lake Reservation annually (+) .

Outcome

Project online as of August, 2017.

Appendix F: Stearns Electric Association (SolarWise) Program

Overview

Stearns Electric Association is a member-owned electric cooperative founded in 1937. With a headquarters in Melrose, MN and a branch office in St. Joseph, MN, it serves nearly 25,000 members in six Minnesota counties including Stearns, Todd, Morrison, Kandiyohi, Pope, and Douglas. The 20.5 kW capacity (50 panels at 410 watts each) SolarWise community solar array was opened in June, 2015, at the St. Joseph branch office. (+)

Stakeholders/Legislation

Great River Energy (GRE) is the wholesale power provider for Stearns Electric and was instrumental in the construction of the Community Solar array, paying for the construction costs. Stearns' membership had interest in solar before GRE approached the cooperatives.

TenKsolar was used as the manufacturer of the panel and equipment for this project. The company's financial problems negatively impacted this project due to delays caused by faulty inverters at the beginning of the project. (+)

Low-Medium-Income Opportunities

No specific carve-out exists for this program, however a financing option does exist. Putting $200 down, subscribers can finance for 24 months at a 5% interest rate. Subscribers can transfer panel output to another member of the Cooperative with the help of the utility, and a discounted buyout option is available. (+) To some extent, this addresses flexibility and short-term adaptability, but has little impact on LMI. If the Member moves out of Stearns' service area and is unable to transfer or donate this license to another Stearns member, the Member may, at the Member's option, accept Stearns' repurchase option.

Rate Design

Members may purchase 410 watt panels for $1,235 per panel with a limit of five panels or the equivalent of their annual electricity usage. Subscribers receive a bill credit for the value of the solar produced which is calculated by percentage of overall production. Panel agreements are good for 20 years. Other than the direct purchase option, a financing model of 24 months at a 5% interest rate is available. (+)

Outcome

34 of the 50 panels are subscribed as of November, 2017. There were roughly 10-15 subscribers when the system went online. "The cooperative deliberately started small with just 50 panels. But there is room to grow and add more if there is a demand for it" said Dave Gruenes, Stearns Electric District Manager, in 2015 (+).

Appendix G: Wright-Hennepin Electric Cooperative

Overview

Wright-Hennepin (WH) Cooperative Electric Association is a member owned non-profit electric utility founded in 1937. Headquartered in Rockford, MN, it operates to 50,000 electric accounts across the area. The first Wright-Hennepin community solar program was organized under the guidance of the Clean Energy Collective (CEC) (+). The utility now operates four projects (+). WH is recognized as having the first community solar program in the state (+).

Table 5. Wright-Hennepin Electric Cooperative Community Solar Projects (+)

Project	Location	Size	Participants	Status
1	WH Headquarters in Rockford, MN	171 panels 180 Watt panels 40 kW system	24 member participants	Online: Sept, 2012
2	WH Headquarters in Rockford, MN	72 panels 410 Watt panels 30 kW system	15 member participants	Online: July, 2014
3	WH Headquarters in Rockford, MN	500 panels 300 Watt panels 150 kW system	30 member participants	Online: Aug, 2016
4	WH's Willow substation in Medina, MN	540 panels 300 Watt panels 150 kW system	10 member participants	Online: early 2017

Stakeholders

Organizations in Rockford have taken interest in CSG and remain a strong supporter of furthering this Minnesota program, the initial program was driven by customer demand. WH's CSG program is available to Carver, Hennepin, Stearns and Wright County. Potential customers must be members of the Wright-Hennepin Cooperative Electric Association in order to participate.

Low-to-Medium Income Opportunities

Customers are able to sell their subscription to another member or donate shares to another individual (+). There are no additional LMI opportunities suggested, but it would seem the only cost burden is the initial subscription fee. Energy is cheaper under Wright-Hennepin's pay-as-you-go system (+).

Rate Design

Members may purchase shares of the (now at capacity) community solar project for $869 to reserve a panel (+). Individuals are then credited on their bill to compensate their personal energy production. The $4.83 per-watt cost for panels utilizes equipment from Minnesota's tenKsolar, which is now shut down. (+) Wright Hennepin's philosophy is to avoid cross-subsidization and political issues by having only the participating CSG subscribers bear the costs of the program, and they would then reap the long-term gains from the program.

CEC provides cooperatives with "RemoteMeter" software allowing them to handle the accounting portion of the community solar project (and a smartphone app to allow participants to track production). They also handle all of the project financing and development, alongside cooperative financing partners.

