Utility Ownership of Rooftop Solar PV

AN EMERGING BUSINESS MODEL FOR MUNICIPAL UTILITIES

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The NC Clean Energy Technology Center

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Disclaimer

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I. OVERVIEW

Distributed solar is becoming increasingly common, with rapid growth taking rooftop photovoltaic (PV) systems from the exceptional towards the mainstream. More than 600,000 homes and businesses now have on-site solar in the U.S.,[1] with installed system costs falling by 60% between 1998 and 2013.[2] Residential solar in particular has seen substantial proliferation in recent years, growing by more than 50% annually in 2012, 2013, and 2014.[3]

With rising customer demand for distributed solar, municipal utilities around the country are investigating how they might be able to offer programs that benefit their customers, enhance grid resiliency, improve utility-customer relationships, comply with environmental regulations and clean energy policies, and address flat or declining revenues.

This guide provides an overview of the issues and opportunities that municipal utilities can expect to encounter in the development of utility-owned rooftop programs. It is not intended to act as an exhaustive guide to the design of such programs, but rather as an introduction to the model and the areas that municipal utilities can consider in the program design process. Furthermore, this guide should not be interpreted as advocating for or against utility-ownership of rooftop solar. Municipal utilities must weigh the overall benefits and costs, including opportunity costs, and must also consider how the program affects both participating and non-participating customers. The guide lays out important considerations and options for designing a utility-owned rooftop solar program, and does not prescribe any particular model (e.g., whether program costs are spread across all utility customers, covered entirely by fees to program participants, or through some other source).

Utility-owned Rooftop Solar

Distributed generation, such as rooftop solar, benefits the grid by supplying power near loads, which reduces line losses while simultaneously mitigating transmission and distribution capacity constraints when output aligns with peak demand. Additionally, when owned by the utility, these assets may be sited where they provide the greatest system benefits, and utilities can unlock advanced inverter functionality to derive ancillary services that enhance reliability and resilience while easing grid integration.

Utility-owned rooftop solar programs could be a proactive approach for municipal utilities to address growing customer demand for clean, distributed energy options. Programs sponsored by the utility provide customers with another solar option beyond owning a system, leasing a system, or entering into a third-party power purchase agreement (PPA), opening the solar market to those who

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[1] Kann, S., et al. (2015). *U.S. Solar Market Insight Report: 2014 Year in Review (Executive Summary)*. Retrieved from https://www.greentechmedia.com/research/ussmi

[2] Barbose, G., Weaver, S., and Darghouth, N. (2014, September). *Tracking the sun VII*. Retrieved from http://eetd.lbl.gov/sites/all/files/tracking_the_sun_vii_report.pdf

[3] Kann, S., et al. (2015). *U.S. Solar Market Insight Report: 2014 Year in Review (Executive Summary)*. Retrieved from https://www.greentechmedia.com/research/ussmi

could not afford those options or find it easier or preferable to go through their utility to acquire solar. This type of program can be complementary to other utility ownership models, including community solar programs and utility-scale solar installations (see Box 1).

This report provides an overview of cutting edge business models for utilities to maximize the benefits of rooftop solar generators, drawing on case studies from three ongoing utility programs: Arizona Public Service (APS), Tucson Electric Power (TEP), and CPS Energy.

Box 1: Differences between Utility-owned Rooftop Solar and other Utility Ownership Models

Community Solar

Community solar refers to a program where customers voluntarily purchase shares of a solar installation located in their community. Some programs base participation on the system's generating capacity while others use the plant's actual energy produced. In either case, customers participate on a voluntary basis and accrue benefits that are paid out over time as credits against their monthly bill. Utility ownership of community solar differs from utility ownership of rooftop solar in that the solar installation is physically located off-site, tends to be larger in size, and allows multiple customers to participate in each project.[4] Municipal utilities, such as the Sacramento Municipal Utility District, have demonstrated leadership in community solar by pioneering many of the first such programs across the country.[5]

Utility-Scale Solar

Utility-owned rooftop solar programs differ substantially from the large central solar energy projects that many utilities—including many municipal utilities—already own as part of the generation profile. These "utility-scale" projects[6] are more akin to conventional power plants than rooftop projects in terms of ownership, financing, and operation. To utility customers, these large projects are simply one among many utility generating plants from which they purchase their energy, rather than a system that is located on their roof and which they directly share the benefits of in some way.

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[4] Campbell, B., Chung, D., and Venegas, R. (20014, September). *Expanding solar access through utility-led community solar: Participation and design trends from leading U.S. programs.* Retrieved from http://www.solarelectricpower.org/media/214973/Community-Solar-Report-Executive-Summary-ver3.pdf

[5] SEPA. (December 2013). *Utility Community Solar Handbook: Understanding and Supporting Utility Program Development.* Retrieved from: http://www.solarelectricpower.org/media/71959/solarops-community-solar-handbook.pdf

[6] While there is no standardized size threshold or definition for the term, the Solar Energy Industries Association considers projects greater than 1 megawatt to be "utility-scale."

II. BENEFITS OF UTILITY-OWNED ROOFTOP SOLAR

Both large-scale and distributed solar projects can benefit municipal utility customers. Larger-scale projects typically offer a lower installed cost-per-Watt, and these projects are increasingly cost-competitive with traditional energy sources, making them an appealing option for many municipal utilities. However, a well-designed municipal utility-owned rooftop solar program can offer additional, unique benefits for both participating and non-participating customers, while also addressing specific customer demand for on-site solar options. In some circumstances, these additional benefits can outweigh the higher installed cost and make distributed solar options like utility-owned rooftop solar an attractive value proposition. By structuring a program to ensure that utility objectives are met, municipalities can improve the level of service they provide to customers while also strengthening the utility's grid and justifying program expenditures.

Benefits to Customers

Municipal utilities implementing utility-owned rooftop solar programs can offer customers the opportunity to save money on their electricity bills through a bill credit or fixed bill, go solar even if traditional financing options are otherwise not available, and enjoy participating in a program proliferating clean, distributed energy.

