Final Report

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Executive Summary:

In 2017, an estimated 400 MW of community solar were installed, with more than 800 MW in the development pipeline for 2018, according to the Smart Electric Power Alliance. The market potential for this business model is vast, encompassing residential and commercial customers whether or not their properties are ideally suited for rooftop solar and whether or not they can afford more traditional solar purchase or PPA options. Community solar is also viewed by some as a driver for adding more local, *community-scale* solar to the resource mix, whether procured on behalf of customers by a conventional distribution utility, or by a community choice aggregator or other entity. Yet the far-reaching promise of community solar will not be realized unless local projects and customer programs are designed to unlock its full net value. As the Community Solar Value Project (CSVP) embarked on this effort, with funding from the U.S. Department of Energy Solar Market Pathways program in early 2015, community solar was a nascent market; there were few players and mostly generic, pilot-scale programs. Most early efforts by solar developers to package community solar solutions proved hard to scale and replicate, largely because they lacked direct engagement with utilities and other stakeholders. State-level community solar policies drove impressive progress in a few states, but policy success also proved contingent on developing broad support for elusive “win-win” strategies that benefit both utilities and participating customers.

It has been the CSVP’s mission to increase the scale, reach, and value of utility-based community solar programs by engaging directly with utilities and their stakeholders, defining that win-win approach in terms that are flexible, scalable and replicable. Over a 2.5-year term, the CSVP team worked directly with a community solar market leader, the Sacramento Municipal Utility District (SMUD), plus the Public Service Company of New Mexico (PNM), more than a dozen other utilities, other Solar Market Pathways awardees, and multiple industry associations to develop improved community solar program designs. The resulting CSVP planning framework and best-practice solutions have reached more than a thousand industry participants through CSVP workshops, reports, webinars, and a web-based toolbox. Conference and media outreach, including repeated coverage in *Utility Dive*, *Public Power Weekly*, the Western *Energy Services Bulletin* and other sources, has triggered a broad and continuing industry conversation. Even in the last quarter since U.S. Department of Energy support has ended, the CSVP website has received an average of almost 700 unique visitors every week. CSVP’s efforts have impacted community solar programs and DER plans, innovating new, integrated “solar plus storage” or demand response approaches among other high-value strategies.

For the customer, community solar may be a choice with economic, resilience and environmental benefits. For the utility, customer satisfaction is important, but it is just one side of the rubric. In order for community solar to reach and sustain its GW-scale annual growth potential, the utility—including individuals across departments—must be able to see the full value in scaling up community solar within an integrated DER portfolio.

The CSVP *directly* engaged the Sacramento Municipal Utility District (SMUD), the Public Service Company of New Mexico (PNM), and more than a dozen other utilities to develop improved community solar program designs. The outcomes include a plan at SMUD for over 100 MW or more of community and shared solar and support for new or expanded programs at 15 other utilities so far. Resulting best-practice solutions have not only informed program applications, but also have generated discussion among experts and

industry associations about the new opportunities and challenges CSVP has brought forth. In these ways, the CSVP has impacted community solar programs and DER plans, competitive innovations and policies nationwide.

The CSVP team has been led by Extensible Energy, LLC, under John Powers, President and CEO. Jill Cliburn, of Santa Fe, NM-based Cliburn and Associates, has served as Principal Investigator. The team also benefitted from expertise from Navigant, Olivine Inc. and Millennium Energy, LLC, in addition to the collaborative and cost-sharing contributions of its utility partners. The CSVP team participated fully in the Solar Market Pathways Program, which was initiated under the U.S. Department of Energy SunShot program and reports to the U.S. Department of Energy Solar Energy Technologies Office.

The CSVP Project Scope and Methodology

As this report details in the Introduction section, the CSVP approach was initially outlined as a complex scope of work, focused on the following objectives:

Create a Successful Program Planning Process / Case Study – Work with SMUD to create a plan to revamp the utility's pioneering community solar program, called Solar Shares, from a 1-MW scale to 6- to 20 MW, planned for roll-out by 2020, and including multiple customer offers.

Apply Technical Knowledge Base to Create a Compelling Market Value Proposition – Provide tools and resources for utility-driven community-scale solar projects and programs, with a focus on cost reduction and value creation.

Innovate Related Business Models, With the Market Potential for 40 MW of Utility-Driven Community Solar and the Long-term Potential for GW-scale Market Growth Nationwide – Work with SMUD and other members of our Utility Forum to ensure that lessons learned with SMUD transfer to other geographies and market / regulatory situations.

Replicate and Disseminate Project Results to Increase Market Impact – Work with Utility Forum members interested in their own community solar projects; disseminate results through webinars, conferences, workshops, the CSVP project website, and the extensive industry networks of CSVP team members.

Complete Documentation of Pricing Strategies– A small modification to the project scope in 2016 called for structured interviews and market assessment, to produce a database of at least 10 current community solar pricing programs that demonstrate a breadth of different options.

To provide better management structure and progress metrics, the CSVP's work quickly took shape as an "event driven" effort, building quarter by quarter and year by year. Many CSVP events were designed primarily to support community solar program design at SMUD and the distillation of SMUD lessons-learned, in collaboration with CSVP's Utility Forum experts from a growing list of utilities, from the initial target of four participants to a total of 15. Throughout the project term, but especially during the latter months, CSVP paid considerable attention to work with the Utility Forum and other industry stakeholders, including third-party developers and service vendors. This assured the replicability and reach of identified best practices, including recommendations on striking the right balance between internal utility work and out-sourced support.

Five CSVP events were focused on work with SMUD, the primary utility partner, with participation in some cases, from Utility Forum members:

- March 2015: On-site Program Kick-Off Workshop in Sacramento, for SMUD stakeholders
- June 2015: On-site Program Design Workshop in Sacramento, including Utility Forum members
- August 2015: Off-site Workshop in Berkeley, with Team, NREL and LBL experts, on Solar Value and Solar-Plus Integration
- February 2016: Off-site Design Charrette on increasing net-project value and achieving competitive pricing, held in Berkeley with SMUD and CSVP Team participants
- March 2016: On-site Meeting with SMUD Cross-Departmental Decision-makers
- August, 2016: On-site Program Design Solutions Workshop with SMUD Stakeholders and Utility Forum

Other key events were relevant to CSVP innovations, replication and dissemination. This includes working with PNM, a leader in demonstrating solar plus storage, and a utility that is seriously considering designing future community-scale solar projects to work in harmony with customer-side thermal storage as well as batteries. A partial listing of such events includes:

- Annual SMP Peer Learning and Leadership Workshops (3)
- October 2015: Initial Meeting On-site With PNM on Replication of Community Solar and Solar Plus
- September 2016: Meeting On-site With PNM to Review Solar Plus Modeling Study
- June 2017: Community Solar Procurements, Programs and Pricing, a Workshop on Project Findings with Utility Forum and Guests, Golden, Colorado
- A total of 15 CSVP-sponsored webinars, scheduled over the project term, to engage a broader audience with CSVP products and processes.

A list of the utilities that participated in Utility Forum activities is included in the Project Results and Discussion section of this report. A review illustrates the range of participants, which were mostly, but not exclusively, located in the Western United States and included:

- 8 public power distribution utilities
- 2 public power wholesale energy suppliers
- 2 electric cooperative distribution utilities
- 3 investor-owned utilities

The CSVP project reach stretched far beyond this group, via conference presentations and media coverage, and to a verifiable array of utility-industry participants, who participated in the June 2017 CSVP Workshop on Community Solar Procurements, Programs and Pricing. As shown in Figure ES-1 below, that workshop drew 80 registrants, including utility participants from 26 states. Of all Workshop participants, 38% said they are planning a program or project to launch within two years, and 28% said they are experienced with community solar and considering program expansion. Further discussion of Workshop results is included below.

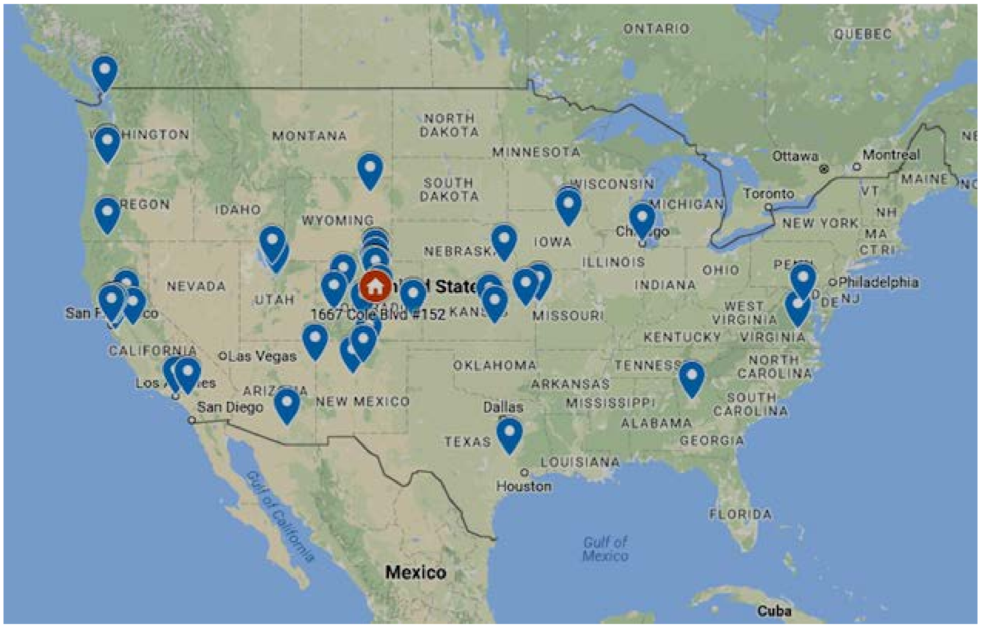


Figure ES-1: CSVP Procurements, Programs and Pricing Workshop Participants

The development of best-practice program design solutions and solution-focused innovations were hallmarks of the CSVP program process. The call for individual processes and tools came from discussions and sometimes polling of SMUD cross-departmental program designers and CSVP Utility Forum participants. Then, during their development, these CSVP draft processes and tools were peer reviewed by industry experts, SMUD staff and Utility Forum participants themselves. The final products in the CSVP Solutions Toolbox cover some familiar bases, but they also take a few highly innovative turns, specifically based on utility- and stakeholder feedback.

This was true in early stages of this effort, with the formation and facilitation of cross-departmental teams, the streamlining of analytics, favoring compelling narratives instead, and the use of hypothetical program scenarios in order to free utility staff (at least in early planning stages) from applying worn assumptions.

The SMUD program-design team was especially attuned to building cost-effective programs, possibly including “companion measures” that put a strong focus on target market segmentation. Utility Forum participants in the 2015 Program Design Workshop (and incidentally at a SEPA-sponsored workshop where CSVP and SMUD co-presented) responded with strong interest in that approach. CSVP subsequently expanded its research on target-market segmentation and commissioned a new market research and segmentation guide. That guide offers a five-step market research process and proven tips for customizing and enhancing existing research cost-effectively.

Reviews by utilities and stakeholders were repeated for developing processes and products in each of CSVP’s major task areas. One example indicates the team’s outstanding responsiveness to Utility Forum feedback and expert peer reviews. This occurred after the 2015 Program Design Workshop, as CSVP embarked on designing a tool for systematically choosing among solar-project design options, matching these with demand-response or storage companion measures, and ultimately calculating the impact on net value. The Utility Forum responded positively at first: Who would not want a tool like that? The team then pursued extensive review of "value of solar" research and methods and intended to build the new tool. Early progress was impressive and as accurate as anything available to that level of detail, according to a lead engineer from the NREL Integration Lab, who provided a peer review. He also participated in a subsequent Workshop on Solar Value and Solar-Plus Integration, which was limited to a dozen expert utility participants and stakeholders. At that point, the group decided that the CSVP's best innovation would be to re-focus, *away* from the complex tool and toward a process for using existing tools more effectively. The aim would not be to calculate a proposed project's full net value (dependent on many utility- and market-specific variables), but rather to streamline the analytic process, focusing on the most consequential issues that utility decision-makers might raise prior to program approval and implementation.

As a result of that Workshop and of subsequent meetings with SMUD, the team developed a streamlined methodology that identifies acceptable ranges for select project costs and benefits, including integration values as applicable. The methodology was applied to three utility solar planning scenarios, demonstrating how streamlined analytics can serve cross-departmental utility decision-making and speed projects to market. This methodology, called the GAP Analysis, also has proved useful as an iterative tool to help planners fine-tune local project value. In that way, community-scale solar may compete reasonably on price with centralized (more typical "green power") solar purchased from afar. In the bargain, utilities gain hands-on experience with grid-integrated DERs. Further illustration of how this process works is discussed under the next section.

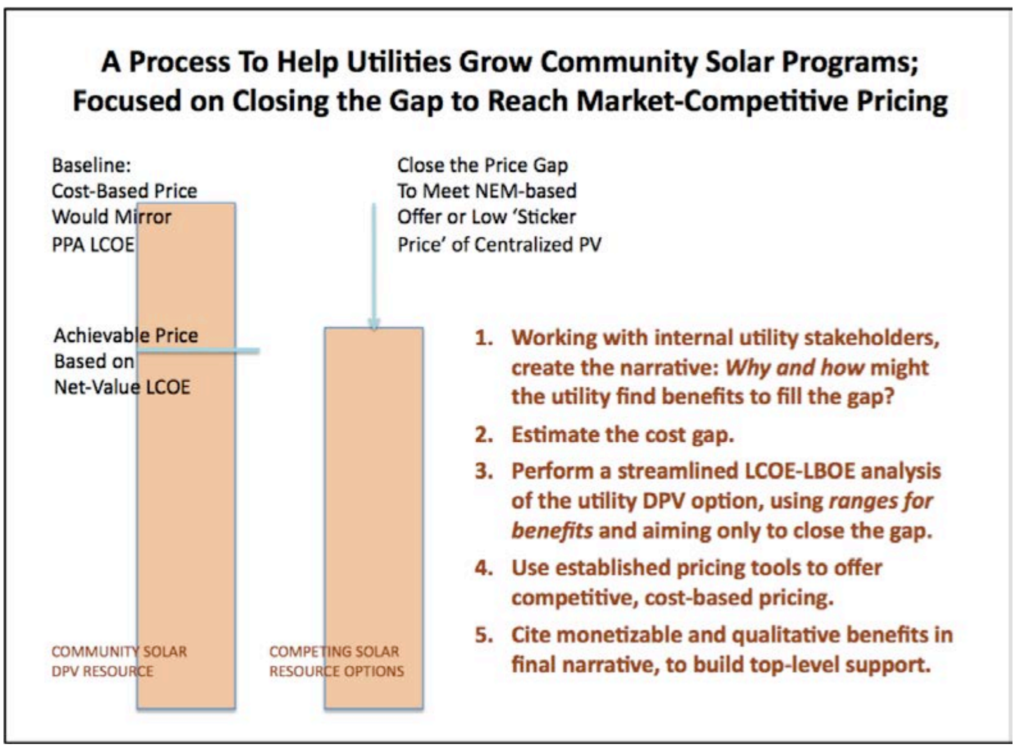


Figure ES-2: Summary of GAP Analysis Process

The above figure summarizes the GAP Analysis Process for improving community solar procurement and pricing. Following a standard for cost-based pricing, utilities would simply "pass through" the cost of a solar PPA, expressed as the gross levelized cost of energy (LCOE), and add wires costs. That approach misses some monetizable utility benefits and often results in non-competitive community solar pricing. CSVP developed a more inclusive, yet project-specific analytic approach to meet utility and customer needs. Three different utility scenarios are documented, showing widespread applicability of the process and its value to utility decision-makers.

