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Design choices and equity implications of community shared solar☆

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ABSTRACT

What is the best way to deploy solar energy to maximize clean energy growth while equitably sharing benefits? A promising model is community shared solar, which enables energy consumers to purchase shares of electricity generated in an offsite project. Noting how different states and utilities have approached program design, we explore how design decisions affect access to solar and the equity of cost and benefit sharing. We conclude with a set of questions for future research.

1. Introduction

The challenges associated with broadening access to technology and equitably distributing costs and benefits in the transition to sustainability is a growing area of scholarship (Anadon et al., 2016). Within this context, the rapid deployment of solar energy is seen as a key strategy to mitigate climate change and reduce other environmental impacts of energy use (IEA, 2016). In the United States, solar energy adoption is growing rapidly, but as of 2015, solar comprised less than 1% of national electricity generation (EIA, 2017). While the hardware costs of solar have dropped considerably in the past decades, large-scale solar deployment presents a significant financing challenge, as the majority of lifetime costs associated with solar deployment are upfront costs incurred at the time of construction. As a result, innovation in "finance and business solutions to expand access to capital" is a major focus of public policies to address the non-hardware costs[1] of installing solar power (U.S. Department of Energy, n.d.).

One promising approach to addressing solar energy's financing challenges is community shared solar (CSS) programs.[2] CSS programs are now mandated by legislative policies in at least 15 states (and the District of Columbia) and have been voluntarily adopted by an increasing number of electric utilities. Traditionally, solar deployment has required either centralized planning for large, utility-scale project development or for energy customers to own or finance single solar projects located on their own property. In contrast to traditional models, CSS programs allow multiple electricity consumers, often in close geographic proximity, to collectively finance an offsite, centralized solar project by purchasing shares or subscriptions to power generated by the project. Participants who finance the development of a CSS project receive compensation for electricity generated by their

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[1] The U.S. Department of Energy estimates that the non-hardware costs, or "soft" costs, comprise 64% of the total installation cost of a new solar power system (U.S. Department of Energy, n.d.).

[2] CSS programs are distinct from, but share several similarities with, green pricing programs. Green pricing programs allow electricity consumers to pay a premium on their electricity bills that the utility then allocates toward additional renewable energy investment. Both green pricing and CSS schemes allow utility customers to participate in the financing landscape for renewable energy development, and both have schemes that aim to allow customers to claim agency for the additional deployment of renewable energy (although this varies across different programs). CSS programs differ from green pricing programs in that CSS projects are typically developed and owned by third-party entities, including in some cases the subscribers themselves. CSS programs also differ from green pricing programs in that subscribers receive returns for their participation, with returns tied to specific projects and capacity shares of CSS projects. In contrast, green pricing programs are typically tied to unspecified renewable generation (but may specify the general type of generation, e.g. "wind energy") and do not yield returns to participants.

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share in the project, typically through so-called "virtual net metering" (VNM) schemes. VNM allows subscribers to receive economic returns for electricity sold to a utility generated from the share of the solar project to which they are subscribed.

CSS programs are generally supported for their potential to increase the rate of solar deployment and expand opportunities to finance solar energy more affordably (Chwastyk and Sterling, 2015; National Renewable Energy Laboratory, 2014). First, relative to rooftop installations, CSS projects can lower average costs of solar energy by capturing economies of scale and by targeting more desirable project sites (National Renewable Energy Laboratory, 2014). Second, CSS programs may be made inclusive to customers who may not otherwise be able to access solar, creating an opportunity to address existing inequities in the energy system. Third, because they pool together many consumers, CSS programs are amenable to affordable finance models, thereby creating the potential to address existing inequities in the energy system for customers currently prevented from having their own solar systems (Funkhouser et al., 2015; National Renewable Energy Laboratory, 2014; Stanton and Kline, 2016). Finally, CSS programs may provide unique opportunities for community-level mobilization of resources (Schroederet al., 2016), which could enable niche-level technology adoption as part of a larger-scale energy transition (Geels and Schot, 2010).

In this paper, we explore the diversity of CSS program design options and discuss the key tensions in existing programs. We highlight three critical design choices: the ownership model for CSS projects, rate design to compensate CSS project developers, and subscriber enrollment. Then, we turn to a discussion of how CSS programs may have equity implications that differ from alternative models of deploying solar energy. Finally, we conclude by sketching out key unanswered questions that we believe should be addressed by future research.