Cost Savings for Program Participants

Participating customers may be able to realize electricity cost savings relative to their normal monthly utility bill, and potentially relative to other solar options. Depending on the program design, participants may earn bill credits or other financial incentives from municipal utilities in exchange for allowing a solar installation to be located on their rooftops. The program can be financially attractive to customers if the utility is able to offer rooftop solar at an equal or lower cost than other providers, which could be possible due to several factors. First, municipal utilities, while lacking the tax liability to make use of federal tax incentives, can issue tax-exempt bonds, providing low-cost financing for a rooftop solar program.[7] Second, municipal utilities could also be eligible for low interest loans from the federal government or other sources.[8] Third, municipal utility investments do not need to earn high returns or profits to satisfy investors or business owners. Finally, municipal utilities could experience lower solar soft costs (such as a reduced cost of finding and enrolling participants in a solar program due to established customer relationships) than the solar market as a whole. While the total costs of a solar project are composed of many complex factors, and there are other factors that lower the costs for privately developed solar projects, these features of municipally

[7] U.S. Department of Energy. (2011, January). Select the appropriate financing mechanism. In *Solar powering your community: A guide for local governments* (2nd ed.). Retrieved from www.solaramericacommunities.energy.gov

[8] For example, some municipal utilities that serve rural areas could be eligible for the USDA Energy Efficiency and Conservation Loan Program (EECLP): http://www.rd.usda.gov/programs-services/energy-efficiency-and-conservation-loan-program

run rooftop solar programs could allow the municipal utilities to offer the solar program at a competitive cost to the private solar market.

Price Stability and Certainty

A utility-owned rooftop solar program offering a long-term contract can provide billing rate stability and bill savings for participants. One novel feature of Tucson Electric Power's (TEP's) program is that it provides customers a guaranteed fixed bill over 25 years, with the monthly bill based on past usage. This arrangement shields participating customers from potential future rate increases. In this respect, a municipal utility-owned rooftop solar program can provide customers with a hedge against the risk of rising energy costs.

Expanded Customer Choice

Programs sponsored by the utility provide customers with another solar option beyond owning a system, leasing a system, or entering into a third-party power purchase agreement (PPA), potentially opening the solar market to customers unable to access these options due to limited financing options or state legal barriers related to third-party solar ownership.[9] For example, a municipal utility may consider implementing a program targeting installations for low-income residential customers or renters who typically have fewer options for financing solar than other customer segments, which may help to accomplish the policy objectives of the utility or broader municipal government.

Customer Preferences

Customers are increasingly demonstrating a strong preference for on-site renewable energy options, so a municipal utility rooftop solar program could be one mechanism for actively addressing these changing preferences. Participating customers can take pride in having an on-site system that provides clean, locally-sourced, renewable energy to themselves or their community. Hosting a renewable energy system may be more appealing to some customers than participating in alternative programs like utility green tariffs or even community shared solar, as an on-site system is tangible, visible, and proximate. Furthermore, some customer participants may choose to enroll in a solar program to enjoy the "conspicuous conservation"[10] of having solar located on-site, which serves as a highly-visible signal to their peers and community of their support for clean power.[11] Finally, there is also evidence that the installation of a residential solar system increases the resale value of a home,[12] illustrating that a solar PV system is typically seen as a positive home feature.

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[9] Kollins, et al. (February 2010). *Solar PV Project Financing: Regulatory and Legslative Challenges for Third-Party PPA System Owners*. NREL. Retrieved from: http://www.nrel.gov/docs/fy10osti/46723.pdf

[10] White, R. D. (1978). Growth versus conservation: A Veblenian perspective. *Journal of economic issues*: 427-433.

[11] Dastrup, S. R., Graff Zivin, J., Costa, D. L. and Kahn, M. E. (2012) Understanding the Solar Home Price Premium: Electricity Generation and "Green" Social Status. European Economic Review. 56(5): 961-973.

[12] Adomatis, S., Jackson, T., Graff-Zivin, J., Thayer, M., Klise, G., and Wiser, R. (2015). *Selling into the sun: Price premium analysis of a multi-state dataset of solar homes* (No. LBNL-6942E). Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA (US).

Benefits to Municipal Utilities

Municipal utility-owned rooftop solar programs can serve as a proactive approach for municipal utilities to accomplish customer service, operational, and regulatory goals. While these programs can help meet the demand of specific customers, the advantages of strategically located and oriented renewable distributed generation on the grid can also benefit all customers and serve the public interest.

Meet Increasing Customer Demand for Solar

While providing safe, reliable, and low-cost power remains the primary function of every electric utility, customers are now demanding more from their utilities. The spread of rooftop solar is among a number of changing consumer preferences with respect to their energy consumption, with customers now demanding more energy choices, greater control over their energy consumption, more reliable power, and cleaner energy options. Municipal utility-owned rooftop solar is a proactive method of addressing this rising demand and retaining customers interested in on-site solar.

Improve the Management of the Electric Grid

Concerns that utilities hold regarding increased penetration of distributed PV include the safety, reliability, and integration of variable solar energy. By owning and operating distributed solar assets, the municipal utility can exercise greater control over portions of the solar generation profile and test and develop advanced grid technologies.

Grid Reliability

Municipal utility ownership of rooftop solar provides a utility a high degree of control over the location of distributed energy capacity additions. Utilities can strategically install rooftop solar at locations on the grid where distribution lines can accommodate or even benefit from additional distributed generation capacity, leveraging their knowledge about the local distribution network to provide benefits including reduced line losses, relieved congestion, or deferred grid investments.[13]

Peak Demand Management

Solar can be a useful and cost-effective technology to manage load under daytime peak demand. For utilities that currently rely on expensive peak generating plants to satisfy peak load or that purchase power through contracts with a demand charge component, the daytime generation that solar provides can reduce or shift peak load system-wide and provide cost savings to the utility. Most solar PV systems face to the south to maximize energy production over the course of the day, but west-facing solar panels can maximize generation from sunlight in the late afternoon to better coincide solar electricity generation with peak demand. Utilities which are particularly sensitive to the

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[13] Edge, R., Taylor, M., Enbar, N. and Rogers, L. *Utility strategies for influencing locational deployment of distributed solar.* Retrieved from https://www.solarelectricpower.org/media/224388/Locational-Deployment-Executive-Summary-Final-10-3-14.pdf

cost of peak load can consider maximizing this benefit by investing in west or southwest-facing solar systems.