It is notable here, that the CSVP presented the *GAP Analysis*, the *Guide To Market Research and Target Market Segmentation*, plus the guide to *Demand-Response Companion Measures for High-Value Community Solar Programs* and other work products to Utility Forum members for detailed feedback in time to revise, build out or refocus products for the Toolbox. For example, one 2017 survey asked how relevant and important specific topics were to our June Workshop participants. Findings included:

- *Ways to make program pricing more competitive and effective* tied for the highest score as being "very important and relevant" to respondents' current work (48%)
- The call for *A process for fostering inter-departmental collaboration in program design* received the same top score for being "very important and relevant" (48%). CSVP's responded directly to this need by emphasizing collaboration in the program design process tools.
- *Market research sources and strategies* and *Innovative approaches to resource procurement to lower net program costs* both ranked next highest, when looking only at the metric that scored them as "very important and relevant." When also taking into account scores for being "*somewhat* important and relevant," it is fair to say these two needs were about tied with the other top-ranked needs meriting significant attention.
- Topics pertaining to solar-plus strategies won moderate support for their importance and relevance to SMUD planners and Utility Forum members, who participated in the survey. It was encouraging that only 14% deemed these strategies "unimportant or irrelevant," even though they are hardly well known today. Yet information on *Storage and DR alternatives to batteries for adding integration value* ranked significantly more important and relevant today than the call for specific *Community-solar plus storage and DR* program designs. This led CSVP to take a broader view in finalizing tools, addressing utility interest in *community-scale* solar plus storage or DR, whether or not the utility sees companion measures specifically as part of a future community solar offer.

The CSVP Process and Solutions Toolbox

In developing a process and best practices for utility-led community solar program design, the CSVP drew largely on experience with SMUD, PNM and other utilities (documented in the full report), as well as extensive review of program outcomes across the community solar field. For Workshops in both 2016 and 2017, the CSVP tested program-design planning processes that not only followed the tried and true, but that also led thinking *outside the box* to yield quicker, more competitive, and utility-acceptable program offerings. In the end, the CSVP team decided to point utilities to an archive of program design processes that they might customize. The real world of utility planning is a bit messy; any planning process must be exceptionally flexible in order to succeed. Thus, the team set a goal to help program designers to find solutions in whichever challenge areas were most pressing to them and whenever those challenges arise. Challenge areas for achieving high-value community solar include:

1. The program-planning and development process itself
2. Strategic solar project design
3. Project financing and procurement
4. Target marketing for customer acquisition
5. Integration with companion measures, e.g., demand-response and storage
6. Streamlining the analytic process, primarily aimed to price the program competitively

Figure ES-3: CSVP Challenge Areas

Figure ES-3 shows how the CSVP presented its planning process with an “outside the box” summary, portrayed on the website as sides of a revolving cube. Each of the six Solutions web pages identified in this way includes a narrative summary of the challenge and recommended tools and each page includes a set of about a half-dozen downloadable tools and resources.

The Project Team produced a large collection of high-quality resources and tools, which are summarized in this report and are available (at least through 2018) on the website at www.communitysolarvalueproject.com. Select publications are listed in this Executive Summary and are available as appendices. A quick review of each challenge area, the related tools and publications provided is offered here:

1. The Program-Planning and Development Process

Here, CSVP offers an overview of its process, in presentation format: *High-Value Community Solar: A Brief Guide to Utility Program Design*. This Guide summarizes lessons-learned and introduces the planning resources on the CSVP website. Second, CSVP offers an archive of community solar process and planning diagrams. This supports CSVP's recommendation that planners review various processes for ideas on how to customize their own. CSVP's own flow diagram puts emphasis on interdepartmental collaboration and opportunities for solar-plus integration. An expanded blog post and resource-linked bibliography is included. Archived webinars on community solar best practices and specifically on lessons learned at SMUD round out the offerings.

2. Strategic Solar Project Design

This challenge area introduces the benefits of community-scale solar, and of designing with strategic integration value in mind. CSVP provides a brief on strategic-design best practices, including ways to properly frame the decision between siting locally or acquiring the solar resource from a centralized, remote project. To show how one design element can be used in strategic applications, CSVP offers a webinar and resource list on solar shade structures. These structures are included in the SMUD plan for high-value community solar products. A fact sheet with links to information on low-income community solar programs and project designs is also included.

3. Project financing and procurement

Whether the community solar resource is utility-developed, acquired by power purchase agreement (PPA) or provided as part of a turnkey program package, the procurement process for community solar services and resources is a rich area for improving net value. Six CSVP tools are offered on this page of the Toolbox site: a community solar market landscape assessment**,** a concise outsourcing decision key**,** and a webinar, including utility guest speakers, which illustrates many lessons learned, especially around the decision to outsource parts of the program-design and implementation process. In addition, we include CSVP's concise outsourcing decision key**,** a report in presentation format. We also provide an introduction to project financing models**,** suitable for investor-owned or consumer-owned utilities. A procurement resource guide offers direct links to publications and model documents for developing a solar project RFP.

Market Research Checklist for Designers of Utility-Based Community Solar Programs

- ☐ **Step 1. Assessing Needs**
  Determine where the utility needs assistance the most (e.g., overall program design, identifying top targets, identifying companion measures, determining marketing messages)
- ☐ **Step 2. Drawing on Outside Research**
  Build on knowledge from other utilities and outside resources (but question the questions, and recognize that education on community solar will be critical)
- ☐ **Step 3. Mining Customer Data**
  Understand what customers want and need through data mining
  - ☐ Explore existing target-market segmentation related to any existing utility programs or services
  - ☐ Assess and tap into existing data sources, such as energy usage patterns or survey data
- ☐ **Step 4. Interviewing Customers**
  Collect program specific data
  - ☐ Determine opportunities to (1) collect data through primary research and (2) leverage cross-departmental resources for gathering data
  - ☐ Conduct qualitative research, e.g., focus groups or in-depth interviews, to explore issues
  - ☐ Conduct customer surveys to test hypotheses and explore alternative options
  - ☐ Analyze all available data to inform the development of the program and marketing plan
- ☐ **Step 5. Developing a Program Design with Feedback Loops to Monitor and Adjust**
  Develop an interactive program-design process, integrating enhancements based on customer feedback with technical concerns, such as project siting and design, pricing, customer sign-up and billing, etc., to create a win-win for both the customer and the utility. Build in feedback loops to monitor and adjust.

Figure ES-4: CSVP Market Research Checklist

4. Target marketing for customer acquisition

Customer-driven program design is a relatively new approach for utilities, but it is required for success with community solar. For best-practice community solar programs, market research is a requisite first step that drives customer acquisition and retention. For this challenge area, CSVP provides a market research checklist and step-by-step guide *to Market Research and Market Segmentation for Community Solar Program Success*. References to other relevant resources and a webinar on this topic are also provided.

5. Integration with companion measures, e.g., demand-response and storage

Interest in solar-plus storage has boomed since CSVP first proposed addressing storage and demand response (DR) as companion measures for community solar. These companion measures do not have to be exclusively tied to the community solar offer, but planners for any community-scale solar acquisitions can benefit from an integrated program-design perspective. A modeling study of solar plus storage and DR, prepared with Utility Forum member Public Service Company of New Mexico (PNM), introduces the technical value of a solar-plus "triple play." Planners can gain an in-depth, practical understanding from CSVP's guide to DR measures, *Demand-Response Companion Measures for High-Value Community Solar Programs: A Guide for Utility Program Designers.* The companion volume, *Solar Plus Storage Companion Measures for High-Value Community Solar: A Guide for Utility Program Planners* is a guide to storage, including options on either side of the meter to complement a community-scale solar project. These are first-of-their-kind publications for utilities that are increasingly interested in learning about solar plus strategies and realistic approaches to balancing increasing amounts of solar on a circuit or across the local system.

This section of the Solutions Toolbox also includes an annotated list of resources and a webinar and presentations, featuring utility and industry guest on strategies that offer a practical way to start.

Figure ES-5: PNM Solar Plus Storage Installation

In Figure ES-5, Jon Hawkins of PNM can be seen explaining the monitoring and control system on the utility's Prosperity solar plus storage project. Hawkins led a modeling study for CSVP aimed to address early-stage questions about using additional, customer-side strategies to enhance solar-plus integration value, framed from the engineering viewpoint.

DR Opportunity Assessment

	DR Option	*Yearly Cost Planning Estimate ($/kW)*	*Avg. Load Impact per Unit*	*Seasonal Availability/ Impact*	*Events Feasible per season*	*Signal-to-response time*	*Duration of Impact*	*Target Customer Class*
1	Curtailable Load (Day-ahead)	$198	Depends on end-use	Most effective during peak season	Frequently limited to less than 50	20-26 Hours	2-6 Hours	C&I
2	Curtailable Load (Day-of)	$228	Depends on end-use	Most effective during peak season	Frequently limited to less than 50	3-5 Hours	2-6 Hours	C&I
3	Auto-DR	$265	Depends on end-use	14% of peak load winter; 16% for summer	Depends on program	5-15 Min	5 min–1 Hour	C&I
4	Direct Load Control (A/C switch control)	$47	0.37 kW -2.06 kW	Warm months only	~100	2-10 min	2-4 Hours	Res
5	Load Management (Smart Thermostat)	$85	.67 – 0.86 kW	0 .61-1.079 kW-	~30	2-10 min	1-4 Hours	Res

Figure ES-6: DR Opportunity Assessment

Figure ES-6 is an excerpt from a two-page table in the guide, *Demand-Response Companion Measures for High-Value Community Solar Programs*, which illustrates a key step in the CSVP process for selecting DR measures that add high-penetration solar integration value.

6. Streamlining the analytic process, primarily aimed to price the program competitively

This sixth section of the CSVP Solutions Toolbox provides detail on CSVP's streamlined analytic process, which speeds the path from early-stage program design to competitive program pricing. It begins with an overview presentation and a paper on CSVP's *GAP Analytic Process.* This approach is characterized by a) framing a program narrative that is brief and meaningful to utility decision-makers, and b) focusing on a limited number of benefits, in order to meet a solar cost target. That, in turn can support competitive program pricing. Three generic scenarios illustrate how this *GAP* analysis applies in different utility settings. A presentation and blog on pricing strategy clarifies the last step in this approach. It applies accepted pricing tools to create the final, competitive program offer.

Finally, the CSVP provides an expanded reference table, *Twelve Community-Solar Pricing Strategies for U.S. Utilities* as an illustrative summary of strategies from utilities in Arizona, California, Colorado, Massachusetts, Iowa, Minnesota and Texas. In each case, the summaries are written from the utility perspective, even though in several cases, state policies have dictated a relatively narrow role for the utility. CSVP embarked on this effort in order to show the range of program and pricing options currently in the marketplace. While each of the utilities featured have incorporated some best-practice elements into their plans, we do not attempt to rank or evaluate them.

The SMUD Solar Shares Portfolio

In developing a process and best practices for utility-led community solar program design, the CSVP drew largely on experience with SMUD. Internal utility planning cycles in 2012-14 cited an objective to revamp and expand SMUD's community solar program. That pioneering program, called SolarShares, was initiated in 2008, supported by a 1-MW solar array. It has continued to serve about 630 SMUD customers. New customers, queued on a waiting list, have joined to replace the few who have withdrawn, but overall the program has been very stable. Its growth beyond the initial 1-MW scale has been constrained because this was designed as a unique program, suited to market conditions and incentives that are no longer in play.

When the CSVP launched in early 2015, SMUD was ready to consider a program expansion that would include one or more locally sited projects and possibly a robust solar-plus-DR offer. Yet one of the CSVP's core "lessons learned" about working with utilities is that utility programs—and especially significant ones—are subject to changes that occur in markets, policies, utility management structures and personnel—all of which are hard to predict. This lesson was already somewhat apparent to the CSVP team, based on previous experience, but it became central to the team's understanding of program replicability: cross-departmental collaboration and flexible strategies are crucial to program-planning success.

By mid-2016, SMUD top-management articulated a far-reaching commitment to shared solar, far beyond the CSVP's initial target of six to 10 MW. The more challenging news was that a large-scale commitment to shared solar would involve several different internal departments and their objectives. By fall 2017, SMUD evolved around a new business model, which is more forward-looking than the technology-driven models that most utilities' community solar programs have followed, and which supports exponential community solar market expansion. In short, SMUD recently reorganized around customer market segments, rather than technical program groups. Programs are discussed as "products" to be packaged and presented together for customers in each market segment. This vision is well suited to best-practice community solar, which draws on a growing fleet of community solar projects and program options.

The leading work group at SMUD for designing its expanded Solar Shares program has continued to be the Integrated DER Strategy group. Its objectives are to help SMUD:

- Be Customers' Preferred Energy Services Provider/Advisor
- Provide Outstanding Reliability & Power Quality
- Reduce Pressure on Rates
- Contribute to Regional Carbon Reduction
- Extend DER Access to Underserved Customers

Working with other internal groups, who manage product portfolios for each customer market segment, the IDER group addresses a number of specific needs, including to:

- Help customers address physical site limitations for siting solar PV
- Integrate DER technologies with community solar to address grid issues
- Pursue cost effective approaches to providing solar energy to all customers

Lessons Learned in SolarShares Program Redesign
(provided by SMUD Staff in Review)

Program
- Have clear program objectives, roles and responsibilities
- Stakeholder buy-in and support is key requirement
- Flexibility is important
- Align clearly with all relevant strategic objectives; gain top-management support

Product
- Have clear product strategy and objectives
- Employ best product development practices
- Sales channels, marketing and communications strategy are key
- Align with customer segmentation business strategy

Pricing
- Establish basic pricing design principles and strategy early and re-evaluate annually
- Work closely with CFO team (Pricing/Rates) to align pricing with revenue/rate strategy
- Test pricing through market research

Resource
- Establish procurement strategy and portfolio management plan
- Work closely with Resource Planning; Energy Trading & Contracts; Power Generation
- Assess market conditions, evaluate siting and location options
- Create sales forecast and robust process for review and update

Figure ES-7: Lessons Learned

The first part of SMUD's expanded SolarShares program focused on a large commercial product offering, with the new Sacramento Golden One Center and the State of California serving as anchor customers for an 11-MW solar project. The Golden One Center is LEED Platinum certified, setting the pace for other private-sector projects that pair shared solar with energy efficiency and smart, grid-tech strategies.

In addition to the 11-MW project, an additional 30 MW were announced for SolarShares in 2017. The total solar resource available to SolarShares was anticipated to reach more than 100 MW over time. The existing residential product has been improved as an interim product, with lower pricing supported by blending the original 1-MW project cost with newer, lower-cost solar resources. However the full rollout of the expanded SolarShares offer for residential customers would be delayed to coincide with the rollout of time-of-use pricing for residential customers, including those on the SolarShares rate. In addition, at least three additional SolarShares products were under development for high-value community solar niche markets, as of Q4 2017:

- Urban Redevelopment
- Commercial On-site PV Plus Shared Solar (Hybrid)
- Community Solar for Sustainable New Developments

The Urban Redevelopment project is planned for the North Franklin neighborhood. It will be aimed primarily to benefit low- to moderate-income customers and small businesses. Most likely it will feature solar on parking structures, integrated EV charging systems, additional energy storage, building and equipment efficiency measures and evaluation of a neighborhood electric shuttle service. The plan was initiate with CSVP in an E-Lab workshop setting, and has been fine-tuned internally by SMUD staff.

The Commercial On-site PV Plus Shared Solar product will meet the needs of commercial account customers who want solar on-site visibility, but whose solar needs are greater than their on-site hosting capacity. This model is also likely to use carport structures.

The Community Solar for New Developments concept is a straightforward solution for new developments that must meet California's near zero energy construction goals. The utility would help developers to offer access to shared solar rather than orienting and designing each home in a new development to host its own PV system.

In addition, a solar-plus SolarShares product is still on the planning docket for SMUD, pending additional planning by the IDER group.