Outcome

The CEC projects solar projects will pay for themselves in roughly 20 years. Other calculations have shown 25 years. Comparatively, an individually owned solar panel will take 32 years or more to pay for itself. The Wright-Hennepin subscription warrants 50 years. WH broke ground on the development of CSS and had "growing pains" as a result.

Wright-Hennepin utilizes battery storage (Silent Power, Baxter, MN) for their first community solar energy distribution, which is uncommon among other project sites in Minnesota (9). Battery storage has been a powerful player for WH and is generating a lot of interest in their program. A benefit of the CSG program are 1) PV energy helps during peak usage periods and 2) most of WH's peak usage occurs in the evening when benefits of battery storage can be advantaged (+).

Future

There are currently no spots available for the 4 established projects, totaling nearly 400 kW-DC of generation. All solar panels are currently online (+). There are reservations available for spots in the next project, still to-be-announced. Contact and live production data is available (+).

Appendix H: Cooperative Energy Futures

Overview

Cooperative Energy Futures (CEF), started in 2009, is a Minnesota for-profit cooperative built around energy efficiency measures. Efforts aim to help reduce energy bills, reduce emissions, and increase efficiency. Their staff is consolidated to only 3 people; a general manager and solar operations and marketing director and a subscription manager. This team handles day to day and project management. There are another 4 people on the board of directors that handle higher level and co-op based decisions.

CEF requires CSS subscribers to become members first. Members pay a one-time fee of $25, with the option to invest in preferred shares (+), to participate in meetings, and vote for the Board of Directors. Memberships entitle members to discounts on products and workshops, access to programs and bulk-buys, and finder's fees on projects they bring to CEF (+). CEF also engages in profit-sharing from businesses participated in (+).

Subscription

CEF has 7 gardens in Minnesota, two of which are full (+). CSS subscriptions are sold in 200W block increments -- limited by up to 120% of yearly usage and 25 years.

Table 6. Cooperative Energy Future's Community Solar Projects

Project	Location	Size (kW)	Status	Details	Partners
Saint Cloud CSG	Sherburne County	1,357	now open for subscriptions	Open to residents, targeting the Park Plaza manufactured housing co-op	Community Power, Minnesota Interfaith Power & Light (MNIPL), Northcountry Cooperative Foundation (NCF)
Faribault CSG	Rice County	1,310	now open for subscriptions	Open to residents, targeting the Sunrise Villa manufactured housing co-op	n/a
Clarks Grove CSG	Freeborn County	1,357	now open for subscriptions	For residents of Hillcrest Community Cooperative; surrounding communities	Northcountry Cooperative Foundation
Waseca CSG	Waseca County	1,300	now open for subscriptions	Eligible to subscribe if within Waseca County; Blue Earth, Faribault, Freeborn, Le Sueur, Rice or Steele counties accepted as well	n/a
Pax Christi CSG	Eden Prairie	217	now open for subscription, right now, sign-up is limited to members of the congregation and low-income families affiliated with the congregation	40% subscribed by the church and the remaining 60% subscribed by congregation members and members of local low-income communities	Pax Christi Catholic Church
Shiloh Temple CSG	North Minneapolis -- Shiloh Temple	n/a (50 households)	Now open for subscription, prioritized to members of the congregation and local residents	CEF's first community solar garden	Minnesota Interfaith Power and Light, Shiloh Temple, Neighborhoods Organizing for Change, and Sierra Club Northstar, Minnesota Interfaith Power and Light
Edina CSG	7450 Metro Boulevard, Edina, Roof of the Edina Public Works Building	618 (60-80 households)	Subscriptions for the Edina community solar garden closed in early November 2016 as the garden has been filled by 66 Edina families.	Garden is full	n/a

CEF offers two options for subscription:

- Pay-as-you-go: Subscribers pay monthly for kilowatt-hours. Monthly payments are designed to be less than the credits received. Rates increase annually for the first few years, then remain flat for the life of the contract (+). In the Edina case study, CEF increased rates 2% annually for the first 8 years before becoming stagnant.
- Upfront: Pay upfront for the subscription. Estimates place 100% coverage for an average home to be $6,000-$12,000. Payments are handled in 3 installments (25% upon signing, 50% when construction begins, and 25% when the garden becomes operational). An additional $6 per year will be collected over the ensuing 25 years (+).

CEF acts as sole developer in conjunction with Xcel Energy. Their roles involve project design, garden construction, panel selection, application procedures with Xcel, property and liability insurance, and metering.