Pilot Advanced Grid Technologies

A municipal utility could also test the use of advanced grid technologies that improve the integration of solar energy, such as "smart" inverters, advanced communication technologies, and energy storage devices (e.g., batteries).[14] Smart inverters can improve operational and maintenance diagnostics, share granular data with the utility on the performance of the solar PV system, and provide dynamic voltage regulation.[15] Energy storage devices can help smooth variable generation, provide a safety net for planning around imperfect weather forecasts, and improve power quality by regulating voltage fluctuations in areas of the grid with high PV penetration.[16] Storage can also help the utility align mismatched periods between peak power generation and peak electricity demand. A utility-ownership program can offer an opportunity to test advanced distributed energy and communications technologies and learn how they can optimize grid services. By implementing these programs in advance of higher levels of distributed generation, a municipal utility can better prepare for grid conditions it is likely to encounter in the future.

RPS Distributed Generation Compliance

Municipal utilities are subject to renewable portfolio standard (RPS) requirements in 19 states, of which 11 states have a solar or distributed generation carve-out.[17] To comply with the RPS, a utility must procure or generate renewable energy certificates (RECs) or solar renewable energy certificates (SRECs) equal to their compliance obligation. While utilities may purchase these certificates from system owners, and sometimes retain REC or SREC ownership when offering incentives to customers for solar equipment, a utility-led rooftop solar program offers another avenue for the utility to acquire RECs or SRECs. Even if the utility is not required to meet RPS requirements, it may be able to capture additional value from selling RECs or SRECs to regulated entities where such trades are allowed.

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[14] Kaufman, K. (2015, January 8). "Arizona's utility-owned solar programs: New price models, grid integration and collaboration." Retrieved from https://www.solarelectricpower.org/utility-solar-blog/2015/january/arizonas-utility-owned-solar-programs-new-price-models,-grid-integration-and-collaboration.aspx

[15] Zipp, K. (2014, January 10). "What is a smart inverter?" *Solar Power World*. Retrieved from http://www.solarpowerworldonline.com/2014/01/smart-solar-inverter/

[16] Energy Storage Association. (2015). "Renewable integration benefits". Retrieved from http://energystorage.org/energy-storage/energy-storage-benefits/benefit-categories/renewable-integration-benefits

[17] These states are CO, DE, MD, MI, MN, NY, OR, SC, UT (RPS goal), VT, and WA. Analysis of data from Database of State Incentives for Renewables and Efficiency. (2015, March). Retrieved from http://www.dsireusa.org

III. OPPORTUNITIES AND CHALLENGES FOR MUNICIPAL PROGRAMS

Municipal Utility Context

This section draws on lessons learned from utility-owned rooftop solar programs developed by investor-owned utilities to inform the development of programs developed by municipal utilities. Investor-owned utilities in Arizona have implemented the two operating residential utility-owned solar programs to date, though there are a few municipal and electric cooperative programs planned.[18] Municipal utilities interested in owning rooftop solar can evaluate whether their programs would be enabled or constrained by the regulatory and market contexts in which they operate.

Regulatory Context

Unlike investor-owned utilities, municipal utilities are not within the jurisdiction of public utility commissions. Instead, municipal utilities are subject to regulation by their respective city councils or boards, who are ultimately accountable to voters.[19] This allows municipal utilities to develop their own rate designs and programs for distributed generation if approved by their governing boards.

While municipal and investor-owned utilities face different regulatory contexts, many of the issues that have arisen regarding investor-owned utility solar programs will be relevant in the municipal context as well. Key issues seen in programs to date include:[20]

- *Concerns of unfair competitive advantage:* Rooftop solar initiatives supported directly by municipal utilities may enjoy several advantages over non-utility-sponsored programs, such as greater flexibility to offer financing options, information asymmetry about customer energy use and distribution grid mechanics, and superior financial stability. Among existing investor-owned utility programs, the potential ability of the utility to incorporate program costs into the rate base has also been raised by the solar industry as an unfair advantage.
- *Proprietary information:* Access to grid data and customer accounts gives utilities the ability to find and target the highest value installations. Utilities also have established relationships with most homes and businesses in a geographic area, which could create significant customer acquisition advantages.
- *Market development:* Solar markets in many parts of the country have become very competitive and currently offer a number of options to customers, including debt-financing, direct

[18] CPS Energy is in the process of designing a rooftop-solar program (see Appendix), and the Wright-Hennepin electric cooperative in Minnesota has plans to implement a program in the future. See Makyhoun, M., Edge, R., and Esch, N. (2015, May). *Utility solar market snapshot: Sustained growth in 2014*. Solar Electric Power Association.
[19] Regulatory Assistance Project. (2011, March). *Electricity Regulation in the U.S: A Guide.* Retrieved from http://www.raponline.org/docs/RAP_Lazar_ElectricityRegulationInTheUS_Guide_2011_03.pdf.
[20] Advanced Energy Economy. (2014, August 7). "STATE: Utility-Owned Rooftop Solar Could Be A Game Changer – But Is It Fair?," Retrieved from http://blog.aee.net/state-utility-owned-rooftop-solar-could-be-a-game-changer-but-is-it-fair.

ownership, and third-party ownership. Utilities could disrupt growth in these markets if the utility program undermines this competition.

While these concerns are valid, there is also reason to think that utility-owned solar programs would strengthen solar markets, particularly in areas with little solar penetration to date. An emerging body of research has shown the peer-effects of solar installations, demonstrating that individuals are more likely to install solar with every additional installation in the area. [21,22] Utility-owned solar programs could provide the jumpstart that is needed to develop local solar markets in new areas. Further, as the utility-owned solar projects described in case studies below all rely on local solar contractors to implement the program, utility-owned programs would contribute directly to the local installer community.