This comprehensive SolarShares plan will require significant solar resources in the mid-term, including resources from centralized, in-state PPAs and local distributed PV projects. SMUD planned for changing markets and needs by leaving additional niche-market offers tentative -- especially those with implementation more than three years out. In Figure ES-8 below, members of SMUD's cross-departmental program design team meet with Utility Forum members to identify possible solutions for community solar program design.

Figure ES-8: SMUD Workshop

Replication and Dissemination

As noted above, the CSVP worked directly with a total 15 utilities through its Utility Forum, in addition to its work with SMUD, to verify the replicability of the CSVP planning framework and "best practices." With each utility, one or more identified best practices were replicated or adapted. Most Utility Forum members planned to adapt aspects of the SMUD experience, but none replicated the SMUD model in its entirety. That is perfectly understandable; community solar is *not* one-size-fits-all.

All six topics selected as Challenge Areas for the Solutions Toolbox were the primary focus of CSVP's replication efforts. For example, strategic solar design, solar procurement and improved target market research registered as areas where utilities could readily adopt improvements that are both achievable and high-value. New opportunities to improve project/program net value also exist in the planning process itself; in effect, time is money, and many utility programs lag in the planning and marketing (customer acquisition) phases. The CSVP offers highly replicable solutions in these areas.

There is also strong interest among utilities in preparing for, if not immediately implementing, solar plus storage and DR program strategies. The CSVP worked extensively with PNM, New Mexico, to understand the technical and organizational parameters for developing a solar-plus program. CSVP presented the community solar model, as a ready "market-based laboratory" for demonstrating how solar plus could become a popular and far-reaching component of any DER program. To address early-stage technical questions, PNM modeled the impacts of local community solar, plus air conditioning load control (pre-cooling) and customer-side thermal storage on a circuit that had experienced voltage fluctuations. The modeling process found that although grid-value was not an economic driver, community solar-plus would address this grid issue. Thus, a combined project could be viable, based on grid value *plus* other program-specific benefits of community solar, DR and storage. In addition, PNM helped CSVP develop a vision for how solar plus customer-side strategies could work compatibly with a *utility-side* battery storage project; PNM has had experience with battery storage installed alongside a 500-kW solar plant.

The CSVP has offered the PNM study along with solar-plus case studies and two detailed solar-plus planning guides, through its Solutions Toolbox. Hundreds of participants indicated their interest by attending one or both of the CSVP's webinars on this topic. Also, a presentation by the Utility Forum representative from PNM was one of the highest rated of all presentations at CSVP's well-attended Procurements, Programs and Pricing Workshop in 2017.

In response to growing interest in solar plus, the CSVP has developed relationships with the Peak Load Management Alliance, American Public Power Association Power Forward Project, and other industry associations to build on the conversation it has begun, regarding utility-led solar plus strategies and ways to capture solar grid-integration value.

CSVP outreach through professional networks has been extensive. This report lists, in the Project Results and Discussion section, presentations and posters at CSVP provided at 20 industry conferences, during the period 2015-17. These included panel leadership and presentations for top conferences such as Solar Power International (SEPA and SEIA), InterSolar North America, meetings of the American Public Power Association, ASES National Solar Conferences, Renewable Energy World and many more. In reaching a broad audience directly, CSVP presented 15 webinars covering all major topics surrounding community solar projects. These events typically hosted 100+ participants and continue seeing regular downloading of the programs. All events are held on the CSVP website under the Archives tab.

CSVP Archived Webinars

2017 Webinar Schedule

- 03.01.2017: *Five Steps to Tailored Market Research*
- 04.13.2017 SMUD Shares Community Solar Lessons Learned
- 05.11.2017 The Best Steps You Can Take Toward "Solar Plus"
- 06.28.2017 Getting At Price: CSVP Findings on Making the Economics Work
- 10.05.2017 What Makes Community Solar Successful?

2016 Webinar Schedule

- 06.30.2016: *Can Regulation Make Community Solar Better?*
- 07.28.2016: *Thermostat Control for Solar-Integration Value*
- 08.18.2016: *Making Solar Carports Happen*
- 09.28.2016: *Community Solar Plus Storage Solutions*
- 10.27.2016: *The Value of Going Local*
- 12.01.2016: *Smarter Procurement for Community Solar Programs*

2015 Webinar Schedule

- 08.27.2015: *Better Community Solar Procurement and Design*
- 09.29.2015: *How DR and Storage Address Solar Variability*
- 10.22.2015: *How SMUD and Other Utilities are Rethinking Marketing*
- 11.19.2015: *Community Solar... for Utilities and Their Low-Income Customers*

Figure ES-9: Archived CSVP Webinars

As noted above, media coverage has been strong, for example, two articles in Utility Dive, two in the Western Energy Services Bulletin, one in Renewable Energy World, one in Solar Industry Magazine, and numerous articles and posts in Solar Market Pathways media.

Equally important have been dialog and relationships built with key industry organizations, ranging from the Peak Load Management Alliance and American Public Power Association to the Interstate Renewable Energy Council (IREC), National Regulatory Research Institute (NRRI), Coalition for Community Solar Access and Regulatory Assistance Project. The CSVP initiated dialog on the importance of taking new approaches and seeking new solutions in many key areas. A sampling includes:

1. Cross-departmental collaboration for truly integrated utility program delivery
2. Adapting national and local market research to develop more successful, targeted marketing

3. Balancing in-house utility expertise and outsourced services to improve community solar value
4. Better and more widespread understanding of grid-integration value and how to monetize it
5. Win-win approaches for utility community solar program pricing
6. Customer-side storage and DR as cost-effective first steps to addressing solar-related duck curve issues

Conclusions

Through this effort, the CSVP has developed and demonstrated a widely applicable planning framework that makes community solar compelling to both the customer and the utility. For the customer, community solar may be a choice with economic, resilience and environmental benefits. For the utility, customer satisfaction is important, but it is just one side of the rubric. In order for community solar to reach and sustain its GW-scale annual growth potential, the utility—including individuals across departments—must be able to see the full value in scaling up community solar within an integrated DER portfolio.

Working with the Sacramento Municipal Utility District, the CSVP supported that remarkable coming together of customer and utility interests. The result: a utility commitment to at least 100 MW of community solar, which will be tailored as a portfolio of customized products within each customer class. Moreover, SMUD agreed with CSVP to invite other utilities and industry stakeholders to participate in on-site planning workshops. The resulting Utility Forum shared in a remarkable give and take, and it also held parallel planning discussions, focused on identifying and adapting best practices.

Work covered six challenge areas. Seventeen utilities, including core Utility Forum members and others, have received support from CSVP in one or more of these challenge areas. Hundreds of others have accessed CSVP's Solutions Toolbox through its website, which will continue to be maintained for at least one year. Subsequently one or more industry organizations, already identified by the CSVP team, will be welcomed to use or further adapt these tools for continued dissemination.

The impacts of the CSVP effort may be measured by the 100+ MW of community solar that will directly result, including some 40+ MW already commissioned by SMUD and Utility Forum members. However, the most important impacts are harder to measure. These are just beginning to manifest, from numerous innovations that CSVP encouraged among the project's direct utility partners and others.

For example, SMUD's embrace of using target market segmentation rather than siloed technologies as the primary organizing principal for its program offerings is exactly the kind of innovation necessary for truly integrated programs (e.g., solar plus storage or DR) to take hold.

One notable finding was that the strategies CSVP introduced for high-value community solar appealed strongly to utilities developing *community-scale* solar portfolios, whether individual, local projects would serve community solar programs or more general utility-led DER needs. The market for the CSVP Solutions Toolbox is likely to reach farther than first expected.

The feedback on CSVP's two solar-plus planning guides (for DR and storage companion measures) indicates that these certainly will have a broad audience. These guides are both first-of-their kind publications. As one CSVP Utility Forum member noted during a review meeting, "We won't face a real need for managing duck curve issues (with DR or storage) for about five years yet, but in terms of the planning horizon, five years is soon enough."

The CSVP team has introduced utilities to numerous high-value strategies for community solar that are market-ready or even "best practice," but are not commonplace. The team and all those working on the ongoing transition of the electric utility industry must acknowledge that although changes—from becoming more customer focused to addressing increasing solar and DER integration—are necessary, they may not be fully realized for three to five years—or more. While it is beyond the scope of the current project, the CSVP team would welcome the chance to continue to monitor progress, measure success and grow better community solar programs and community-scale solar projects.

Table of Contents

Background:

Community solar has been a popular concept in the solar industry for more than a decade. From initial projects more than 15 years ago, the vision of a solar array shared in a local community has captured the imagination of solar advocates and green community leaders. Over the past decade, that vision has grown into an industry with over 400 MW of capacity installed to-date and some 180 utilities either supporting or planning programs for their customers. Because the market potential is vast, with the promise of serving customers who (for locational or economic reasons) otherwise could not access solar, community solar has drawn attention from research, business, policy and advocacy sectors.

The Community Solar Value Project (CSVP) has contributed to this body of knowledge by focusing our efforts in underexplored areas of applied research. First, in the conception of this project, the CSVP team made a conscious decision to focus on *utility-driven community solar program design.* The team included Stephen Frantz of the Sacramento Municipal Utility District (SMUD), an early utility pioneer in community solar, and SMUD signed on as our primary utility partner. While many solar advocates take an adversarial position with utilities, the CSVP team decided to explore avenues where a “win-win” solution between utilities and community solar customers could be found. To date, community solar “enabling legislation” and related rules are in place in just 16 states (plus the District of Columbia); however, utility-led community solar is possible in every state, even without such legislation.

The CSVP team has an extensive background working both with utilities and with the solar industry, and it put that background to work throughout this project. In particular, by understanding the program design and planning processes already in place at many utilities, the CSVP team was in an excellent position to drive improvements in the area of community solar program design. Unlike the past research into *what* utilities were doing (as cited above), the team focused on *how* utilities could add value and expand or replicate their community solar programs.

To capture the diversity of utility situations (including size, expertise, stage of solar development, quality of solar resource, etc.), and to meet the Solar Market Pathways goal of project replicability, the CSVP decided not to work with a single utility partner, but with a larger group, which over time grew to 15. This Utility Forum identified real-world barriers and opportunities, reviewed team for critical deliverables and incorporated CSVP innovations and lessons learning into their ongoing community solar efforts. In large part, the project focused on productive stakeholder engagement, both inter-departmentally within the utility and outside it.

The Utility Forum included two investor-owned utilities; a joint-action agency and its four municipal members, and five other public power utilities. (A matrix, listing Utility Forum Members and other utilities that played a strong role in CSVP is found in the Appendix.) By the third year of the project, the Forum had expanded, adding one more IOU, two electric cooperatives, many more public power utilities, and advisors from the Western Area Power Administration, American Public Power Association and National Rural Electric Cooperative Association. As the project became more engaged in replication, the CSVP leveraged another relationship, with the Peak Load Management Alliance and its utility members, to develop its effective reach even further. CSVP Utility Forum contacts are provided in an Appendix.

From within the Utility Forum, the CSVP selected Public Service of New Mexico (PNM) as a prospective “replicating utility” that could learn from SMUD’s experience and develop its own program, including taking advantage of unique capabilities with a solar plus storage model.

Within the selected area of utility-driven community solar program design, the CSVP team initially chose four “challenge areas” on which to focus:

1. Strategic solar project design;
2. Project financing and procurement;
3. Target marketing for customer acquisition; and
4. Integration with solar-plus companion measures, such as demand-response and storage.

In 2016, the Project SOPO was amended to include a fifth area of focus -- “win-win” program pricing.

Expertise in these five challenge areas varies widely from one utility to another. One key advantage of working with a diverse group of utilities became obvious within the first few months of project activities--utilities like to learn from one another, and appreciate well-facilitated opportunities to exchange information about real-world issues. For example, on this Project, SMUD has very strong expertise in market research and target marketing; SMUD’s market research professionals had the opportunity to advise other Utility Forum members in this key area. On the other hand, Tucson Electric has a very strong solar procurement team and practice, and was able to provide advice that will help other CSVP participants in buying smarter.

Since its inception, CSVP contributed to the advance of the state of the art for community solar. The team researched available research and practices in each of the CSVP's five areas of concern and reviewed findings, often with members of our Utility Forum. Where existing resources were strong, the team collaborated with their sources, in order to make them more widely available. Where existing resources left important questions unresolved, this Project introduced innovative new works.

In some of those cases, the CSVP took a research orientation, participating in a scientific or policy collaboration. Team members published in proceedings and industry publications with editorial review. The Project produced several publications that are suited for wide dissemination and for use as a basis for further development to advance the state of the art. Sometimes, however, the market has been best served by a more action-oriented, informal approach, so in those cases, the team used presentation formats for webinars and workshops.

The overarching process for CSVP was based on energy-services program design processes advanced by the authors, which has been fine-tuned and applied industrywide, since its introduction in the 1980s. The innovative focus on cross-departmental collaboration (aka “silo-busting”) was rooted in more than a dozen published papers, including some offered by the Harvard Business Review. Specific publications are documented in a resource list that appears on the CSVP Solutions web pages.

As detailed in the full report, CSVP built on existing research and market experience, including best practices, in each of its five focus areas. For example CSVP made a careful study of the market research work already assembled by SunShot award recipients. The team also studied innovative market-research work at SMUD, and it and worked with its Utility Forum to identify remaining areas of need. As a result, CSVP developed a five-step guide to customizing existing market research and accessing the benefits of target marketing more cost-effectively.

Likewise, CSVP built on existing work in the area of strategic project design, especially focusing on carports as a potential solution for SMUD and other urban utilities.

The CSVP GAP Process (described in Results, below) embodies market-based research and innovation in several areas, including strategic project design, target marketing, procurement and pricing. Its roots were in the examination of how solar value analysis works (effectively or not), in advancing utility programs that are internally driven, rather than part of a prescribed regulatory process. Some shortcomings of value-of-solar (VOS) analytics and needs for improvement were outlined just prior to this Project in a report by Cliburn and Associates for SEPA: *Ratemaking, Solar Value and Solar Net Energy Metering (2013)*. That report, in itself, was based on many works in the field of solar value, and on input from 14 industry stakeholders.

The GAP process was developed in stages over the course of the CSVP, and it was finalized through a Solar Market Pathways Technical Assistance (TA) agreement with the National Renewable Energy Laboratory (NREL). The first stage was a 2015 TA consultation, which framed questions about how to assess the value of strategic community solar, plus DR and storage. After that meeting, which was hosted by Lawrence Berkeley National Laboratory (LBNL) and included NREL plus Utility Forum members and stakeholders, the CSVP team concluded that flexibility and streamlined implementation were keys to developing a new, market-oriented analytic process.

This was underscored in subsequent meetings with upper-level management at SMUD, who called for an economic-modeling process that could "build a compelling narrative" for local community solar, rather than a process that risked kicking off protracted internal debate over relatively unimportant inputs to the model. The resulting GAP process was market-tested with SMUD and subsequently with the Platte River Power Authority and through a more generic approach, with Arizona's IOUs. Generic versions of each modeling scenario are posted on the CSVP website.

Each of the five challenge areas overlaps with significant research in valuation of solar (and other) resources, solar technology design and applications, storage applications, DER integration, demand response program design, and utility customer segmentation; we discuss research in each topic in context below. Extensive resource guides with annotated links to dozens of carefully selected references are available on the CSVP website.

Notably, the team found essentially very little substantive research on the application of utility procurement processes to distributed solar projects. Some foundational work was adapted from other sectors. For example, the U.S. Environmental Protection Agency, offered procurement advice in publications promoting solar development on mitigated waste sites, through its "Green Fields" initiative. Some work from the U.S. DOE Better Buildings program was also used, though again, procurement advice was written from the point of view of a utility customer, not of the utility itself. Since before the inception of this project, Cliburn had worked with the Rocky Mountain Institute on community-scale solar, whose current Shine project (with co-funding from the New York Solar Energy Research and Development Authority and Green Bank) has demonstrated utility procurement approaches that significantly lower costs. CSVP supplemented all this work with field reports from its Utility Forum members, and it widely disseminated new best practices.

