Energy Research & Social Science 10 (2015) 90–101

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

Business model innovations for deploying distributed generation: The emerging landscape of community solar in the U.S.

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ARTICLE INFO

Article history:
Received 8 April 2015
Received in revised form 1 July 2015
Accepted 10 July 2015

Keywords:
Community solar
Utility Business Model
Distributed generation
Net energy metering

ABSTRACT

Increasing penetration of residential photovoltaic (PV) systems has intensified concerns over the related impacts on utility revenue and the equity of deployment subsidies. Community solar (CS) has surfaced as an alternative deployment model for PV that could potentially mitigate these concerns, while integrating distributed solar PV. Given the potential that CS holds in stabilizing the customer-utility relationship amid deeper penetration of distributed solar, in this paper we combine four complementary datasets to analyze how policy, regulatory, and market factors impact the deployment of CS. Specifically, we present a detailed assessment of CS deployment in the United States, including pertinent insights relating to nameplate capacity, billing models, propensities of off-taker utilities to adopt different types of CS, and local market and policy drivers. We find that accounting for both underlying demand and policy/regulatory conditions is essential for understanding the nuanced connections between utility strategy and CS adoption. A particularly interesting finding, stemming consistently across the multiple data streams we analyze, is that utilities are motivated to develop CS not only to satisfy consumer demand or regulatory requirements for renewable energy, but also to alleviate revenue losses related to residential solar PV.

1. Introduction

Large-scale penetration of customer-sited solar photovoltaic (PV) systems portends a potentially disruptive change in the customer-utility relationship. The increasing penetration of distributed solar PV systems *within the existing customer-utility relationship context* has intensified concerns over the related impacts on utility revenue and the equity of deployment subsidies between PV adopters and non-adopters. When customers shift demand to distributed generation (DG), under many *existing* rate structures the fixed costs of maintaining and upgrading the grid may not be fully recovered, and non-solar customers may end up bearing a bigger portion of the overall costs of grid infrastructure [20]. This is especially prominent in the case of net energy metering (NEM), which compensates solar customers for the electricity generated from their on-site system at the retail rate [4,6,19,34,35]. Because residential solar customers tend to have higher levels of income and electricity consumption [27], the revenue impact is exacerbated for rate structures that have a higher portion of the fixed costs recovered through volumetric charges [6,8,20,34,35].

Beyond the contentious issue of fixed-cost recovery, the weather- and time-dependency of solar leads to both potential benefits and costs for generation and grid infrastructure that vary substantially depending upon the local infrastructure and rate context [6,26].[1] Currently, calculations of value of solar ("VOS") – disaggregated accounting of the various components of benefits and costs of solar DG – are more art than science [6]. The difficulty in unambiguously calculating the VOS is one of the main factors in debates across the U.S. and in other countries on how exactly to accommodate customer-sited solar within the utility context.[2] In response to these emerging issues, residential solar programs have seen resistance in recent years from many U.S. utilities [7,25,34]. Generally, a win–win solution would keep utilities

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[1] One uncontroversial benefit to utilities of residential PV is greater generation capacity [6,26]. However, it is unclear how much residential solar PV offsets utility investment in additional capacity or delays other utility expenses [6,11].

[2] Some utilities also appear to oppose various forms of distributed solar purely for self-interested strategic reasons, often sidelining and even fuzzing technical considerations.

http://dx.doi.org/10.1016/j.erss.2015.07.004
2214-6296/

whole while integrating solar DG, aligning the interests of utilities and other stakeholders in the electricity generation value chain with the broader diffusion of solar DG [33]. Community solar (CS) – PV projects ranging from a few hundred kW to a few MW on the distribution grid (i.e., non-customer-sited) administered by the utility or a third-party entity in which multiple customers can participate – offers one such middle ground.

1.1. Paper overview

Given the potential that CS holds in stabilizing the customer-utility relationship with deeper solar penetration, this paper seeks to address the following question: *how do policy, regulatory, and market factors shape the adoption of CS by U.S. utilities?* Answering this question serves to elucidate the nuances of the CS deployment model(s), and speaks directly to two larger-picture questions in energy research and social science [31]: (1) how socio-political configurations affect decisions about energy? and (2) how the role of non-state actors in energy is deepening involvement, and indeed shaping, decision-making in energy? Our focus on diffusion of CS within the U.S. reflects two factors that become reinforced throughout this paper. First, as discussed later, approximately 60 MW of CS has been deployed in the U.S. in the last six years. Further, CS is poised to grow at least an order of magnitude in the U.S. over the next few years, greatly exceeding the scale of various CS models in other national contexts. As a result, the U.S. far and away leads in developing, demonstrating, and deploying CS, thus making the U.S. market an important focus of study in this area. Second, though uptake of CS has rapidly picked up, there is little systematic understanding of the nuances and drivers of various CS deployment models. With that in mind, we note that the analysis herein is not a single country case study of a new, uniform PV deployment model, rather it is an *examination of drivers and characteristics of multiple emerging CS deployment models* within the U.S.