Given these and other issues related to investor-owned utility rooftop solar programs, no clear consensus has yet emerged across state public utility commissions regarding the public benefit of these types of programs.[23] As public utility commissions continue to discuss the merits of these programs, municipal utilities are in a unique position to offer rooftop solar programs at low cost to their customers due to their relative regulatory autonomy. Municipal utility staff should be prepared for debate and discussion around program offerings that mirror the debates currently seen in in investor-owned utility territories, even though the regulatory context may be different. Currently, the only example of a utility-owned rooftop solar program at a municipal utility is at CPS Energy in San Antonio, Texas (Case Study C).[24] There are many examples of other types of successful solar programs offered by publicly-owned utilities which have enabled customers to access solar energy, such as community solar programs.

Market Context

Municipal utilities interested in a utility-owned rooftop solar program must consider how it fits within its market context and its operational strategy. Among other factors, utilities can consider the following:

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[21] Graziano, M., and Gillingham, K. (2014). Spatial patterns of solar photovoltaic system adoption: the influence of neighbors and the built environment. *Journal of Economic Geography* (forthcoming).

[22] Bollinger, B and Gillingham, K. (2012). Peer effects in the diffusion of solar photovoltaic panels. *Marketing Science,* 910-912.

[23] Regulatory bodies in different states have treated the issue of rooftop solar owned by investor-owned utilities differently. The Arizona Corporation Commission (ACC) approved programs proposed by Arizona Public Service (APS) and Tucson Electric Power (TEP) (Case Studies A and B, respectively). Notably, these programs are small in size, designed to target specific customers, and have not yet been determined by the ACC to be a prudent cost (i.e., utilities do not yet have approval to spread program costs across their entire rate base). The program impacts will be evaluated during the next rate case for both utilities. In contrast, the New York Public Service Commission (PSC) recently adopted a regulatory policy framework as part of the state's Reforming the Energy Vision initiative that prohibits utilities from owning local generation assets to preserve market competition.[23] The PSC rules made exceptions for market segments that the current competitive landscape is not reaching, such as low-income and multi-family households.

[24] Makyhoun, M., Edge, R., and Esch, N. (2015, May). *Utility solar market snapshot: Sustained growth in 2014*. Solar Electric Power Association.

Generation Ownership

Does the utility own generation or purchase from other generators?

Developing solar projects of any type displaces energy that would otherwise need to be supplied by other sources. Although utility-owned rooftop solar programs only provide a small amount of a utility's total electricity needs, municipal utilities can benefit by considering such a program in the context of its generation ownership. Municipal utilities that generate all of their electricity will need to produce less from existing power plants or could avoid or delay the construction of additional plants. Utilities that purchase power—whether from wholesale market auctions or bilateral contracts—will need to purchase less power than they otherwise would without the developed solar resources. Municipal utilities should therefore carefully consider how a program fits within the terms of existing power supply contracts.

Uncommitted Demand

What portion of the utility's long-term generation needs are met by existing power plants or contract?

Utilities can consider their long-term demand and supply forecasts and consider what portion of future expected demand, if any, will not be met by power sources and supply contracts currently in place. Solar PV systems can be expected to last for at least 25 years, and often longer. If a utility does not have supply in place to meet all of its projected demand, utility-owned rooftop solar could be an option for increasing supply. If a utility has accounted for all of its generation needs, it can consider its options and flexibility in incorporating new resources.

Designing a Utility-Owned Solar Program

A thorough program design process can help a municipal utility identify a feasible program structure and successfully implement a rooftop solar program. Six main areas that utilities may wish to grant close attention to in the design process include:

1. Goal Setting & Stakeholder Outreach
2. Economics and Financing
3. Installer Selection
4. Site Identification and Solicitation
5. Contractual and Programmatic Details
6. Program Evaluation

Goal Setting & Stakeholder Outreach

The first step for municipalities in designing a utility-owned solar program is to understand what the primary program goals are and what design elements are key to achieving those goals. Several potential utility goals—and a program structure that could allow them to be reached—are listed in Table 1 below.

Table 1: Program Structures to Achieve Potential Utility Goals

Utility Goal	Considerations for Program Structure
Reduce peak net load	Orient PV panels to maximize on-peak production
Address distribution grid constraints	Target specific geographic area
Expand access to solar energy	Target low or moderate income customers
Meet customer demand for solar	Engage stakeholders to identify top priorities

Municipalities can set program goals and determine program structure in tandem with a stakeholder engagement process. Municipalities could consider stakeholder groups both within municipal government and in the broader community that could provide insight into the design of a program or would be affected by such a program. Table 2 includes a preliminary list of relevant stakeholders.

Table 2: Stakeholders for Utility-Owned Solar Programs

Internal Stakeholders	External Stakeholders
Elected leaders	Current power purchasing partners
Utility staff (resource planning, grid management, interconnection, etc.)	Solar installer community
Building department (permitting for solar systems)	Local environmental organizations and clean energy experts
Planning department (zoning and other issues)	General public
Municipal counsel and finance	

Among internal stakeholders, municipalities may consider consulting staff responsible for utility resource planning, interconnection, and legal affairs early in the process. Municipalities should also engage elected leaders or other decision-makers early on.

If a municipal utility has entered into long-term contracts for power, it may wish to discuss its solar program with its power purchasing counter-party to allow any issues to be identified and addressed early. If the utility is part of a municipal utility electricity buying group, it may also wish to inform its peer utilities of the program as well.

Through public meetings, social media campaigns, bill inserts, and other communication avenues, a municipal utility can engage local stakeholders to ensure it understands the preferences and concerns of groups within the community. Existing utility-owned solar programs, such as the TEP program described in a case study below, were met with some resistance when proposed due to concerns that the utility could monopolize the solar market or favor certain solar contractors to install solar systems under the program. Installers, solar advocates, and the general public may have strong opinions on how municipal utility-owned solar programs should be structured. Other members of the community may be especially motivated by how the program could open the solar market to customers that have traditionally not been able to afford rooftop solar. Incorporating public

feedback into the program design process early on can avoid unnecessary conflicts during program implementation.