In addition to CSVP's detailed "solar plus DR" and "solar plus storage" guides, the team produced a solar plus storage modeling project with PNM staff. It was rooted in research experience of PNM, gained in completing the U.S. DOE ARRA-funded demonstration grants program. Sandia National Laboratory evaluated that solar plus storage project, and that evaluation helped to spark the alternative, strategic scenario that PNM modeled with CSVP in 2017.

Introduction:

As described above, the "challenge areas" selected were relatively unexplored in the context of community solar. As a result, the CSVP team was able to make some significant technical contributions in each area. In addition, thanks to the decision to focus on utility-driven community solar program design, the CSVP team had an unusual degree of access to utility staff throughout this project. Hence many of the most valuable results from the CSVP project come in the form of lessons learned in *how to apply* our technical results effectively in the context of utility planning processes.

As stated in the Statement of Project Objectives (SOPO), the CSVP had five primary objectives, which can be summarized as:

Create a Successful Process / Case Study – Work with SMUD to create a plan to reimagine Solar Shares (its community shared solar program) from one MW to an expanded program with multiple shared solar components with six to 20 MW by 2020.

Apply Technical Knowledge Base to Create a Compelling Market Value Proposition – Provide tools and resources required for utility program designers contemplated community-scale solar projects, focused on cost reduction and value creation.

Innovate 3 Related Business Models to Capture Market Potential of 40 MW and mid-term Market Potential of 10GW or More – Work with SMUD and other members of our Utility Forum to ensure that lessons learned with SMUD transfer to other geographies and market / regulatory situations.

Replicate and Disseminate Project Results to Increase Market Impact – Work with Utility Forum members interested in their own community solar projects; disseminate results through webinars, conferences, workshops, the CSVP project website, and the extensive industry networks of CSVP team members.

Complete Pricing Case Study – A small modification to the SOPO called for structured interviews and market assessment, to produce a database of at least 10 current community solar pricing programs that demonstrate a breadth of different options. This objective was added in early 2016, as a result of feedback from CSVP utility partners and other SMP-funded projects that indicated pricing was a significant challenge.

As ambitious as this research agenda was when the CSVP began, all objectives have been met. *Of particular note is Objective 1 – SMUD has committed to a multi-faceted Solar Shares program that will procure over 100 MW of solar resources for SMUD* *residential and commercial customers. This impressive result is discussed in more detail below.*

To accomplish these objectives, the CSVP team and DOE agreed to a scope of work structured in five tasks:

Task 1: Primary Stakeholder Process and Plan – Work with SMUD and other stakeholders in Sacramento to develop a plan for a re-imagined and expanded Solar Shares program.

Task 2: Community Solar Business Model Design, Analysis, and Customization – Work with SMUD, PNM, and Utility Forum members to improve on existing community solar business models by identifying additional sources of value to incorporate into new program designs. Amended in 2016 to include pricing work described above.

Task 3: Solar Project Strategic Design and Integration – Identify new technical sources of grid value for more advanced solar designs and strategies for integrating community solar programs with "companion measures" in demand response and storage.

Task 4: Utility Collaboration and Replication of the Process/Plan – Work with the Replicating Utility and with representatives from the Utility Forum to ensure that the methods developed at SMUD can be applied successfully in other utility program designs.

Task 5: Dissemination of the Project Tools and Results -- Disseminate results through webinars, conferences, workshops, the CSVP project website, and the extensive industry networks of CSVP team members.

Project Results and Discussion:

This section will summarize major accomplishments in each task area, with discussion of particularly important (Go/No-Go) milestones. This section also provides a summary of its engagement and impact on stakeholders throughout the industry. Finally, the discussion focuses on the meaning and continuing impact of this work.

Summary of Results by Task Area

Major accomplishments in each area included:

- Task 1. Working through a facilitated interdepartmental planning process with SMUD, including feedback from Utility Forum members, consider multiple candidate business models and program designs for an expanded SMUD Solar Shares program. At the conclusion of the CSVP, SMUD was proceeding with plans to place community solar—broadly defined—at the center of its new resource development plan. *It will implement a 150-MW Solar Shares program with multiple shared solar "products" to serve different market segments and customer classes.* Implementation has begun and will expand over the next two to five years.
- Task 1. The CSVP introduced a flexible model for utility-led community solar program design, based largely on the planning experience with all Utility Forum members, and especially with SMUD. The model focuses on cross-departmental collaboration and on effective ways to balance in-house and out-sourced expertise—two challenge areas that Utility Forum members and other utility stakeholders have deemed to be both difficult and imperative to address.

- Task 1. The over-arching accomplishment was reflected in evaluation surveys, completed in each year (2015-17), after the major workshops. These surveys explored Utility Forum and SMUD staff responses on project decision points outlined in the SOPO, and they guided work moving forward.
- Task 2: In the areas of procurement and pricing, CSVP identified numerous opportunities for reducing soft costs and expanding the market. As noted above, CSVP provided guidance in balancing in-house and out-sourced expertise and contributed to market-pressure that led third-party providers to offer utilities more flexible community solar products. CSVP identified a need for refining the RFP and procurement process, and responded by developing a resource guide and a current RFP archive. Smarter procurement is also reflected in the CSVP GAP analytic process. All these market-based innovations were applied in some part by Utility Forum members and disseminated widely.
- Task 2. CSVP developed methods, resources, and a guide for customized market research and targeting. Areas of innovation: how to assess and customize widely-available market research, how to work cross-departmentally to leverage internal market-research information, and how to tailor the offer and the message to specific segments that can help advance *high-value* community solar options. These innovations were applied by Utility Forum members and disseminated widely. Strikingly, the market segmentation model and customer-driven program design that CSVP identified as best practices are now central to a revamped utility wide business model at SMUD.
- Task 2. Pricing sub-tasks may be categorized under business model innovation. CSVP cataloged 12 utility-led community solar pricing offers. These are not necessarily best-practice, but they reflect the range of options in the market today. CSVP also produced a detailed critique of California (IOU) pricing models for community solar, which has been published and discussed in the industry press. CSVP engaged in technical-support discussions with the Regulatory Assistance Project, to refine its understanding of possible solutions. Finally, in an overlap with the Task 3 element, on the GAP analytic process, CSVP extended that economic-analysis to incorporate market-ready solutions for more competitive, yet utility-friendly solutions for community solar pricing.
- Task 3. In the area of strategic community-solar project design, CSVP focused on engaging Utility Forum members and the industry at large to incorporate more high-value design elements. These ranged from better siting to greater use of solar carports and shade structures, to developing distributed and well-operated fleets, and integration with DR and storage measures (see documentation below). Market-based research in these areas was documented and disseminated through various means. In particular, CSVP produced two guides that are the first of their kind—introducing program managers and utility decision-makers to the value of solar plus DR and storage. These guides exemplify how CSVP has taken research out of the labs and place it into the market.
- Task 3. Work under Task 3 is also embodied in the GAP analysis process, which CSVP has innovated and tested with Utility Forum members and more widely (see documentation below). That work opened greater opportunities for further

development and application; some of which will naturally take place in the market, and some of which CSVP continues to advocate.

- Task 4. The replication work completed with PNM included meetings with cross-departmental stakeholders, including on the customer-programs side, the policy side (investigating low-income program options), the pricing side, and the DER-innovations group. PNM reports that it is likely to implement full-scale community solar in two to five years, pending possible state legislation. Initially, PNM was motivated to re-introduce a voluntary green-power program, which had fallen off in recent years. Further, discussions are currently underway between PNM and the City of Santa Fe to advance a community solar pilot.
- Task 4. PNM's contribution to advancing the CSVP solar plus DR and storage strategy stands on its own, as a way to engage grid-engineers in considering distributed community solar solutions. A PNM solar-plus modeling project was presented and discussed at utility industry events, prior to recent publication of a final report. PNM staff continues to take this work forward.
- Task 5. CSVP initiated relationships with many organizations in the industry, including American Public Power Association, National Rural Electric Cooperative Association, Western Area Power Administration, National Community Solar Partnership, and Peak Load Management Alliance. At the urging of Extensible Energy, the CSVP Prime, PLMA has launched an Integration Interest Group, which works on renewables integration strategies in collaboration with other PLMA interest groups in DR, storage and clean electrification. Specific channels used (webinars, workshops, presentations, publications, interviews, one-on-one meetings, etc.) are documented in an Appendix. Several of these relationships hold promise for continuing to deliver the message and tools of the CSVP.

With respect to the positive results at SMUD, it is worth noting that multiple SMUD departments as well as senior management have all made specific commitments for procurement and customer enrollment in multiple community solar program "products," which, taken together, may well represent the largest community solar program led by a public power utility in the country by 2020. The SMUD community solar strategy was publicly introduced at the APPA Customer Connections Conference in Sacramento in November 2017 (see Appendix C for this presentation).

CSVP cannot take all the credit for this remarkable transformation in the SMUD Solar Shares program. External pressure from customers (particularly commercial customers including key accounts with ambitious sustainability goals), steady internal work by product champions and the continuing decline in solar hardware and project costs all contributed to a fertile environment for SMUD's expanded program vision. Nevertheless, CSVP contributed many elements to the resulting program design and scope.

Five events were of particular importance *in our work with SMUD*, our primary utility partner:

- March 2015: On-site Program Kick-Off Workshop for SMUD stakeholders
- June, 2015: On-site Program Design Workshop, including Utility Forum

- August, 2015: Off-site Workshop on Solar Value and Solar-Plus Integration
- February, 2016: Off-site Design Charrette / Pricing Workshop
- August, 2016: On-site Program Design Solutions Workshop with Utility Forum

Additional events, relevant to other project tasks included

- Annual SMP Peer Learning and Leadership Workshops (3)
- June 2017: Community Solar Procurements, Programs and Pricing with Utility Forum (Golden, Colorado)
- CSVP-sponsored webinars (see below), scheduled to engage a broader audience with CSVP products and processes.
- Presentations at some two-dozen industry events (see list in Appendix)

Below, these events are discussed in context of the key milestones and deliverables. In Year 1 CSVP completed all Go/No-Go milestones. These assured that:

1) Work to incorporate high-value community solar strategies in the SMUD revised Solar Shares plan would be off to a strong start

2) The team would be off to a strong start in customizing the baseline SMUD business model (also called the “strawman model”) in order to support a portfolio of high-value options with elements from each of CSVP’s five challenge areas

3) Particular effort would be focused on defining opportunities to tap integration value for community-scale solar. This included innovating ways for utilities to consider solar plus storage and DR measures, in order to increase the net value of their programs.

In Task 1, *Primary Stakeholder Process and Plan*, the CSVP team engaged closely with stakeholders from SMUD staff and other representatives to identify community needs and opportunities, understand SMUD’s internal planning processes, locate important data resources, and build consensus around the issues to be addressed in SMUD’s Solar Shares plan. This included an initial kick-off meeting with a nascent cross-departmental working group and follow-up onsite meetings. Task 2 and Task 3 activities dovetailed into this developing stakeholder process, as SMUD initiated its expanded high-value community solar plan.

At the same time, CSVP had concerns about the replicability of the process and outcomes. SMUD had unique characteristics—its level of experience, extraordinary commitment to customer satisfaction, program cost and pricing concerns, staff organizational model, etc. The team recognized that Utility Forum member also had unique characteristics, and that one of the greatest challenges in growing the market for community solar is bridging the differences among utilities and identifying widely applicable best practices.

Thus, a Business Models Workshop (also called a Program Design Workshop), held June 22-23, 2015 in Sacramento, was aimed at both furthering SMUD’s specific plans and at engaging Utility Forum members in building replicability from the start. The workshop introduced SMUD’s baseline community solar business model, and then worked with the full group to discuss how that model could be customized to meet specific, strategic utility and target-market needs.

Community solar program customizations for three SMUD situations were discussed:

- Neighborhood redevelopment – A project targeted at a specific neighborhood, focused on low income customers. Participants identified opportunities to work with neighborhood organizations, local merchants, and city initiatives that would allow a community solar program to leverage other investments as part of a larger redevelopment effort.
- Key accounts – This situation pertained to an interest in customizing the community solar offer for key account customers. What specific solar-project designs, companion measures, and pricing plans would meet the needs of customers, such as large health care businesses or local data centers? Program net value could increase as the utility helps customers meet sustainability goals and as it might incorporate suitable solar-design measures or DR and storage directly into the program design.
- Competitive residential offer – This discussion was focused on defining ready target groups within the residential sector and on making an innovative offer, including pricing that would focus on bottom-line value rather than side-by-side comparisons with rooftop solar or other alternatives.

SMUD was ideally suited to host this discussion, because the utility already had committed to offering more than one community solar product in a portfolio. During this workshop, SMUD staff and Utility Forum members alike came to a better understanding of how various iterations of “high-value” community solar differed from a standard baseline model. In addition to breakout discussions, specific presentations were provided on strategic solar design, strategic financing and business model solutions, how target marketing works, and defining solar plus storage and DR opportunities. More than two dozen members of SMUD staff from multiple departments joined the CSVP team, DOE Project Manager, and eight Utility Forum representatives for a deep dive into issues of market trends, technology, and program design in community solar and storage.

In terms of the SOPO, this Workshop showcased the results of work on Assumptions for Baseline CSS Business Models and on Existing Market Research Relevant to Preferred (High-Value) Program Models. ***The Workshop and featured presentations on business model assumptions and on existing, relevant market research constituted successful completion of three go/no-go decisions for Budget Period 1.***

As a follow-on to the Business Models Workshop, the CSVP team began work to promote and replicate SMUD innovations in market research. This included focused interviews with staff and a review of internal documents on research practices and studies. The SMUD market research team is far ahead of many utilities in their approach to market segmentation and targeting. In fact, their strategy was recently adopted to drive a utility-wide reorganization around market-segment needs, instead of technology areas. That could become a huge innovation in the realm of utility-based energy services. The results of this work were initially presented at the 2015 SPI conference (Las Vegas, September 2015) and at a national conference on promoting energy efficiency and renewable energy options through behavioral-change (BECC Conference in Sacramento, October 2015). They were refined in subsequent years and resulted in a step-by-step guide to *Market Research and Market Segmentation for Community Solar Program Success* (December 2016), as well as an annotated resource list for those who want to dig deeper into the topic. In addition, the Team released a simple checklist tool. This work complemented the national survey work by SEPA and Shelton Group, as it focused on how to customize nationally available resources for local use, regardless of the size and budget of the replicating utility.

Market Research Checklist for Designers of Utility-Based Community Solar Programs

- ☐ **Step 1. Assessing Needs**
  Determine where the utility needs assistance the most (e.g., overall program design, identifying top targets, identifying companion measures, determining marketing messages)
- ☐ **Step 2. Drawing on Outside Research**
  Build on knowledge from other utilities and outside resources (but question the questions, and recognize that education on community solar will be critical)
- ☐ **Step 3. Mining Customer Data**
  Understand what customers want and need through data mining
  - ☐ Explore existing target-market segmentation related to any existing utility programs or services
  - ☐ Assess and tap into existing data sources, such as energy usage patterns or survey data
- ☐ **Step 4. Interviewing Customers**
  Collect program specific data
  - ☐ Determine opportunities to (1) collect data through primary research and (2) leverage cross-departmental resources for gathering data
  - ☐ Conduct qualitative research, e.g., focus groups or in-depth interviews, to explore issues
  - ☐ Conduct customer surveys to test hypotheses and explore alternative options
  - ☐ Analyze all available data to inform the development of the program and marketing plan
- ☐ **Step 5. Developing a Program Design with Feedback Loops to Monitor and Adjust**
  Develop an interactive program-design process, integrating enhancements based on customer feedback with technical concerns, such as project siting and design, pricing, customer sign-up and billing, etc., to create a win-win for both the customer and the utility. Build in feedback loops to monitor and adjust.