Outcomes

CEF sometimes engages in CSS projects in the 200-250 kW range, purposefully staying away from the 1 MW cap. They claim that while this lessens economies of scale, its viability rests in its higher REC rate and reduced construction and interconnection costs (+). CEF engages communities by proxy of geography, culture, or faith, often dictated by the site. Remaining subscriptions will be pulled from other community, if necessary. CEF prioritizes access to low- to moderate-income individuals and renters. They still accept 40% anchor subscribers but do not design projects that primarily benefit a small number of very large subscribers (+). CEF states that they secure "large energy users to back-up defaulting subscribers, reducing risk and creating access for low-income families" (+). In the Edina case study, subscribers are expected to save 7% immediately on their energy bills; forecasting expected energy price hikes, CEF projects a 25 year savings of 24% on a subscribers energy bill.

Seven core principles guide the CEF business model:

1. **Open, voluntary membership**: anyone can become a member of CEF
2. **Democratic member control**: all members can vote and run for the board - keeping CEF functions accountable to its members.
3. **Member economic participation**: Members own the business and its capital in proportion to the amount of business they do with it. CEF does not look to make more money than to cover development, operational, and administrative costs, along with operating reserves. Any excess funds are distributed to members proportionally to the size of their membership.
4. **Autonomy and independence**: Choice of partners such as contractors is done with member priorities in mind (low cost, local hiring, and social equity goals such as minority- and women-owned businesses).
5. **Education and Training**: Engage members to become advocates for clean energy. Weatherization training programs and energy efficiency bulk-buying provides members the ability to build on their energy savings, particularly targeting LMI members.
6. **Cooperation among co-ops**: Collaborate with and support the development of other cooperative CSG organizations.

7. **Concern for community**: Focus projects on broad community benefits. Working to develop job-training programs and partnerships with local governments, organizations, and financial institutions to benefit LMI community (not just members).

Characteristics of CSG installations:

- **Size/Scale**: Typically rooftop units in 200-250 kW range, but also 1MW ground-mounted systems. Not interested in grouping multiple MW around a single interconnection.
- **Type/Size of Subscribers**: Targets residential customers, but may have small commercial or organizational subscribers as well. Some sites may have larger subscribers (usually host organization) of up to 40% of capacity. CEF do not design projects to benefit large subscribers.
- **Financing**: CEF uses affordable tax equity sources to reduce overall subscriber costs by leveraging federal tax incentives and partnerships with community lending and alternative finance networks to enable pay-as-you-go subscriptions. Exploring options for community financing, allowing community members to invest in projects and share the financial benefits, above and beyond normal membership.
- **Subscription Methods**: Described in detail above.

CEF won $50,000 in seed funding from the U.S. Department of Energy to compete in the "Solar in Your Community Challenge," a prize competition that aims to expand solar electricity access to all Americans. This seed funding would go towards developed 4.42 MW of solar, including the 0.201 MW Shiloh Temple CSS project in North Minneapolis, a 1MW project outside Clarks Grove, MN serving residents of a manufactured housing park, and a 1MW parking garage canopy serving LMI residents in Minneapolis (in partnership with MNDOT) (±, ±).

Appendix I: Cash Flow Analysis

Standard Assumptions:

We have assumed the values of the following parameters while performing the calculations:

- Degradation factor for the PV panel is taken to be 0.5%
- Annual energy cost increase is considered to be 2.5%
- Discount rate for generating the cash flow is taken to be 5%

Contract Details and Underlying Assumptions:

- The utilities provide an option of subscription size of full panel/ half panel/ full house/ half house based on their project.
- The following forms of payment models are available to the subscribers:
    - The pay up-front model: where the subscriber is required to pay a one-time lump sum for subscribing to a garden.
    - The pay-as-you-go model: In this model the co-op charges a subscription tariff for every kWh of energy produced by the subscriber's portion of the array. For a

couple of contracts, the co-ops also charge a pay-as-you-go escalator which is a steady percentage increase in the payment to be made by the subscriber year on year.
    - The loan-lease model: In this model the subscriber makes a fixed monthly payment to the co-op as a fee for subscription. The payment duration for the loan-lease model can either be lasting for a couple of years or can even extend upto the lifetime of the contract. The loan-lease option for certain contracts also charges a fixed interest on the monthly payment to the subscribers.
- A contract typically has project details such as the nameplate capacity of the solar array, the subscription size, the crediting mechanism along with other payment information.
- It is interesting to note that for a single project for a co-op, the subscriber can opt for different payment options offered in the contract. We have assumed that a project operated by a co-op is 100% subscribed by a specific payment model. So the analysis has been carried out by taking each payment model one by one for the same project.
- For ease of understanding, we have done all the calculation in a per panel basis. However, to account to make the analysis from a common ground, the NPV has been calculated on a per W basis.