Economics & Financing

Municipalities must consider whether a utility-owned solar program makes sense financially, in terms of both cost-effectiveness and project financing.

As noted previously, solar installations can yield several kinds of financial benefits for municipal utilities, including the avoided cost of generation or energy purchases, the avoided use of expensive peaking plants or reduced demand charges through peak shaving, and reduced constraints on distribution feeders. A number of jurisdictions have completed solar cost-benefit studies, which include additional factors such as reduced transmission and distribution losses, grid reliability benefits, avoided environmental compliance payments and other environmental benefits, fuel price hedging, and other factors.[25] Given these benefits, municipal utility staff may determine whether, where, and how much solar is cost-effective in their jurisdiction.

A significant consideration for municipal utilities will be how to finance the costs of the program, including upfront costs of solar systems. While investor-owned utilities implementing rooftop solar programs have financed the programs with capital from investors, municipal utilities do not have this option. Municipal utilities with an appetite for debt may use bonds (or federal loan programs such as the USDA's Energy Efficiency and Conservation Loan Program[26]) to initially pay for solar systems, with several options for repayment. Utilities may also opt to recover the costs of implementing such a program by increasing rates for all residential customers, though the utility and its customers may be resistant to such an increase. The utility may also wish to evaluate the fairness or equity of such a financing model, or if the program addresses overall community needs and desires. While the costs of Arizona Public Service's (APS's) and TEP's rooftop solar programs have not been incorporated into the their rate base, other types of investor-owned utility programs have incorporated generation assets into the utility's rate base and recovered them through customer bill payments.

Selecting an Installer

A municipal utility must also determine how to qualify or select contractors to install systems through the program. In existing utility-owned rooftop solar programs, utilities have competitively selected one or more installers through a bidding process. Selected contractors install all of the systems in the solar program.

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[25] National Renewable Energy Laboratory. (2015). "Value of Solar Tariffs." Retrieved from http://www.nrel.gov/tech_deployment/state_local_governments/basics_value-of-solar_tariffs.html

[26] United States Department of Agriculture. (2015). "Energy Efficiency and Conservation Loan Program." Retrieved from http://www.rd.usda.gov/programs-services/energy-efficiency-and-conservation-loan-program

Using a competitive process allows a municipal utility to work with the installer(s) that it feels will provide the best value through a highly transparent process. However, there are concerns that such an approach could harm the competitiveness of the residential solar market in some circumstances. For example, installers hired under the transparent bid process then enjoy market access that non-bid-winning installers do not. This concern has also arisen in some group purchasing programs (e.g., Solarize). Utilities could look to best practices from those campaigns to ensure a bidding process that addresses the concerns of smaller installers.

Another possible approach to installer selection could be to structure the program as a standard offer to qualified installers. In this approach, a utility would offer a fixed payment to any installer that is able to develop a system that satisfies the utility's stated criteria. To ensure quality projects, the utility would establish criteria regarding both the contractors that are able to participate in the standard offer program (based on previous experience, relevant licenses and certifications, and so on) and the types of projects that would be acceptable (such as size or geographic limitations). This approach has the advantage of allowing multiple installers to participate in the program. One drawback is that the utility may not be able to work as closely and directly with installers than if they had selected a single contractor.

Municipalities could determine which installer partnership pathway is right for them through the stakeholder engagement process. Particular groups to confer with might be local installers and solar advocates about their preferences regarding market competition, and staff responsible for utility interconnection and municipal permitting about their concerns regarding installation quality. Utility staff may also wish to consult municipal counsel regarding the requirements for procurement, which vary from state to state.

Site Identification

The goal-setting process can help municipal utilities determine what types of projects they would like to solicit. Municipal utilities may, for example, determine that size limitations are appropriate, that they would like to encourage either south-facing systems that maximize solar production or west-facing systems that reduce peak load requirements for utilities with late-afternoon system peaks, or that they would like to incentivize projects in specific areas to mitigate or avoid distribution grid constraints.

Municipal utilities can consider collecting and publishing information on their website to aid in site identification. If participation will be encouraged or discouraged in certain geographic areas, utilities could publish maps that clearly note where those areas are. For example, New York utilities publish Strategic Location Maps[27] that designate areas where PV would be effective in mitigating grid constraints, and both the Sacramento Municipal Utility District[28] and the Hawaiian Electric

[27] New York State NY-Sun Initiative. (2015). "Forms/Manuals/Tools." Retrieved from http://ny-sun.ny.gov/For-Installers/Forms-Manuals-Tools

[28] Sacramento Municipal Utility District. (2015). Interconnection Information. Retrieved from https://www.smud.org/en/business/customer-service/rates-requirements-interconnection/documents/InterconnectionMap.pdf

Company[29] provide maps of the areas where existing PV penetration would enable or constrain the potential for further development. Utilities may also wish to invest in site identification tools such as the Cambridge Solar Map,[30] which helps residents and installers understand which homes receive adequate sunlight to install a solar system.

Contractual & Programmatic Details to Consider

Municipal utilities have many contractual and programmatic details to consider before implementing a rooftop solar program. Several of these are described below.

Compensation Structure

Utilities have three primary options in how to structure the financial arrangement with host customers:

1. The first, used by APS, is to pay customers a flat monthly fee for hosting a solar system. This is likely the simplest approach that a utility could take.
2. The second, offered by TEP, is to charge customers a fixed fee for energy based on their average consumption before installing solar, allowing them to save money on future rate increases. This design offers a protection against revenue erosion to the utility, as revenue from solar hosts is locked-in. However, as this model provides no immediate cost savings to hosts, it may be a less popular option for customers.
3. A third option would be to offer payments to customers that vary based on system size, site location or orientation, or production. Offering higher payments to customers who can host a system that produces greater value to the utility would be one method of shaping program participation to best suit the utility's needs.