Figure 1: CSVP market research checklist for designers of utility-based community solar programs.

In 2015, CSVP also published a short report on *Community Solar Project Ownership Structures and Financing.* This proved popular, because public power utilities in particular could not easily access information on financing that addressed their needs. (Most existing materials have been written for utility customers or municipal governments, outside of the utility. After a successful webinar on this topic, co-author Andrea Romano (Navigant) presented at three or more national conferences, including InterSolar 2015. She led CSVP in engaging with the third-party developer sector, which was led to a strong evolution in CSVP's approach. The project continued to promote utility leadership, but also smart procurement of out-sourced products and services. CSVP found tremendous savings opportunities in that strategy.

This evolution also influenced the third-party developer sector, as they responded well to the utilities' call for more customized services and greater transparency. This impact began in 2015, but built throughout the project, well into 2017.

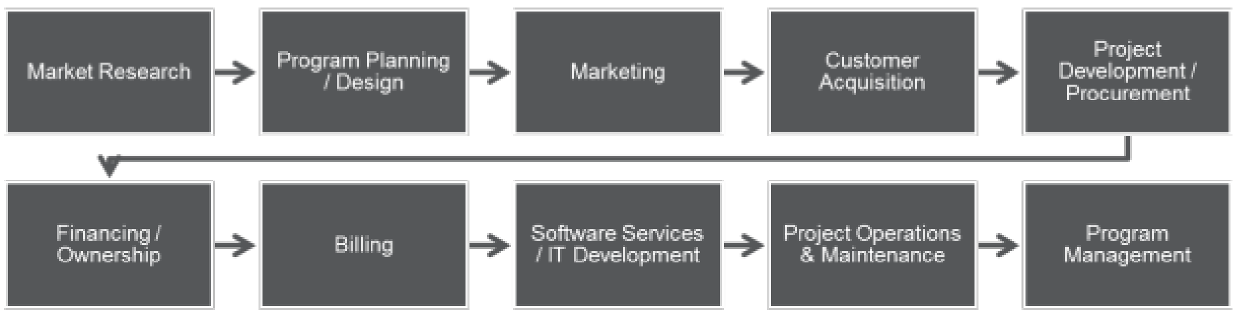


Figure 2: Simple Community-Solar Program Value Chain. Source: Navigant.

For example, the CSVP team identified a number of companies that provide products and services all along the community solar value chain and divided them into four categories. This helped utilities to get a better feel for the kinds of third-party help that is available, and specifically, where to look for it

- *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 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 management 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).

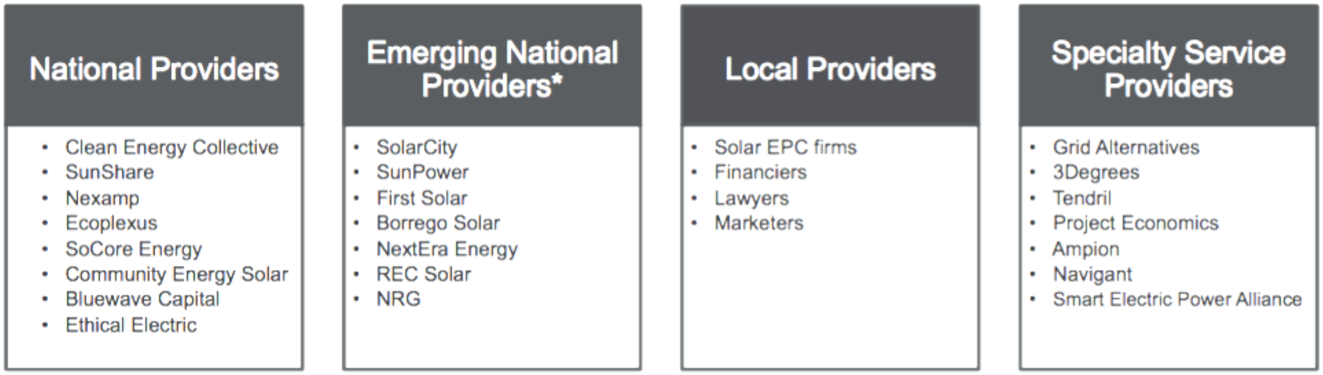


Figure 3: Community Solar Third-Party Players. This reflects a market assessment as of late-summer 2016. Listings of companies are representative, but not all-inclusive. Source: CSVP

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

Utility Forum members also played a key role in this evolution. Forum members had different levels of expertise and preferences in solar procurement, some contributing from their own procurement innovation, and others learning and including innovations in their future program plans. For example, Tucson Electric Power expressed the view that solar was a core part of their business, and that procurement of solar should be as important as procurement of “wires and poles.” TEP brought a policy leader, a procurement specialist and an in-house solar developer to meet with other Utility Forum members. Some TEP innovations were embraced. In other cases, utilities expressed the view that building such expertise internally should not be a prerequisite for undertaking their first community solar program; they expressed a greater willingness to outsource either some or all of the elements in a community solar program. The dialog was a great help in developing CSVP’s flexible, customizable processes.

The CSVP Team developed multiple program deliverables to assist in procurement-related decisions:

- The *Outsourcing Decision Key* begins with a community solar value chain (See Figure 2), and helps utilities to assess their own expertise and bandwidth in the roles and responsibilities typically assigned to the various portions of this chain. This document also provides valuable information on vendors active in different areas of this value chain.
- A longer *Community Solar Market Landscape Brief* delves more deeply into these considerations, and provides examples of how utilities are managing these decisions to achieve savings in scalable community solar programs through smarter procurement decisions.
- A *Procurement Resources Guide* provides annotated links to some of the best resources available for pursuing various solar procurement strategies.
- A library of RFPs for utility-led community solar procurements provides access to the specific RFP language used in more than 10 utility procurements.

- A *webinar from December 2016* with speakers from three leading utilities discussing three different approaches to community solar procurements.
- Featured presentations at a 2017 workshop, focused on Procurements, Programs and Pricing for Community Solar, including presentations from TEP, Rocky Mountain Institute's Shine Program, and other Utility Forum members who shared positive procurement case studies. Also, hands-on support in two workshop breakout sessions. A total of about 30 utilities were involved.

Two key takeaways from this extensive review of utility procurement practices are 1) that there is no need for utilities to start from scratch with the procurement of their first community solar project; a wealth of information (including that compiled on the CSVP website) can jump-start their process, and 2) when the utility get to the point of issuing and reviewing the project RFP, there are many ways to reduce net project costs and improve outcomes.

Based on our work Utility Forum members and especially TEP, SMUD, Pedernales REC, and researchers at Rocky Mountain Institute (a non-utility participant in several Utility Forum efforts), we believe our utility best-practices can reduce average installed-solar costs by at least 15%, and that average total program costs may be reduced by an additional10%, up to a best-case scenario of 30% or more. Conversely, procurement mistakes can drive up community solar program costs, including the cost of program delays and troubleshooting. The CSVP team is prepared to complete a more refined impact analysis on procurement best practices, if funding is available.

It should be clear from this discussion that the achievement of a Go/No-Go milestone in Year 1, or in any year, could not be viewed as a final achievement. The key milestones achieved early in the project created a strong foundation for further work.

This was true of the **Year 1 Go/No-Go milestone for Task 3, Solar Project Strategic Design and Integration, which was fulfilled by the Integration Workshop, held August 28, 2015.** The focus of this Workshop was to explore integration measures that could be implemented with or around community-scale solar development of solar, demand response (DR) and storage measures, as a "solar triple play" program. Key questions included

- What aspects of integration value are being addressed by other aspects of grid planning, besides strategic use of DERs?
- What are the best roles for DERs, in the context of a community solar program, in order to increase integration value?
- How would experts from the national energy labs and industry assess the preliminary work that CSVP had done in developing a solar-plus value model?
- What are top next-steps to accomplish?

The meeting was held at Lawrence Berkeley National Laboratory, thanks to the DR assessment team led by Mary Ann Piette, and it brought together the SMUD program manager, representatives of all firms on the CSVP team and multiple leading outside experts from LBL, Clean Power Research, and NREL. Brian Palmintier of NREL was available to CSVP, thanks to a Solar Market Pathways TA. He provided materials for study before the meeting and consulted on-site. The team filed a complete report on that TA.

The outcomes of that one-day workshop were pivotal. First, CSVP gained a more sophisticated understanding of integration value, which is still much needed throughout the utility and solar industries. The team determined that its preliminary efforts to develop a comprehensive solar-plus value model would be better re-directed at a streamlined approach, pertaining directly to the internal utility decision-making process, rather than on fixed values. While the labs and other institutions continue to develop sophisticated models, we confirmed our early decision to focus on the "solar market pathway," and *field-ready modeling*, which could subsequently provide input for more refined models and market growth.

Second, this workshop helped CSVP to move forward specifically toward completing its two guides for implementing companion measures with community-scale solar programs. The first, *Demand Response Companion Measures for High-Value Community Solar,* was subsequently completed in draft in 12/2015, after a detailed review by the Utility Forum. ***This satisfied the final Go/No-Go condition for BP1, which pertained to Task 3.***

Table 4-1: DR Opportunity Assessment (Options 1-7)

	DR Option	*Yearly Cost Planning Estimate ($/kW)*	*Avg. Load Impact per Unit*	*Seasonal Availability/ Impact*	*Events Feasible per season*	*Signal-to-response time*	*Duration of Impact*	*Target Customer Class*
1	Curtailable Load (Day-ahead)	$198	Depends on end-use	Most effective during peak season	Frequently limited to less than 50	20-26 Hours	2-6 Hours	C&I
2	Curtailable Load (Day-of)	$228	Depends on end-use	Most effective during peak season	Frequently limited to less than 50	3-5 Hours	2-6 Hours	C&I
3	Auto-DR	$265	Depends on end-use	14% of peak load winter; 16% for summer	Depends on program	5-15 Min	5 min–1 Hour	C&I
4	Direct Load Control (A/C switch control)	$47	0.37 kW -2.06 kW	Warm months only	~100	2-10 min	2-4 Hours	Res
5	Load Management (Smart Thermostat)	$85	.67 – 0.86 kW	0 .61-1.079 kW-	~30	2-10 min	1-4 Hours	Res

Figure 4. Excerpt from a two-page table in Demand Response Companion Measures, providing guidance on selecting DR measures for added solar-integration value

In 2016, to proceed from BP2 to BP3, the team met additional Go/No-Go Decision criteria. One of these criteria focused on work with PNM as a replicating utility, which brought specific interests and expertise in the area of solar plus storage and DR. PNM had an interest in exploring how to optimize utility-side storage, possibly by utilizing it *in combination with* circuit-level solar plus customer-side storage and DR. **The CSVP**

milestone for Enhanced Solar-Plus Guidance in collaboration with the replicating utility was achieved in BP2, first by producing a draft guide to ***Community Solar Plus Storage***, which outlined solar-plus options for utilities like PNM, and then by designing and implementing a study, which was later documented in the report, ***Community-Scale Solar Plus Thermal Storage and Demand-Response: A Modeling Study of Local Grid Benefits*,** with PNM. It shows how a solar-plus strategy would perform technically, on an actual PNM circuit, which was experiencing frequent low-voltage conditions.

The completed modeling study looks at the grid benefits of combining well-sited solar with water heater storage and AC load control operated for demand-response (DR). It uses field data to model and optimize the strategy, as it would mitigate low-voltage issues on a local utility feeder. The report concludes that a combination of distribution-scale solar, plus DR control of customer thermal storage, would eliminate all instances of low voltage in the optimized scenario tested. The study demonstrates a replicable methodology and underscores the importance of including technical as well as market and policy considerations in designing a high-value community solar plan.

Lessons learned in working with PNM, as well as lessons learned in working with SMUD on its specific DER community-solar products, led the team to refine and publish a final version of the CSVP guide, ***Solar Plus Storage Companion Measures for High-Value Community Solar***, which provided technology, economic, and application guidance for including storage measures on either the utility or customer side of the meter, in community-solar program design.

This guide provides a five-step process for utilities designing a solar plus storage program. While conceived as a process for community solar programs, the process applies to any community-scale solar resource, regardless of whether it is presented to customers as a community solar program offer.

Figure 3 summarizes the steps recommended. They are comparable to steps in any utility program-design process, where the early steps involve defining needs and opportunities, and the later steps involve ranking and then customizing viable solutions.

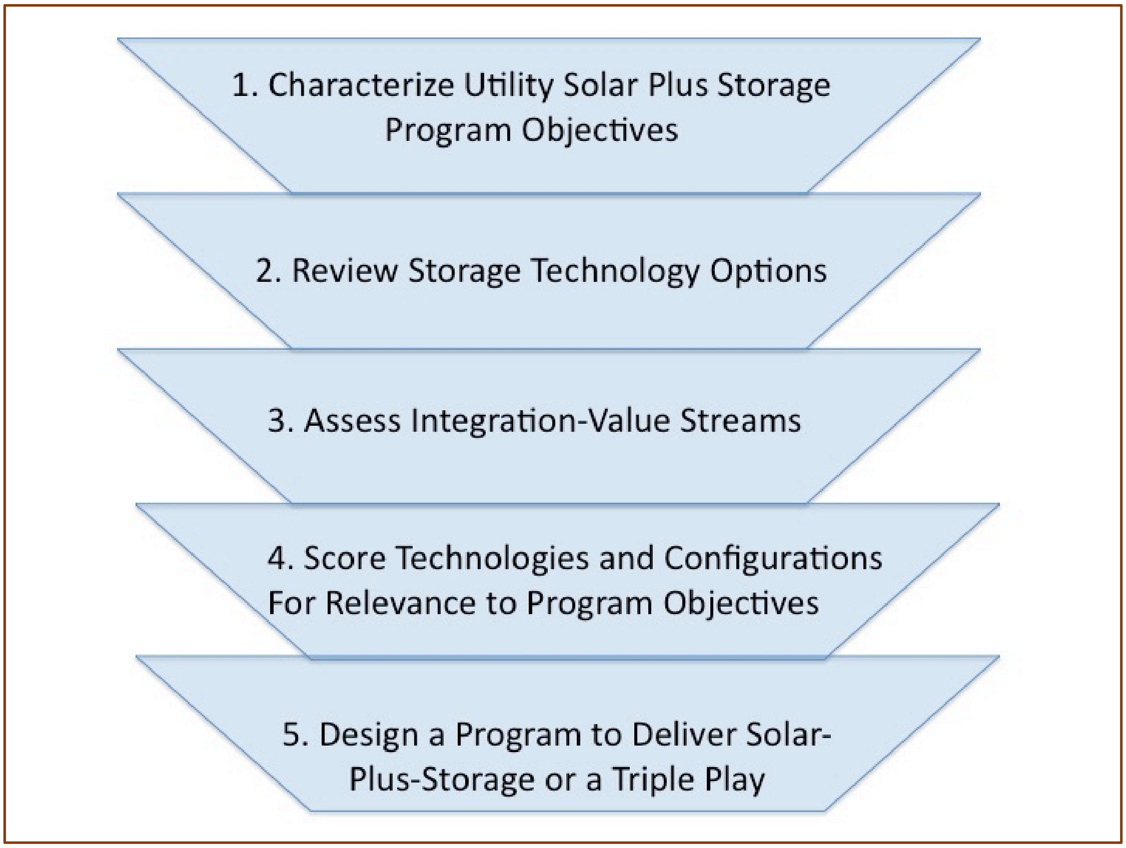


Figure 5: Utility Planning Steps for a Solar Plus Storage Program or Triple Play

The summary below briefly describes each step in this process, and it summarizes supporting information that is in the guide.