This paper focuses on utility strategic decision making vis-à-vis CS product offerings. We do not delve much into normative customer factors[3] (e.g., satisfaction, decision periods, consumer economics) because, by design, our data and framework are inherently structural and utility-centric. However, we note that the customer is centrally important to our argument and in understanding our findings. We reiterate the point that CS broadens the reach of the solar market to consumers who otherwise do not have the fair opportunity to participate in the solar PV market. Furthermore, we find that the potency of customer demand and the value of retaining residential customers within the traditional utility-customer relationship are prominent drivers of CS uptake by utilities. Thus "customer as a driving factor" is a central line of argument we pursue in analyzing various pieces of data.

We use complementary methods and data sources to triangulate the questions outlined above. The nature of utility decision-making, constrained differently according to ownership type by various contextual and market factors, and the nascence of CS necessitate the analysis of multiple data sources to assess the drivers behind CS deployment. Section 2 provides the background context for CS deployment, while Section 3 describes the various data and methodologies used. In Section 4 we analyze the development of CS across the U.S. from 2003 to 2014, along with the changing policy, regulatory, and rate-regime landscape. In Section 4 we empirically evaluate utility strategy vis-à-vis green pricing, solar DG, and CS programs using survey data collected from electric utilities across the U.S. The findings of the survey data are augmented by insights gleaned from semi-structured interviews conducted with utility experts. Furthermore, we build a hazard-type model to evaluate the influence of contextual factors, specifically within-territory penetration of residential PV, on the utility decision and timing to adopt CS. Section 5 offers concluding insights based on our findings.

2. Background and related literature

Definitions of CS vary, often focusing on the aspects of CS that enable adoption by consumers for whom solar DG is a poor fit due to home ownership status or rooftop potential [5,10]. However, these definitions do not fully recognize that CS also cultivates utility, policy, and private, non-utility activity – the sort of broad capacity building that is not so readily apparent for other solar DG models like rooftop solar. For example, CS systems potentially provide power and/or financial benefit to multiple stakeholders [5,10], while also ameliorating some of the revenue concerns for utilities that solar DG engenders.

2.1. The promise of community solar for utilities

Utility-sponsored community solar (USCS) projects are owned and administered by utilities [10,33] and vary widely in size, between 2 MW and 20 MW.[4] USCS provides some obvious advantages to utilities over traditional residential solar PV. *First*, with USCS the customer's total demand continues to pass through the utility. To the degree that residential customers elect CS over on-site generation, USCS stabilizes residential demand (and revenues) within the utility's service area [5,21]. *Second*, economies of scale and utility-guided siting protocols can further improve costs of CS over customer-sited solar PV [5,10,18,21], potentially benefiting both the utility and the customers.

Third, CS projects enable utilities to retain the existing customer-utility relationship, while expanding renewable energy product offerings beyond green pricing programs, which rely on customers' willingness to pay a premium for environmental stewardship. Depending on how the programs are structured, CS can include consumer incentives like fixed solar rates [33] and shared investment returns [10], enabling customers to realize savings over time rather than paying a premium. In this sense, environmental concern need not be a salient consumer preference for "going solar" because CS offers to provide a meaningful economic return – be it return on investment or a hedge against increases in future electricity prices.

Finally, and perhaps most importantly, CS cultivates a new segment for solar penetration, since a large constituency of would-be solar customers rent, live in multi-family homes, or have roofs poorly suited to solar PV installation [4,5,10,21,33,36]. Residential PV has not been an option for this significant segment of customers. Only one quarter of residential rooftops in the U.S. are suitable for solar PV [24], and over 30 percent of Americans rent [23]. In addition to opening access to solar DG for this segment, CS potentially lowers entry costs and risk to homeowners [10].[5]

2.2. CS benefits for utilities vary by type

USCS is not the only approach that has gained traction in recent years. CS projects that are constructed and administered by special purpose entities (SPEs) have also proliferated. SPEs provide some

[3] For recent discussions on customer-side social, behavioral, and economic factors impacting solar PV adoption decisions see [13,30,28,16,29] and [12].

[4] Descriptions of CS systems derived from our deployment database. See Section 3 and Supplemental information, SI.2 for details.

[5] However, this new segment of customers mostly includes those unlikely to obtain traditional solar DG; and so should not be considered part of preserving the residential utility demand. This 'additionality' increases the reach of solar DG and does so in a sustainable way, but only customers opting for CS over traditional solar DG contribute to preservation of demand from the utility's perspective.