In addition to the determining a mechanism for compensating customers, utilities must determine the overall value of payments to customers. For example, program participation benefits can be calculated as equal to the value of a solar project to the utility, as comparable to average solar savings with a customer or third-party owned system, or as the minimum value the utility anticipates would incentivize customers to join the program. In one example seen thus far, APS noted in a filing to the ACC that its distributed solar program will be approximately at cost-parity for net metering.

System Maintenance

Solar PV systems require little maintenance but may require occasional work such as minor panel cleaning, component replacement (particularly the inverter), and repairs in the event of system malfunction. Solar PV operations and maintenance has been estimated to cost roughly $20 per kW per year.[31] Generally, this will be the responsibility of the utility as the system owner. The utility can

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[29] Hawaii Electric Light Company. (2015). Address Search Tool. Retrieved from http://www.hawaiianelectric.com/portal/site/heco/lvmsearch

[30] Mapdwell. (2015). Solar System Cambridge, MA. Retrieved from http://www.mapdwell.com/en/cambridge

[31] National Renewable Energy Laboratory (2013, August). Distributed Generation Renewable Energy Estimate of Costs. Retrieved from http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html

consider how to establish a process for maintaining the systems over their lifetime. If the utility prefers not to maintain systems with its own staff, it could require participating installers to be responsible for system maintenance or could reach a separate agreement with a contractor specifically for the purpose of providing this service. Other considerations, such as roof replacement during the life of the system, can also be built into the program. APS will cover the cost of system removal for one roof replacement over the 20-year system life. Similar models can be implemented for other expected maintenance costs, such as inverter replacement.

System Liability

The utility may wish to consider and clearly articulate any liability, warranty, and insurance issues for customers hosting the system. Residential rooftop PV systems are typically covered under standard homeowner's insurance.[32] However, as described above, PV system performance will likely be the responsibility of the municipal utility in a utility-owned PV rooftop program, so customers will want to know if they will be liable for any equipment failures, replacement costs, or unforeseen damage to their own property attributable to hosting the system.

Decommissioning

Municipal utilities can also consider how to manage decommissioning at the end of the project's lifetime. Utilities may wish to reserve funding for eventual system decommissioning. A utility may choose to structure installer partnerships in a manner that gives the installer this responsibility, in which case the utility could ensure that the installer has a decommissioning bond in place to fund system removal should the installer not be in business at the end of the contract term.

Metering

A municipal utility can consider how it would prefer to meter installations in the solar program in conjunction with how customers are compensated for participating in the program. Systems could be installed "behind the meter," in which case the existing utility meter would only capture a home's net consumption. Alternatively, systems could be metered using separate production meters that allow utilities to separately track home energy consumption and solar production.

The decision of how to meter a system is tied to the compensation structure that utility decides on. If utilities choose to offer a per-kWh payment to host customers, they will have to install a separate meter and account for consumption and generation separately. Regardless of the compensation structure used, utilities may wish to track system performance for quality assurance and grid management reasons.

Distribution Planning

Since the municipal utility's primary obligation to its customers is to provide safe and reliable electric service, a distributed solar program could enhance the utility's ability to "keep the lights on." Utility managers can therefore include elements such as strategic siting and the incorporation of

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[32] Speer, B., Mendelsohn, M., and Cory, K. (2010, February). "Insuring Solar Photovoltaics: Challenges and Possible Solutions." Retrieved from http://www.nrel.gov/docs/fy10osti/46932.pdf

complementary grid enhancement technologies. Municipal utilities could identify areas where distributed generation capacity would provide a benefit to the grid, as well as areas where additional capacity may present reliability issues, and incorporate these findings into their rooftop solar deployment plan.

Solar can be an effective tool in mitigating distribution constraints on the electric grid by reducing feeder and transformer load in addition to line losses. Municipal utilities may find it useful to develop distributed resources on distribution feeders that are subject to constraints, mitigating the amount of energy that must be moved to these areas during peak hours and thereby avoiding the need to upgrade infrastructure. Distributed generation requires less power to be transported through constrained areas of the grid, particularly during peak periods. For example, in Rhode Island, National Grid has implemented a (customer-owned) residential solar program that targets solar development in particularly constrained areas of the electric grid.[33] In New York, large solar projects located in constrained Strategic Load Zones receive a special bonus incentive for mitigating these constraints.[34]

On the other hand, high levels of solar penetration on particular areas of the distribution network can also be a stress on the grid. In several states with robust solar markets, utility interconnection standards place limits on how much solar can be put into place on a particular distribution line before requiring a detailed engineering study that determines whether grid upgrades are needed. In California, for example, a solar installation that would cause cumulative installed solar capacity on a distribution line section to exceed 15% of that line section's peak load is subject to detailed engineering review.[35] However, in Hawaii, where one-in-nine residences have solar[36] and installed solar exceeds 50% of peak load on a number of distribution circuits,[37] Hawaiian Electric recently announced plans to allow further solar development with the assistance of advanced inverter technologies that mitigate grid reliability concerns.[38]

As utilities consider how to integrate solar into their distribution grid, they can identify areas of the grid network that would benefit from the addition of solar resources as well as those where more distributed solar installations might not be appropriate, incorporating these considerations into the structure of their program.