2. Design considerations in community shared solar

CSS programs aim to achieve two related objectives: (a) increase the overall level of solar energy deployment, and (b) broaden access to the benefits of adopting solar energy (Chwastyk and Sterling, 2015; Funkhouser et al., 2015). By expanding the market for solar energy adoption to electricity customers who cannot self-finance solar projects, CSS programs potentially double the number of residential and commercial electricity customers who can access solar energy (Feldman et al., 2015; National Renewable Energy Laboratory, 2014). And by creating new opportunities for consumer-financed solar deployment, CSS programs potentially lower the balance of costs for deploying new solar energy.

As states and utilities consider adopting or reforming CSS programs, it is critical to build on the experience of the electric utilities and states that have been early adopters. No two CSS programs are identical (Augustine and McGavisk, 2016; Coalition for Community Solar Access, 2016; Interstate Renewable Energy Council, 2016), and this heterogeneity in program design enables a useful context to learn about the impact of various CSS program design features.

2.1. CSS program design choices

Taxonomies of CSS program design choices have been proposed by several different groups. Chwastyk and Sterling (2015), writing for the non-profit Solar Electric Power Association, identify "12 key decisions" that define a CSS program. A recent study by researchers at Princeton University identifies nine characteristics that define a CSS program (Chang et al., 2017). Writing in this journal, Augustine and McGavisk (2016) propose a taxonomy of five program design considerations. We briefly summarize Augustine and McGavisk's five considerations here, supplementing their taxonomy with elements from the broader literature:

1) Ownership model: projects within a CSS program may be owned by a utility, a third party, a special-purpose entity created by a utility or by customers, or a charitable nonprofit. Ownership models have direct implications on how a project is financed.
2) Subscription model: CSS programs may allow customer participation through offers to buy or lease solar panels, invest a fixed amount in the system, or buy energy or capacity. Within these different models, customer payments may be upfront, paid over the course of the contract, or credited on monthly electric bills.
3) System and site selection: CSS programs may allow developers to site projects in specific locations or more generally, and may have specific rules regarding grid interconnection, power purchasing, net metering, and other aspects of rate design and developer compensation.
4) Subscriber enrollment: CSS programs vary in how they recruit subscribers. Some engage in extensive community engagement, outreach, and marketing campaigns, while others will use existing channels between a utility and their customers. Subscriber enrollment may have certain restrictions or additional incentives for certain customer types, such as low- to moderate-income (LMI) customers.
5) Program management: Over the lifetime of a CSS project, operations and maintenance must be performed and bill and subscription management must be carried out (e.g. managing unsubscribed electricity and subscriber attrition). Programs vary in their implementation of these functions and which actors bear responsibility for these functions. Program management may also include consumer protection, data reporting, and regulatory compliance.

In the taxonomy of CSS program design choices presented above, several key features have emerged as being particularly important in overall program performance. Here we highlight three issues for deeper exposition: ownership model, rate design, and subscriber enrollment (note: rate design is an element of "system and site selection" in Augustine and McGavisk's taxonomy). We note however, that even if every aspect of program design is considered in the creation or evaluation of a CSS program, one must recognize that each of the decisions, "is made within the context of the greater regulatory and utility regime, and can affect one another" (Chwastyk and Sterling, 2015).

2.1.1. Ownership model

Program designers must take into account the utility structure in every context where CSS operates. CSS is inherently flexible and therefore offers different benefits to the utility and customer (Funkhouser et al., 2015; Trabish, 2017). The most common differentiation in the literature is between utility-owned and third-party-led programs (Coughlin et al., 2011), although special-purpose entity (SPE) ownership models and non-profit models have also been implemented. Here we present tradeoffs between these different ownership models, extending the comparison by Augustine and McGavisk (2016).

In utility-administered programs the utility is in charge of every aspect of CSS construction, interconnection, design (subject to constraints by the legislature), operation, and billing. These programs are more likely to occur in vertically integrated, regulated utilities than in deregulated states (Stanton and Kline, 2016). Smaller municipal utilities, and electric cooperatives have generally begun their foray into CSS through programs of less than 500 kW and contract out specific support services (billing, operations, maintenance) (Chwastyk and Sterling, 2015). In several states, electric cooperatives were the early adopters of CSS, and offered a combination of up-front and pay-as-you-go payment options. This earlier experience in some states appears to have influenced the wider adoption of CSS programs, including through legislation. Larger investor-owned utilities (IOUs) may begin with a pilot program but generally have larger programs of over 20 MW (Chwastyk and Sterling, 2015). Finally, utility-led programs tend to use virtual net metering where the participant receives a credit for their