Calculating the Annual Energy Output from the Array:

- We used a standard 15% capacity factor for all projects, based on the spread of PV Watts Calculator's [pvwatts.nrel.gov/pvwatts.php] Minnesota locations for each project site.

Calculating the Crediting Rate:

- The retail rate has been calculated using the net revenue from sales and subtracting the fixed charge for every kWh of energy produced.
- Also, all the calculations for crediting rate has been done basis the data from 2017. So for accuracy, this value has been appropriately discounted to account for the rate escalation basis the year when the project was energized.

Calculating the Net Present Value of Subscription for Subscriber:

- We have considered the following gain/expenditure for the subscriber while formulating the final cash flow.
- According to the terms of the contract, the subscriber gets credited at NEM or ARR. Certain contracts do not offer any credits for subscription as well. So this amount is reflected in the cash flow as a gain to the customer.
- Next, according to the payment option the customer has opted for, he/ she will pay a subscription payment to the co-op.
- For certain contracts with an interest on loan-lease, the subscriber may be required to pay a fixed interest as well.

Sensitivity Analysis

We re-analyze the contracts described in Section 5.2 under alternate discount rates: 3%, 5%, and 7% as well as different annual retail electricity rate increase rates: 1%, 2.5%, and 4%.

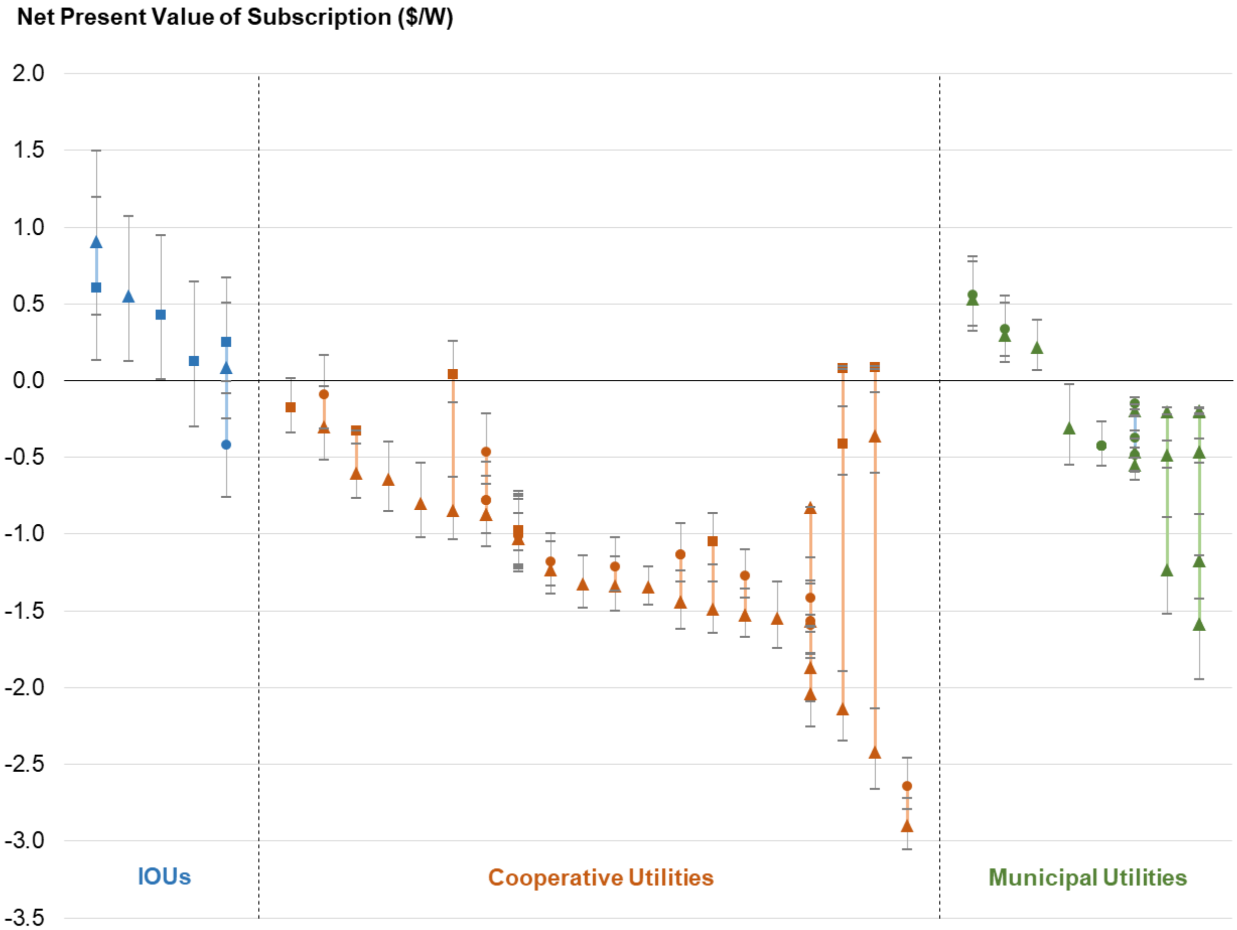

Figure 11. Sensitivity Analysis of Subscription NPV to Alternative Rate Escalators
Range of net present values for subscription contracts for annual rate escalation rates of 1%, 2.5% (colored dots), and 4%.