1. Characterize Utility Solar Plus Storage Program Objectives. The list of possible program objectives is long, and it is divided by perspective, whether from the utility view or from the customer view. Within the utility category, these include needs to address system wide renewable energy penetration; to address renewables penetration on a particular circuit; to address local power quality problems; to respond to customer interest; to test storage configurations for technical and market-based applicability; to manage market risks from so-called grid defection, and to respond to emerging policies and regional markets (e.g., an ISO that will monetize some integration values).

On the customer side, there may be specific reliability or power quality needs. More often, the need to deploy integration technologies arises from a desire to cut electricity bills, to take advantage of special incentives, to promote emergency service resilience or to decarbonize energy used. Upon completing this step, the planner should be able to answer the all-important question, *Why* pursue solar-plus at this utility today? With the answer in hand, the planner is more likely to gain all-important top-level support.

2. Review Storage Technology Options. The guide describes currently useful storage technologies, which may be deployed on either side of the meter. Familiarity with the range of technical options and applications (e.g., the types of batteries and their merits; types of thermal storage and their merits) will give the planner a better understanding of which technologies belong in the utility's solar-plus plan.

3. Assess Integration Value Streams. Another section of the guide describes integration value streams, which drive interest in solar plus storage. These are divided between those realized by the utility directly and those that are primarily realized by the customer. An example would be a value stream from frequency regulation, which could be monetized under certain local or regional market conditions. Completion of this planning step results in a short list of technologies that merit further consideration. A subsequent section will help planners to envision suitable deployment configurations, which can capture targeted value streams.

4. Score Technologies and Configurations for Relevance to Program Objectives. This step refines the planner's understanding of technical choices, and it helps define and prioritize which value streams would be most attractive to the utility and the customer. The storage guide offers two matrices for scoring value: one from the utility's perspective and one from the customer's perspective. If the utility plans to offer customer-side storage companion measures, then both utility and customer value streams are relevant. A supporting discussion focuses on understanding how different program assumptions impact outcomes and how utilities can customize scoring matrices, to suit their assumptions.

5. Design the Program to Deliver Solar-Plus-Storage or a Triple Play. At this step, the planner may refer to the overall, iterative CSVP process, taking input from both the utility/technical and marketing side. This section does not provide detailed program design advice, but it can help planners to set the stage for program-design success.

In the course of this work the CSVP team found that in many cases, utility-side storage is more economical when designed to tap multiple value streams, rather than closely integrating the storage resource with a specific solar project. Second, in behind-the-meter storage, in most markets, thermal storage (grid-interactive water heaters (GIWH), ice storage systems, etc.) is highly competitive with even the most aggressive forecasts for battery cost decreases over the next 3-5 years. As a follow-up effort, CSVP characterized the overall impact of a solar-plus strategy on reducing net solar costs, but learned that the study of grid-integration value is still evolving within the industry. The grid-integration value of community-scale solar plus storage and/or DR is significant, but difficult to generalize from market to market. It will be centered on the net reduction to customer-acquisition costs and reduced net program-implementation costs, until a greater number of utilities improve their capabilities to monetize grid-integration values. CSVP has identified several projects (federal lab consortium efforts and industry-led efforts) that are working on grid-integration value questions, and the CSVP team is well-positioned to contribute, if opportunities arise.

Two additional Go/No-Go decisions for BP2, moving into BP3, pertained to supporting the SMUD project in 1) assessing their specific community solar business-model/s and 2) technical project configuration/s. The objective was not merely to assist SMUD, however; it pertained to distilling replicable processes and lessons learned. **CSVP achieved these Go/No-Go milestones for BP2 in 2016, and it refined its understanding throughout the remainder of the project, in order to facilitate replication.**

CSVP worked with SMUD since the inception of the project on considering different community solar models, targeting specific customer groups, and treating each community solar offer as a "product" in a larger portfolio. CSVP proposed this as a "distributed solar fleet strategy," for capturing greater total net-value benefits, in terms of solar geographic dispersion, procurement cost-reduction, customer acquisition success, and more. CSVP identified numerous high-value solar project design elements. These are summarized in a 2017 publication ***Abstract: What is the GAP Process, and How Does It Help to Maximize Strategic Solar Design Value?*** and detailed in other publications on GAP. The team recognized that the best way to capture benefits would be to match specific project designs within a fleet to the target market segment that would be addressed *and* to the specific utility economic circumstances which define available value streams. (E.g., this might be for addressing a late-afternoon peak or addressing a locational grid-support opportunity or addressing non-utility interest in monetizing external value streams).

Further, in the context of real-world program design, the ultimate measure of success is a program that satisfies both customer and utility needs—generally recognized through pricing that both attracts/retains customers and is accepted by the utility as cost-based.

Two other pivotal events in early 2016 provided direction for what would ultimately become the GAP Process. First, in February 2016, an off-site Design Charrette / Pricing Workshop engaged the SMUD project lead with team members from each of the four consultancies participating in CSVP in an innovative exercise, walking back from a desirable program price point, through a review of business-model and strategic-design options that would be needed to get there, given the utility's market- and policy-based requirements. The following meeting at SMUD engaged leadership at the vice-president level. The team outlined the new, proposed economic-analysis process. One comment, in feedback, was that this practical approach was much-needed. Rachel Huang, Director of Distributed Energy Strategy, commented that she needed a "compelling argument," for local community solar, supported by economics, but not overshadowed by detailed and potentially contentious analytics.

This was the genesis of the GAP Process. The team recognized that, like SMUD, many utility-led community solar programs struggle with the economics of community-scale solar and the need for pricing that is both cost-based and competitive. Thus, instead of recommending a single business model or technical configuration, CSVP focused on developing a process, which could be applied to different utility situations. Note that this process was designed primarily to support community solar program design, but it is also a tool for utility decision-making around other distributed PV procurements.

The name for the GAP process refers both to the goal of finding just enough benefits to fill the gap between a standard PPA LCOE and a net LCOE that would support a competitive program price. It also refers to the acronym for "getting at price." GAP objectives include

1. Basing the analysis on a program narrative, which concisely describes all the benefits of the procurement and the community solar program;
2. Utilizing the analytic processes as a tool for decision-making, and not as an end in itself;
3. Encouraging the introduction of customized solar design elements that add strategic net value;

4. Including a rigorous solar- benefits analysis, narrowly focused on achieving the GAP pricing goal;
5. Adapting familiar rate-design strategies for pricing the offer.

The initial GAP analysis was developed for SMUD, especially focusing on the question of whether local community solar could compete favorably with generation purchased from large utility-scale projects and delivered via transmission to local customers.

To confirm that the process would be replicable, the CSVP team also analyzed multiple potential solar project configurations in three locations in the Western US: Northern California (using generic data, based on SMUD's experience), the Desert Southwest (using generic data, based on publicly available data from Arizona Public Service), and the Rocky Mountain West (using generic data, based on experience with the public power joint-action agency, Platte River Power Authority). Each scenario included a full 8760-hour analysis of realistic utility marginal costs for a portfolio of 2-MW distribution-sited solar facilities.

GAP Process analytics are notable for using a relatively novel approach to calculating the net levelized cost of energy (LCOE), which is more appropriate than the LCOE that is typically presented in a power purchase agreement (PPA) pro forma. LCOE is defined as the net present value (NPV) of project costs divided by the NPV of generation (kWh), evaluated over the life of the project. When nearly all generation resources were centralized on the transmission grid, this metric was simply applied to various resource acquisitions. But increasingly, distributed energy resources are providing strategic value as well as kWh generation, and utilities must also consider the incremental levelized benefits of strategic distributed PV (DPV), as well as the levelized costs. The generic equations for this net LCOE are:

- $LCOE_{DPV\ NET} = LCOE_{DPV\ GROSS} - LBOE_{DPV}$

Where $LBOE_{DPV} = LBOE_{GENERATION} + LBOE_{TRANSMISSION} + LBOE_{DISTRIBUTION} + LBOE_{SOCIETAL}$

(Here, $LCOE_{DPV\ GROSS}$ represents the PPA price, and $LBOE_{DPV}$ represents the DPV benefits.)

We refer readers to a complete compilation of documents on the CSVP website (http://www.communitysolarvalueproject.com/assessment.html) that detail the process. Here, focusing only on the calculations themselves, we note that a range of strategic benefits may be included in the project narrative, but only project-specific benefits that can be monetized are included in the LBOE. Thus, the net LCOE reflects an *adjusted PPA*. It may be used to compare community solar project choices—e.g., a local project with grid benefits vs. a larger, remote project, or a half-dozen smaller, strategic projects vs. a standard larger-scale project. Figure 4 summarizes how a small number of benefits can impact the net LCOE and help to meet a target price.

	PV PPA Price ($LCOE_{GROSS}$)	$0.075
Baseline Cost ↗		

	DPV Value Category (LBOE)	Value ($/kWh)
	DPV Benefit Category #1	$0.010
	DPV Benefit Category #2	$0.005
	DPV Benefit Category #3	$0.005
Aggregated DPV Benefits ↗	**TOTAL OF DPV BENEFITS ($LBOE_{GROSS}$)**	**$0.020**

	PPA Price Adjustment Calculation	Value ($/kWh)
	Baseline PPA Price ($LCOE_{GROSS}$)	$0.075
	Aggregated DPV Benefits ($LBOE_{GROSS}$)	$0.020
Cost Minus Benefits ↗	**Adjusted PPA Price ($LCOE_{NET}$)**	**$0.055**

	Program Price Offering Calculation	Value ($/kWh)
	Adjusted PPA Price	$0.055
	Non-Bypassable Wires Charge	$0.045
Indicative Pricing Estimate ↗	**Community Solar Program Price**	**$0.10**

Figure 6: Generic 'Gap Analysis' Calculations

Elements of this approach are familiar; the innovation is in how they are applied to enhance specific project net value and meet a program pricing target. Here planners engage in an iterative process that emphasizes reaching agreement quickly. Typically, utility staff are asked to provide ranges for each value, and to apply caveats as needed. The analyst also may offer strategic improvements to the baseline project design. If accepted, these can increase the levelized benefits of energy (LBOE) for the community solar project and make strong progress toward competitive pricing.

While the strategic design area included extensive analysis of many potential solar project configurations, some of the Project's most widely appreciated work was in the area of parking structures. One interesting scenario showed that flat carport installations can actually provide higher value than tilted installations, because of the higher avoided cost of energy during the summer months in region studied. The team identified multiple carport vendors with aggressive cost-reduction strategies, and identified multiple sources of non-energy value for solar installations over parking lots. For example, in areas with significant snow, automobile dealers report that solar parking structures can dramatically reduce the cost of moving vehicles to clear the parking lot of snow. In hotter areas, customer loyalty for retailers with solar carports that provide shade is a real value (if more difficult to quantify). The CSVP Webinar on solar carports (August, 2016) was well attended, and the Project's *Resource Links on Solar Carports and Canopies* has been widely distributed.

During the course of the Task 3 activities, the CSVP team continued to engage with SMUD on these “solar plus” issues in context with their program plan. In addition, with the addition of our fifth objective at the beginning of 2016 (the analysis of community solar pricing options), we engaged with the SMUD team on issues related to the “Gap Analysis” described above.

On February 24, 2016, the CSVP team convened a meeting originally described in the SOPO as a “design charrette” which evolved workshop focused more sharply on cost and pricing issues. The workshop was held at Extensible Energy’s offices with the SMUD Program Manager and key members of the CSVP team in attendance in person or via remote hook-up. SMUD had already approved a Solar Shares tariff – in theory. However, until the program was in the field with specific resources underlying PPA cost assumptions, there were many obstacles to creating a clear narrative that could be part of a compelling customer offer. Further, some members of SMUD management were discussing a less “local” version of a shared solar offer that featured low-cost utility scale solar as the resource to be sold through a Solar Shares product. The CSVP team wanted to ensure that at least some significant portion of the program had a local component for customers who preferred such an offer.

In meetings with SMUD management, including the Director of Distributed Energy Strategies, it became clear that the best way to proceed with results that could be used at SMUD and beyond was to develop a “realistic hypothetical,” using the “Gap Analysis” approach described above, along with some specific tariff “tweaking” recommendations that would not require a full re-design of the existing Solar Shares rate. Using avoided costs for a “typical” Northern California municipal utility (very close to those that would apply at SMUD), the Team prepared for this meeting with some preliminary components of the Gap Analysis based on a portfolio of distributed solar resources.

Focused work on the GAP analysis for SMUD supported its final program design, which includes three and potentially four local community-solar products. An initial procurement for SolarShares, totaling 60 MW of solar generation, was completed in January, 2017, with additional acquisitions of up to 100 MW scheduled to begin in 2019.

In addition, we believe that future negotiations about solar resource acquisitions, intended to fill out the utility’s expansive total portfolio, will ultimately include more local, distributed community solar, as early stage projects are built, sold out and evaluated.

One final key milestone for this project pertained to pricing. This was not expressed as a Go/No-Go decision, but in agreement during BP1 review, as we recognized the widespread conclusion that pricing is a major (if not *the* major) barrier to successful utility-led community solar. As noted above, the GAP process is aimed squarely at pricing. The team concluded that there are at least three ways to reflect project net benefits and the final net LCOE provided by the GAP Process in a customer-facing rate. These include

- Reduce the utility wires charge;
- Adjust the PPA cost;
- Provide a direct customer credit, similar to a payment for energy efficiency or demand response program participation.

All of these methods are familiar to utility rate designers, and all provide the same net benefit to the customer participating in a community solar program. However, some utility staff have strong preferences regarding these issues, and when conducting such analysis, it was very useful to have the SMUD program manager in the room to provide guidance regarding these important internal concerns. In the end, in SMUD's case, the adjustment of the PPA cost provides the most convenient mechanism for incorporating agreed-upon value benefits, because the tariff specifically allows for PPA cost adjustments before passing those costs through to ratepayers. Regardless of the specific mechanism selected, a key takeaway from this Project is that getting pricing right is critical to presenting an appealing offer to customers, and that it is important for utility program designers to get their rates department on board early in the process.

The CSVP also fulfilled its objective to share current utility experience in pricing by developing ten (and ultimately 12) brief case studies. These are provided in the CSVP publication, ***Twelve Community-Solar Pricing Strategies for U.S. Utilities.*** This publication includes summaries from utilities in Arizona, California, Colorado, Massachusetts, Iowa, Minnesota and Texas. In each case, the summaries are written from the utility perspective, even though in several cases, state policies have dictated a relatively narrow role for the utility. While each of the utilities featured have incorporated some best-practice elements into their plans, we do not attempt to rank or evaluate them.

Additional Achievements in Replication and Dissemination

The discussion above concludes CSVP's report on Go/No-Go milestones and major project commitments. However, Task 4, which focused on replication, and Task 5, which focused on dissemination, bear further discussion, as they represented a large share of our Project effort and impact.

As discussed above, the completion of program modeling for solar-plus storage and DR, in collaboration with Public Service of New Mexico, replicated an important best-practice model for "solar-plus" and helped to meet an important milestone related to high-value solar project design. The modeling experience and accompanying meetings with PNM management and staff in rates, customer programs, and distribution engineering departments laid the groundwork for PNM program design.

PNM was not able to culminate a community solar program-design process during the term of this grant, but the value of its contributions were significant in developing the replicable processes that CSVP has widely introduced. As noted, the utility greatly supported CSVP efforts to advance market applications for solar plus strategies. In addition, it demonstrated the importance of working cross-departmentally within the utility culture. This became an important theme in the CSVP Solutions approach.

Thirdly, PNM demonstrated the importance of complexity of working with utilities in a time of transition, guided by state regulators who are themselves in the early stages of understanding the impacts and opportunities of community solar and various DERs.