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[33] Solarize Rhode Island (2014, November 12). Solarize Tiverton Solar Installer Request for Proposals. Retrieved from http://www.purchasing.ri.gov/RIVIP/ExternalBids/QuasiPublicAgencies/RIComCorpBids/RFP-2166.pdf

[34] New York State NY-Sun Initiative. (2015). "Forms/Manuals/Tools." Retrieved from http://ny-sun.ny.gov/For-Installers/Forms-Manuals-Tools

[35] See, for example, Southern California Edison's Rule 21 Interconnection Tariff: https://www.sce.com/NR/sc3/tm2/pdf/Rule21_1.pdf

[36] Wesoff, Eric. (2015, April 1). "Hawaii's Utility Is Approving a Backlog of More than 3,000 Solar Installations." GreentechSolar. Retrieved from http://www.greentechmedia.com/articles/read/Hawaiis-Utility-is-Approving-a-Backlog-of-More-Than-3000-Solar-Installati

[37] Hawaii Electric Light Company. (2015). Address Search Tool. Retrieved from http://www.hawaiianelectric.com/portal/site/heco/lvmsearch

[38] Wesoff, Eric. (2015, April 1). "Hawaii's Utility Is Approving a Backlog of More than 3,000 Solar Installations." GreentechSolar. Retrieved from http://www.greentechmedia.com/articles/read/Hawaiis-Utility-is-Approving-a-Backlog-of-More-Than-3000-Solar-Installati

Interconnection Access

The utility may also want to examine its interconnection policies for non-utility owned solar during this process. By ensuring the policies are clear and specifying that the interconnection rules do not provide preferential treatment for utility-owned generation over third-party owned generation, the utility may be able to alleviate some industry concerns over fair competition.

Many of these objections may be mitigated or avoided by adopting industry best practices regarding interconnection, such as establishing a tiered system that differentiates small (less than 10-15 kW) and large systems and adopting a simple, streamlined application for qualified small projects. A fuller list of interconnection best practices is available from Vote Solar's *Freeing the Grid* resource center,[39] and a model set of interconnection guidelines is available from the Interstate Renewable Energy Council.[40]

Evaluation and assessment of program

Before implementation, a municipal utility can identify key metrics that can be used to evaluate the program's outcomes. Once the solar program is operational, a municipal utility can collect data on important measures and evaluate the degree to which the program is effectively meeting the goals it identified during the program design phase. If the program is falling short of the expectations of either the utility or key stakeholders, the utility may wish to consider undergoing another round of stakeholder outreach and goal setting to determine if it should continue to offer a utility-owned rooftop solar program, and if so, how the program can be revised to achieve its desired outcome(s).

[39] http://freeingthegrid.org/#education-center/best-practices/
[40] http://www.irecusa.org/model-interconnection-procedures/

IV. APPENDIX: CASE STUDIES

Arizona's Renewable Energy Standard and Tariff (REST) requires investor-owned utilities to generate 15% of their electricity from renewable energy sources by 2025.[41] In 2014, both Arizona Public Service Corporation (APS) and Tucson Electric Power (TEP) filed their REST implementation plans for 2015 with the Arizona Corporation Commission (ACC). These plans outline how each utility intends to meet its annual obligations. Both utilities extended funding for existing programs and proposed utility-owned distributed solar as a new strategy to meet a portion of their targets.[42]

These Arizona programs are the first two case studies highlighted in this Appendix; the third is a municipal utility in San Antonio, Texas (CPS Energy).

Case Study A: APS Residential Rooftop Solar Program

The ACC approved a revised[43] $28.5 million, 10 MW utility-owned distributed solar program for APS to meet its REST obligations.[44] APS proposed that customers in the distributed solar program would receive a non-transferrable monthly bill credit of $30 for use of their roof space while APS would own and maintain a system on the host site. The Solar Partner program is designed to serve approximately 1,500 customers. In comparison, APS currently has over 1 million customers in its territory. APS estimated installed costs of $2.85-$3.50/W in its proposal to the ACC.[45]

APS emphasized several programmatic elements that a utility-owned program could provide in its comments to the ACC. Systems could be oriented westward to assist with peak demand, and marketing could be targeted towards areas of need on the grid and lower-income households. APS also intends to use advanced inverters and utilize the program's results for research. The impact of the program will be addressed in the next rate case. As part of the approval process, APS confirmed that third-party-owned systems will continue to be fairly interconnected.[46]

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[41] Arizona Corporation Commission. (2015). *Renewable Energy Standard and Tariff*, accessed April 9, 2015, http://www.azcc.gov/divisions/utilities/electric/environmental.asp.
[42] Trabish, Herman K. (2015, January 7). "Arizona's Utility-Owned Solar Programs: The New Business Models Utilities Are Looking For?," *Utility Dive*. Retrieved from http://www.utilitydive.com/news/arizonas-utility-owned-solar-programs-the-new-business-models-utilities-a/348331/.
[43] APS initially submitted a proposal for 20 MW from a single solar installation or distributed installations. However, since there was already substantial third-party activity in APS' territory, it was likely that APS would meet its REST target without the additional 10 MW. The ACC also had concerns about the cost of a 20MW program.
[44] Arizona Corporation Commission (2014, December 31). "In the Matter of Arizona Public Service Company for Approval of Its 2015 Renewable Energy Standard Implementation Plan for Reset of Renewable Energy Adjuster." Docket No. E-01345A-13-0140. Retrieved from http://images.edocket.azcc.gov/docketpdf/0000159166.pdf.
[45] Arizona Corporation Commission (2014, December 31). "In the Matter of Arizona Public Service Company for Approval of Its 2015 Renewable Energy Standard Implementation Plan for Reset of Renewable Energy Adjuster." Docket No. E-01345A-13-0140. Retrieved from http://images.edocket.azcc.gov/docketpdf/0000159166.pdf.
[46] Arizona Corporation Commission. (2014, November 4). "Arizona Public Service Company for Approval of Its 2015 Renewable Energy Standard Implementation for Reset of Renewable Energy Adjustor. Docket No. E-01345A-14-0250. Retrieved from http://images.edocket.azcc.gov/docketpdf/0000157661.pdf.

APS launched the Solar Partner program in 2015 and intends to complete all of the installations by the end of the year. The program uses a rolling RFP process with three solicitations for local solar contractors to install and maintain systems of 4, 6, or 8 kW during the program. The average system size in Arizona is approximately 7 kW; thus, most systems will likely be at the top of the range. Bill credits will be administered internally by APS.[47]

The Solar Partner program will maintain the system throughout its useful life, including removal of the system for a roof replacement. Systems can be decommissioned if a future homeowner wants to opt-out of the program with appropriate notice. Sites for the program are selected based on a series of factors including shading, home orientation, available roof space, and feeder need at the host's location. Customer interest in the program has been high, though final participation numbers will not be available until the third and final RFP solicitation is complete.