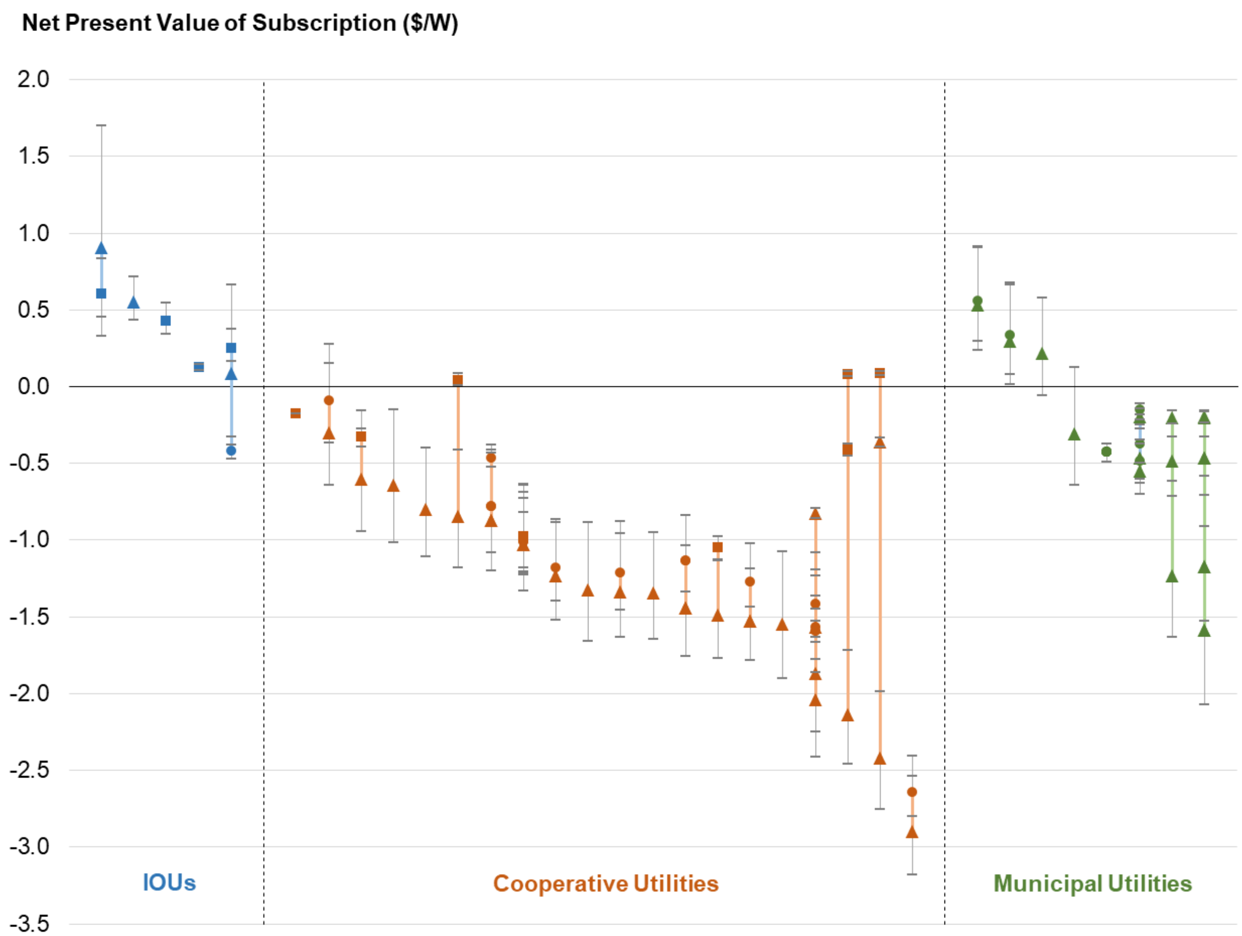

Figure 12. Sensitivity Analysis of Subscription NPV to Alternative Discount Rates
Range of net present values for subscription contracts for discount rates of 3%, 5% (colored dots), and 7%.