During the course of our project PNM was entangled in a protracted rate case. Internal priorities and staff availability shifted. Staff that was assigned to work with CSVP early on was re-assigned or laid off. The team was fortunate to have continuity and support from Jon Hawkins, Manager of Advanced Technology and Strategy and in later stages of our work, from Stella Chan, Director of Pricing and Load Research. At different stages, CSVP supported PNM review of community solar plus DR opportunities, community solar for the low-income market, and community solar as an enhancement to a greenpower program that had gone fallow in recent years. As one near-term result of CSVP's support, the greenpower program will be enhanced to include solar resources. Further, the utility is reportedly in talks with the City of Santa Fe about community solar options.

One likely outcome is that state legislation for community solar, along the lines of the Colorado model (which was introduced as a priority of the New Mexico League of Conservation Voters in 2017, but failed) will be reintroduced and pass within the next few years. The Public Regulation Commission held two workshops on community solar in the past year to pave the way for this likely, major policy shift. Ultimately, it seems that, while PNM is not forbidden from proposing a community solar pilot program to the Commission, the utility is more inclined to wait for clear policy guidance.

This in itself is a powerful lesson learned—a lesson for those who focus on the policy pathway to solar development. Policy uncertainty is a detriment to community solar advancement. The CSVP has been market-focused, but the team has engaged on several occasions with support from IREC and the Regulatory Assistance Project (RAP), and also with the National Regulatory Research Institute (NRRI) to support the regulatory and legislative dialog necessary to speed community solar development and to optimize its value to the grid and the community at large. Examples of this effort include participation in two webinars (one archived on our website) with NRRI staff, and also engaging RAP in our 2017 *Workshop on Community Solar Procurements, Programs and Pricing.*

Also, in response to the experience with PNM, CSVP turned more attention to working with Utility Forum members, identified as the most "program ready" of these participants. CSVP team members engaged in program design assistance for Palo Alto Utilities (California), Platte River Power Authority (Colorado) and its members, including Fort Collins Utilities (Colorado), as well as Colorado Springs (Colorado), Cedar Falls Utilities and City of Ames (Iowa) and others. CSVP also provided support to community solar service providers and late additions to the Utility Forum, including Municipal Energy Agency of Georgia. As a result, all are proceeding with replication plans. These and other engagements are summarized in a table provided with the discussion of Dissemination task, below.

Examples of Utility Involvement with CSVP (Utility Forum Members and TA Support)		
Organization	**Years**	**Contacts and Comments**
City of Cedar Falls Utilities, Cedar Falls, IA	2015-17	Erin Buchanan, UF member. CFU was not able to send its representative to annual workshops in 2015-16, but she participated as a panelist in webinars, reviewed documents, and became a featured panelist at the 2017 workshop. CFU had completed a successful 1-MW community solar project, and by 2017 was in early stages of developing a second project (up to 2 MW). CFU contributed greatly to defining best practices for business-model design, including financing and

		procurement. TA discussions between CSVP and CFU centered on how to reach target markets with customized communications, in order address the market beyond early adopters.
Electric Dept. of Ames, IA	2016-17	Donald Kom, CEO; CSVP TA assistance This city was influenced by CFU, in deciding to develop its own 2-MW community solar program, beginning in late 2016. The level of assistance requested exceeded what CSVP could provide, but the team directed Ames to use CSVP resources. In addition, it provided TA support, including a customized version of the CSVP program-design presentation by teleconference, with Q&A. The project has proceeded, and the utility is in negotiations with its selected developer.
City of Fort Collins Utilities, Fort Collins, CO	2015-2017	Norm Weaver, UF member; followed by John Phelen (CEO) and Rhonda Gatzke. FCU was a leader in community solar, collaborating on a 600-MW CEC project. A second, 2-MW, utility-led community solar project was announced in 2016, to broaden access to the L/M-income market, with co-sponsorship from the Colorado GEO. After the first UF representative's retirement, the FCU CEO stepped in, while new staff was getting up to speed. CSVP contributed support in helping to develop a rate/offer that could meet both customer and utility needs for program roll-out, anticipated in early 2018. CSVP also discussed CFU interest in solar-plus strategies with a new UF representative, who is designing a program option for key accounts.
City of Palo Alto Utilities, Palo Alto, CA	2015-17	Aimee Bailey, UF member; also various staff in the customer-programs group led by Lindsay Joye, including Sonika Choudhary. Palo Alto received on-site TA in 2015, pertaining to an early-stage community solar program plan: 1) considering whether to integrate energy efficiency and DR with local solar and 2) asking how to address community solar siting challenges. This contributed to CSVP's focus on shade structure options. CSVP also provided full-group presentation with Q&A. Bailey critiqued a preliminary CSVP economic modeling tool, and then participated in the 2015 Integration Workshop, sharing insights based on exceptional engineering qualifications. Upon her leaving CPAU, the team continued to discuss program options with Joye, and in 2017, made another on-site TA, assisting staff in responding to board questions about DER benefits, pertaining to the draft community solar program plan. CPAU found continuing interest in community solar, even after the utility had "greened" its entire resource portfolio.

Colorado Springs Utilities, Colorado Spring, CO	2015-17	Gabe Caunt and Rich Swope, UF members. CSU was an early member of the Utility Forum, with interest in community solar plus DR companion measures. CSU already served nearly 5 MW of community solar, owned by third-party providers. Although the utility supported these projects, it wished to explore ways to reduce subsidies, to broaden access to solar benefits, and to begin managing a mismatch between solar generation and peak load. CSU staff provided useful input to CSVP's solar-plus Guides, including a conclusion that, while not urgently needed today, renewables-integration problems would emerge after 2020. In 2015, a costly fire at the city's coal-fired power plant affected CSU's ability to participate fully in the UF. However, Caunt was an active participant in the 2017 CSVP Workshop. The utility recently announced plans for 100 MW of utility-owned solar. We also anticipated a resurgence of interest in solar plus measures at CSU.
CPS, San Antonio, TX	2016-17	Shannon Wagner, Rick Luna, UF members. CPS joined the UF after participation in a CSVP webinar, showcasing its experience working with a third-party community solar developer. CPS participated in the 2016 annual Workshop, presenting on its outsourcing decision and requesting follow-up TA on target marketing, including the process outlined in CSVP's 2016 Guide on that topic. CPS has considered developing additional community solar, using a hybrid model that relies less on the third party for program implementation and reaps greater value for the utility. Wagner left the company in 2017, but Luna has maintained involvement. A case study of the CPS program was featured in CSVP's online Forum.
Iowa Municipal Utilities Association	2015	Joel Logan, UF member. Statewide public power association; representing 120 local utilities. Initial contact during early-stage CSVP development, as IMUA was leading a DER initiative, including solar and storage. Retirement, with involvement falling off in 2016.
Kit Carson Rural Electric Cooperative, Taos, NM	2017	Luis Reyes, CEO, UF Advisor. Reyes, whose utility hosted the first community solar project in New Mexico and one of the first provided by CEC, was an early advisor to CSVP, during project formation. Kit Carson turned attention to building a broad high-penetration renewables portfolio, and Reyes withdrew from active participation in the UF. However, he participated in the CSVP 2017 Workshop, providing what turned out to be a keynote address and participating in a round-table discussion. The story of how Kit Carson has approached community solar and

		DERs became the topic of a CSVP Forum blog in summer 2017.
Los Angeles Department of Water and Power (LADWP), Los Angeles, CA	2017	Michael Buck, CSVP TA Assistance. Buck and colleagues from LADWP expressed interest in the 2017 Procurements, Programs and Pricing workshop, but were unable to attend. Subsequently, LADWP requested specific advice on pricing for a new community solar offer. Community solar program designers were constrained by a stalled transition to a new utility-wide billing process. Powers and Cliburn provided a phone consult and follow-up resources.
Minnesota Power, Duluth, MN	2016	Tina Koecher, Katie Frye, UF members. Thanks to a referral from the Solar Market Pathways Program, Minnesota Power joined the UF in 2016. Frye participated in the 2017 annual Workshop, presenting on utility-led program administration strategies. MN Power provided best practices in this area, well-received by other utilities. MN Power has a 1-MW community solar project, which is distinct from the typical Minnesota model, in that it is utility-led. Frye expressed particular interest in learning CSVP market-research techniques and in considering more cost-effective procurement methods. MN Power received follow-up information from CSVP in these areas. The utility has not been active with CSVP this year.
Municipal Utility Agency of Georgia, Atlanta GA	2017	PT Nielsen, UF Member. MEAG joined the UF in 2017 after a CSVP presentation to a Community Solar Workshop (SEPA/SEIA) in May. Nielsen attended the CSVP Workshop in June, and obtained TA in preparing a presentation to the MEAG board, introducing the community solar concept and providing a market update and opportunities assessment. MEAG is a power supplier to 49 public power communities in Georgia. While IOUs and co-ops in the Southeast have begun to offer more solar options, public power has been relatively slow in this market. MEAG is now working with Electric Cities of Georgia, and that agency held a solar workshop for members in August 2017.
Platte River Power Authority, Fort Collins, CO	2015-17	Joel Danforth, UF member. Joint Action Agency serving 4 municipal utilities. 2015 TA on community solar pricing analysis; 2016 TA on market research and a GAP scenario for PRPA. PRPA is currently planning to provide broadly-defined community solar, from a 30-MW (PPA) in its territory, commissioned in 2016, as an option for member utilities whose customers desire more solar than would be included in the standard product. PRPA also supports local solar developments, such two

		community solar projects in Fort Collins, a member community.
Public Service of New Mexico, Albuquerque, NM	2015-17	Replicating Utility, with Focus on Solar-Plus strategies. Jon Hawkins, Local Project Lead. This effort is summarized in the text of the CSVP Report and in the *Solar Plus Storage and Demand Response* modeling study.
Sacramento Municipal Utility District, Sacramento, CA	2015-17	Primary Utility Partner. Stephen Frantz, Local Project Lead; Obadiah Bartholomy, Manager of Distributed Energy Strategies. This effort is summarized in the text of the CSVP Report and in a separate document.
Steele-Waseca Electric Cooperative, Owatonna, MN	2016-17	Syd Briggs, CEO, UF Advisor. Though not an active member of the CSVP UF, Briggs has been a generous advisor to the CSVP. He participated in a SEPA Community Solar Workshop panel that CSVP organized and chaired, and he has been a participant in the 2016 Integration Working Group of the Peak Load Management Alliance. The Steele-Waseca Community Solar-Plus project (Sunna Project), has been a best-practice for the community solar plus model.
Tucson Electric Power, Tucson, AZ	2015-17	UF members: Carmine Tilghman, Sr. Director of Energy Supply; Jeff Krauss, Solar Development Manager, Ruth Estrada, Procurement Officer. TEP provided insights from its successful ongoing, community solar program and from its efforts to gain approval from Arizona regulators, for an innovative restructuring of that program. Tilghman provided detailed tutorials on how TEP designed its program and on how it reduced solar soft costs, in a webinar and at both the 2015 CVSP Workshop and at the 2017 Workshop. In 2016, staff from the TEP program contributed to best-practices development around the topic of reducing solar procurement costs. In turn, TEP staff engaged with other UF members to consider program alternatives, including target marketing and solar-plus strategies. Though TEP has not integrated community solar and storage, its recent solar-plus development (100 MW solar plus 30 MW storage) reportedly holds the records for low-cost procurement at a combined LCOE of less than 10 cents/kWh (4.5 cents per kWh including subsidies).
Xcel Energy, Denver CO	2017	Eric Van Orden, Utility Forum. Xcel participated to a lesser degree in early years of the CSVP, initially with input from Susannah Pedigo manager of DSM and Renewable Energy Strategies. After her departure, CSVP communicated with various staff. In 2017, Eric Van Orden participated in the CSVP

		Workshop. He presented on the Xcel experience, and also participated in discussions about how to lower procurement costs. His interests stemmed from the utility's recent commitment to expand of its community solar portfolio.

Task 5, **Dissemination of the Case Studies, Decision Framework, and Tools**, has been perhaps the most valuable and successful set of activities in the entire CSVP.

Early in the project, we realized that the communication of project interim results to the Utility Forum and beyond was best accomplished interactively—nobody engages fully with a "status update" email, especially when they come every month over a 33-month period. The CSVP Dissemination Plan included

1) Regularly scheduled webinars on topics related to work progress

2) Periodic invitations to review and respond to new material on the CSVP website

3) Invitations to the Utility Forum and others to major events (one or more annually)

4) Outreach and engagement through industry conferences and events

5) Collaboration with key industry players, including utility associations, solar associations, non-profit energy-service organizations and third party providers

6) Media outreach via interviews and publications.

<u>Dissemination in Areas 1-3: CSVP-led Activities</u>

In all, the CSVP organized, hosted and recorded 15 Webinars, all archived on the CSVP website. In 2015, CSVP collaborated with a regional non-profit, Clean Energy Ambassadors, which reached many electric co-ops and public power utilities in the Midwest and West. That relationship gave CSVP a strong audience to start. Participation then grew, as CSVP utilized its own webinar system in 2016-17. By 2017, it was typical to have 100+ registrants, with nearly that many attending webinars in real time and others accessing the recording.

2017 Webinar Schedule

- 03.01.2017: *Five Steps to Tailored Market Research*
- 04.13.2017 *SMUD Shares Community Solar Lessons Learned*
- 05.11.2017 *The Best Steps You Can Take Toward "Solar Plus"*
- 06.28.2017 *Getting At Price: CSVP Findings on Making the Economics Work*
- 10.05.2017 *What Makes Community Solar Successful?*

2016 Webinar Schedule

- 06.30.2016: *Can Regulation Make Community Solar Better?*
- 07.28.2016: *Thermostat Control for Solar-Integration Value*
- 08.18.2016: *Making Solar Carports Happen*
- 09.28.2016: *Community Solar Plus Storage Solutions*
- 10.27.2016: *The Value of Going Local*

- 12.01.2016: *Smarter Procurement for Community Solar Programs*

2015 Webinar Schedule

- 08.27.2015: *Better Community Solar Procurement and Design*
- 09.29.2015: *How DR and Storage Address Solar Variability*
- 10.22.2015: *How SMUD and Other Utilities are Rethinking Marketing*
- 11.19.2015: *Community Solar... for Utilities and Their Low-Income Customers*

Among our special, interactive teleconferences, one in late 2015, focused on solar plus demand response options, was especially productive. All Utility Forum members attended; all had studied the draft CSVP Guide to Solar Plus Demand Response Measures. The directed discussion directly influenced further development of that guide and of the subsequent Guide on solar plus storage measures. It also served to start a far-reaching discussion among Utility Forum members, which made dissemination of the final document and related conference presentations more effective.

Participation in major events included an annual CSVP Workshop focused on Program Design. In 2015, this workshop put a relatively focused group of Utility Forum members in direct contact with cross-departmental staff at SMUD. Breakout group discussions (already discussed above) greatly informed the SMUD program-design process, as well as inspiring new program development among Utility Forum members.

In 2016, the annual program-design workshop, called Community Solar Solutions was again held at SMUD headquarters in Sacramento. This time, participants from both SMUD and Forum utilities responded to community solar works-in-progress. These included presentations from Tucson Electric Power, Minnesota Power and CPS Energy (San Antonio), as well as SMUD and CSVP. Other utility participants at that workshop also provided detailed input from their own project experience; one outcome was the decision to start an online archive of community solar RFPs, to facilitate more timely and cost-effective procurements. These workshops were documented and also evaluated.