Case Study B: TEP Residential Solar Program

As part of its REST implementation plan, TEP also proposed a utility-owned residential solar program, but components of its design substantially differ from the APS proposal. Prior to the 2014 proposal, TEP had a similar program for commercial roofs called the Bright Roofs program, which was discontinued due to limited interest. In recent years, residential solar installations in TEP's territory have increased significantly. In 2014, TEP proposed the Residential Solar Program,[48] a pilot residential rooftop solar program of 3.5 MW. TEP proposed spending up to $10 million dollars on the program in 2015 with an estimated installed cost of $2.85-3.00/W.

TEP's program requires customers to pay an initial $250 enrollment fee, after which the customer will receive a system sized for their electricity usage and have a fixed monthly bill equivalent to their current average bill. For a typical TEP customer, this amount is approximately $93 before taxes. The utility will install, operate, and maintain the system through a network of competitively contracted providers. Customers have the option to buy the system or opt-out of the program for a fee if home ownership transfers. Like APS, TEP also intends to target high-value installations and integrate new inverter technologies into its program.

Program participants are charged the equivalent of the average bill for a typical TEP customer. The difference in fees above the required customer charge and any remaining fixed costs to serve residential customers offsets the cost of the program.

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[47] Interview with Arizona Public Service Commission Staff. Phone. (April 16, 2015.)

[48] Arizona Corporation Commission. (2014, December 31). "In the Matter of the Application of Tucson Electric Power Company for Approval of Its 2015 Renewable Energy Standard Implementation Plan.." Docket No. E-01933A-14-0248. Retrieved from https://www.tep.com/doc/renewable/ACCOrder-TEP_2015_RES_Plan.pdf.

Table A1- Recreated from TEP's Proposal to the ACC

Bill component	Typical Existing Customer	NEM Customer- Net Zero	Utility-Owned Solar Program Participant
Customer Charge	$10.00	$10.00	
Remaining Fixed Costs	$30.80		
Delivery Margin	$20.20		
Fuel	$32.00		
Monthly Fee			$93.00
Total	$93.00	$10.00	$93.00

The fixed monthly fee for program participants is subject to change if the customer's monthly consumption increases or decreases by over 15%. The ACC also is requiring TEP to notify customers that the program is being offered on a pilot basis and that rates or the program may change. TEP did not propose using existing REST surcharges to recover costs for the program.

Some stakeholders objected to TEP's ownership of distributed assets. The ACC disagreed and stated that TEP did not need commission approval to build or site new generating assets. It also noted that the small size of the pilot program and the program's budget would not likely have a large impact given the large size of TEP's territory. The program's effectiveness will be considered in the next rate case. The Residential Utility Consumer Office, which represents the interests of residential ratepayers, was supportive of the program providing customers with additional choices to go solar, as long as TEP's program remains competitive with net-metered systems and allows a level playing field for third parties to compete.[49]

TEP expects to launch the program in the summer of 2015 for approximately 500-600 customers and plans to complete the installations by the end of the year. It is currently accepting program registrations from interested customers.[50]

Case Study C: CPS Energy Rooftop Solar Project

CPS Energy, a municipal utility in San Antonio, TX with approximately 740,000 electric customers, is in the process of launching a utility-managed rooftop solar pilot program that will begin enrolling customers by May 31, 2015. CPS issued a request for proposals (RFP) due March 6 from companies

[49] Arizona Corporation Commission. (October 17, 2014). "In the Matter of the Application of Tucson Electric Power for Approval of Its 2015 Renewable Energy Standard Implementation Plan- RUCO's Comments." Docket No. E-01933A-14-0248. Retrieved from http://images.edocket.azcc.gov/docketpdf/0000156790.pdf.

[50] Arizona Corporation Commission, Utilities Division (2014, November 4). "Arizona Public Service Company for Approval of Its 2015 Renewable Energy Standard Implementation for Reset of Renewable Energy Adjustor." Docket No. E-01345A-14-0250. Retrieved from http://images.edocket.azcc.gov/docketpdf/0000157661.pdf.

to install and maintain customer-sited PV systems. CPS sought proposals for a 1 megawatt (MW) aggregate output but would also consider proposals for 5 MW or 10 MW. As written in the RFP, developers will be responsible for marketing, recruitment, finance, installation and maintenance, alleviating administrative and program burdens for the utility itself.

CPS has not finalized or released the full program details yet, but intends to enter into power purchase agreements (PPAs) with the solar provider chosen through the RFP process. In this way, the CPS program differs from the TEP and APS programs, where the utilities themselves own the solar assets. Such a PPA arrangement may be more beneficial to a municipal utility, which cannot take advantage of tax credits that result from placing solar assets in service. By entering into a buy-all, sell-all agreement with the solar developers, the utility will still receive reliable revenues from customers, unlike net-metered customers who may zero out the usage (per-kWh) portion of their bills during some months. The utility will also be able to negotiate the price it pays for the solar energy, which is likely to be closer to wholesale electricity rates and below the retail rate credited to net metering customers. In the RFP, CPS stated it will retain all RECs generated under the program.

Partner installer(s) will benefit from a guaranteed revenue stream from CPS and direct access to a new market segment. Customers who participate in the program will see a financial benefit from participation as well, most likely in the form of a monthly bill credit or payment in exchange for use of the customer's roof. Utility leadership also described the intent of the program as providing access to solar for customers that have typically not been able to participate in the solar market, and sees the program as an exciting and desirable offering for its customers. So far, the utility has received a high level of interest from customers, including many who have looked into purchasing their own PV system but were not able to afford the upfront costs.[51] One criteria of the RFP is to see creative marketing plans from developers in order to reach high participation levels in neighborhoods that currently have relatively few installations, better aligning customer interest and actual solar adoption.

[51] Flahive, P. (2015, March 11). The source: CPS Energy wants to rent your roof. *Texas Public Radio.* Retrieved from http://tpr.org/post/source-cps-energy-wants-rent-your-roof