Another set of works-in-progress discussed at that 2016 workshop pertained to CSVP's objectives to create a flexible program-design process and tools that utilities everywhere could use. CSVP summarized the draft program design process presented in this report, using a six-sided cube as a visual tool (Figure 6) for organizing the decisions required in the five challenge areas described in this report, and a sixth side representing the process itself. The draft GAP Process was also presented and discussed, so that refinements could be completed. One surprising outcome was that Platte River Power Authority, a Utility Forum member, stepped up at that meeting to work with CSVP on a GAP process scenario to meet its needs. (Platte River subsequently committed to community solar program development, which began in 2017.)

Figure 7: The CSVP "Thinking Beyond the Box" Process for Utility-Led Community Solar

Dissemination in Areas 4-6: CSVP Participation with Industry Partners

The CSVP exceeded its SOPO commitment to engagement in industry conferences and events. In successive years, team members became more and more in demand at these events. A summary list is provided in the table below:

Industry Presentations and Conference Engagements (Excluding CSVP Sponsored Events)		
Event/Organization	**Presentation/Date**	**Comment**
InterSolar 2015	*Community Solar Business Models,* Andrea Romano (Navigant), July 2015	Also attended by Cliburn and Powers.
Solar Power International, convened by SEPA and SEIA, Anaheim, CA	*Making Community Solar Better* Jill Cliburn, September 2015.	Main Conference Event; Also attended by Karin Corfee and Andrea Romano, Navigant team members
Behavior Energy and Climate Change Conference, convened by American Council for an Energy-Efficient Economy, BECI at UC Berkeley, and Precourt	*A Prosperous Marriage? Targeting Community Solar Program Design for Solar Plus DR* Jill Cliburn, October 2015	

Center at Stanford University, Sacramento, CA		
National Community Solar Partnership, convened by industry partners and SunShot in Washington, DC	John Powers participated for CSVP	
Peak Load Management Alliance, Semi-Annual Conference, San Francisco, CA	*Demand Response and Distributed Solar: Lessons from the CSVP for a Pre-Conference Workshop on Integration Strategies* John Powers, April 2016 *Value in the Balance: Solar, Storage, and DR Options* (Main Conference) Jill Cliburn, April 2016	Co-authored with Jon Hawkins, PNM
National Community Solar Partnership Spring Workshop Denver, CO	*Panel on Optimizing the Utility Role* Organized by John Powers and including Joel Danforth (PRPA) and Norm Weaver (Fort Collins), UF members, plus others.	Conference also attended by Jill Cliburn, Andrea Romano; included stakeholder discussions
SEPA Community Solar Workshop, Denver, CO	*High-Value Community Solar Panel,* Organized by Jill Cliburn and including Cliburn, Stephen Frantz (SMUD) Syd Briggs (Steele –Waseca) April 2016	Workshop prior to the SEPA Utility Solar Conference.
NRRI Webinar Series	*Community Solar Made Better: Policies for Utility-Led Programs* Jill Cliburn, May 2016	Invited by Tom Stanton, NRRI; contributed to NRRI publication on community solar policy
National Solar Conference of the American Solar Energy Society, 2016 San Francisco, CA	*A New Tone of VOS: Improving the Argument for Local Community Solar* Jill Cliburn, July 2016	Co-authored with Joe Bourg and John Powers; paper published by ASES
InterSolar 2016, San Francisco, CA	*Panel Presentation on Solar Plus Storage and DR Experience* Beth Reid (Olivine), July 2016 *Powerhouse Booth* John Powers	Presentation on broader topic by CSVP partner firm Powers presented CSVP information, as a participant in the Powerhouse incubator project show-floor booth
Renewable Energy World	Panel on “Connecting, Integrating and Enhancing the Value of PV Generation” – as part of that panel, John Powers	

	presented *Solar, Demand Response, and Storage: Lessons in Utility Integration from the Community Solar Value Project* Orlando, FL December 2016	
Peak Load Management Alliance, Semi-Annual Conference, Nashville, TN	*Meeting of the DER Integration and Community Storage Interest Groups,* Co-chaired by John Powers, April 2017 *Community Solar Plus: Initial Findings and Opportunities for Collaboration* Jill Cliburn	PLMA interest groups formed with utility and vendor members, to advance solar-plus strategies, of interest to CSVP.
Solar Southeast, Pre-Conference Workshop on Community Solar, SEPA and SEIA, Atlanta, GA	*Community Solar Matters… With Strong Design and Solar-Plus Options* Jill Cliburn, May 2017	
InterSolar 2017	July 2017	John Powers and Joe Bourg attended, participated in discussions of CSVP through Powerhouse booth
Coalition for Community Solar Access, Denver, CO	Andrea Romano CSVP partner from Navigant attended July, 2017	
Solar Power International, SEPA and SEIA, Las Vegas, NV	*Utilities Solve for Solar: Practical Analytics for Local Community Solar Planning* Jill Cliburn, Poster session September, 2017	Also attended by co-author John Powers
National Solar Conference of the American Solar Energy Society	*Taking Community Solar to the Next Level with Customer-side Storage and DR* Jill Cliburn, Panel session October 2017	Cliburn also participated in on-site *Solar in Your Community Challenge* Workshop. Presentation post-contract, but preparations were completed prior to 9/30
Public Power Customer Connections Conference	*Community Solar That Works… And Sells* Jill Cliburn, Panel session November 2017 *The SMUD Solar Shares Program* Patrick McCoy, SMUD, Panel session	Session shared by Cliburn and McCoy, with focus on community solar program design and SMUD lessons-learned. Presentation post-contract, but preparations were completed prior to 9/30

Peak Load Management Alliance, Semi-Annual Conference, Cambridge, MA	*Meeting of the DER Integration Interest Group,* Chaired by John Powers November 2017	Included a presentation by Powers on CSVP's new guide to storage solar-companion measures and on other CSVP resources. Discussion included considerations for continued application and building out CSVP resources. Presentation post-contract, but preparations were completed prior to 9/30

Often, engagement in industry events was preceded or followed by significant collaboration with industry players. CSVP sought to multiply its impact on the development of community-scale solar by collaborating as much as possible with these players, and disseminating information through their networks.

It was among CSVP's objectives to establish especially strong relationships with one or more industry organizations that could carry on parts of the Project's work after culmination of SunShot funding.

Three external organizations have been part of this strategy:

The *Peak Load Management Alliance (PLMA)* is an organization of demand response professionals from utilities, vendors, and research organizations. The CSVP Project Officer is co-chair of the DER Integration interest group at PLMA, a post he assumed in 2015, with this Project underway. He has led efforts to present CSVP results in interest group meetings, PLMA conferences, and through PLMA webinars. Selected results may soon be available through the PLMA website (see the Path Forward section below).

The *American Public Power Association (APPA)* is the voice of community-owned public power utilities serving more than 2,000 cities and public power districts nationwide. The CSVP Principal Investigator has worked with APPA, beginning with a letter of support prior to initiation of this Project. She has led efforts to present CSVP results in publications, meetings, and APPA conferences. Selected results may soon be available through the APPA networks, including its DEED interest group, which focuses on energy efficiency, renewables and grid innovations (see the Path Forward section below).

The *Solar Market Pathways* portfolio of SunShot awards allowed for formal and informal exchange of ideas throughout the Project; contacts made through these facilitated interactions led to multiple opportunities for adoption of CSVP results in other projects. Major results from the CSVP are already available through the SMP website, with more being compiled in the next several weeks.

Finally, in terms of media outreach, CSVP and the individual firms that it has drawn upon have provided continuous information outreach and dialog that has been shared through our website, individual firm websites, industry publications, and other media forums.

Conclusions:

Through this effort, the CSVP has developed and demonstrated a widely applicable planning framework that makes community solar compelling to both the customer and the utility. For the customer, community solar may be a choice with economic, resilience and environmental benefits. For the utility, customer satisfaction is important, but it is just one side of the rubric. In order for community solar to reach and sustain its GW-scale annual growth potential, the utility—including individuals across departments—must be able to see the full value in scaling up community solar within an integrated DER portfolio.

Working with the Sacramento Municipal Utility District, the CSVP supported that remarkable coming together of customer and utility interests. The result: a utility commitment to at least 100 MW of community solar, which will be tailored as a portfolio of customized products within each customer class. Moreover, SMUD agreed with CSVP to invite other utilities and industry stakeholders to participate in on-site planning workshops. The resulting Utility Forum shared in a remarkable give and take, and it also held parallel planning discussions, focused on identifying and adapting best practices.

Work covered six challenge areas. Seventeen utilities, including core Utility Forum members and others, have received support from CSVP in one or more of these challenge areas. Hundreds of others have accessed CSVP's Solutions Toolbox through its website, which will continue to be maintained for at least one year. Subsequently one or more industry organizations, already identified by the CSVP team, will be welcomed to use or further adapt these tools for continued dissemination.

The impacts of the CSVP effort may be measured by the 100+ MW of community solar that will directly result, including some 40+ MW already commissioned by SMUD and Utility Forum members. However, the most important impacts are harder to measure. These are just beginning to manifest, from numerous innovations that CSVP encouraged among the project's direct utility partners and others.

For example, SMUD's embrace of using target market segmentation rather than siloed technologies as the primary organizing principal for its program offerings is exactly the kind of innovation necessary for truly integrated programs (e.g., solar plus storage or DR) to take hold.

One notable finding was that the strategies CSVP introduced for high-value community solar appealed strongly to utilities developing *community-scale* solar portfolios, whether individual, local projects would serve community solar programs or more general utility-led DER needs. The market for the CSVP Solutions Toolbox is likely to reach farther than first expected.

The feedback on CSVP's two solar-plus planning guides (for DR and storage companion measures) indicates that these certainly will have a broad audience. These guides are both first-of-their kind publications. As one CSVP Utility Forum member noted during a review meeting, "We won't face a real need for managing duck curve issues (with DR or storage) for about five years yet, but in terms of the planning horizon, five years is soon enough."

The CSVP team has introduced utilities to numerous high-value strategies for community solar that are market-ready or even "best practice," but are not commonplace. The team and all those working on the ongoing transition of the electric utility industry must acknowledge that although changes—from becoming more customer focused to addressing increasing solar and DER integration—are necessary, they may not be fully realized for three to five years—or more. While it is beyond the scope of the current project, the CSVP team would welcome the chance to continue to monitor progress, measure success and grow better community solar programs and community-scale solar projects.

Path Forward:

Extensible Energy and Cliburn and Associates have committed to maintain the CSVP website for at least one year as a resource for community solar program designers and others in related areas. CSVP team members have discussed partnering with industry organizations like the PLMA or APPA as a longer-term repository of the extensive CSVP results; further integration with the Solar Market Pathways website is underway.

The published works of this project may be used far beyond the original scope of community solar program design within utilities. Utilities, regulators, policy makers, and third-party solar developers can make use of (and expand upon) the “gap analysis” and related valuation work. The Companion Measures guide (for both demand response and for storage), the Market Research Guide, the Outsourcing Decision Key, the Procurement Resources Guide, and several other publications are intended to provide value to anyone working in community-scale distributed solar for years to come.

Beyond the simple maintenance of existing materials, the CSVP results are being applied today at multiple utilities, most particularly SMUD, PRPA, Cedar Falls Utilities, Fort Collins Utilities, and other Utility Forum members. Individual CSVP team members see opportunities to assist additional utilities in the application of the methods and tools developed in the Project.

The prospects for building on the methods and tools developed in the CSVP depends on future support from both DOE and other sources. The results developed in this project offer several areas of promising additional research. In particular, the use of community scale solar projects as learning laboratories for new grid integration strategies featuring novel behind-the-meter technologies is a fertile area for future applied research. The CSVP findings and methods solar plus and “solar triple play” options lead the team to believe that well-documented field tests can help to break this area of the market open.

If DOE funds to support these efforts are tight, DOE can still play an important role in convening experts at conferences, workshops, and similar events where the state of the art is being advanced. DOE possesses assets in addition to funding, including visibility into numerous related projects, deep staff expertise, and policy influence – all of which can help advance the work presented here.

References:

From the voluminous work in related fields, the CSVP has compiled more than 100 references on the CSVP Web site. Of particular note are “resource guides” that include links and careful annotations:

Storage:
http://www.communitysolarvalueproject.com/uploads/2/7/0/3/27034867/2017_7_26_storage_links.pdf

Procurement:

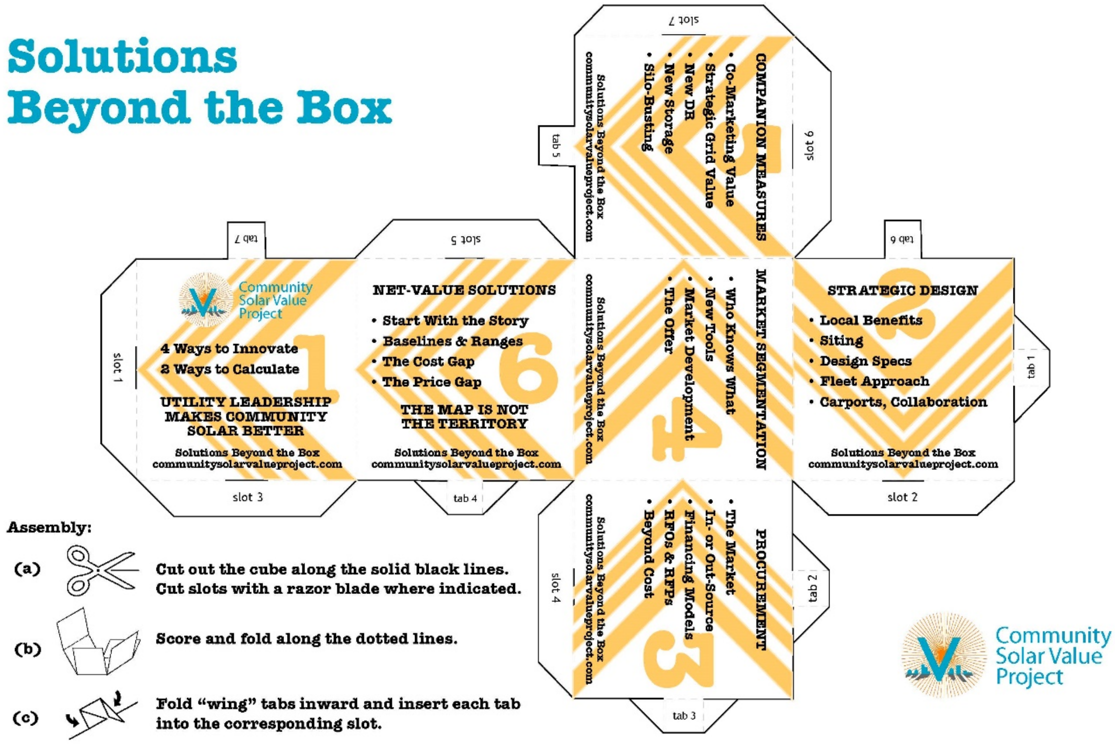
http://www.communitysolarvalueproject.com/uploads/2/7/0/3/27034867/2017_02_01_procurement_resources_guide.pdf

Market Research:
http://www.communitysolarvalueproject.com/uploads/2/7/0/3/27034867/2016_01_08_market_research.pdf

Solar Design – Carports:
http://www.communitysolarvalueproject.com/uploads/2/7/0/3/27034867/20170913_5_final_solar_carport_links.pdf

Pricing:
http://www.communitysolarvalueproject.com/uploads/2/7/0/3/27034867/20170929_csvp_pricing_matrix_1_.pdf

Appendix A: Solutions Beyond the Box



Appendix B: Budget, Schedule, Project Administration

Budget and Schedule

When the CSVP was approved in January, 2015, the original project budget was $1,000,000, including a DOE share of $800,000 and cost share of $200,000. The budget was revised twice; in 2016, an additional $69,751 was approved to cover the addition of new analysis and a new deliverable on community solar pricing issues. In 2017, the period of performance was extended until 9/30/2017 and an additional $18,883 was approved for additional dissemination activities at 2017 conferences and events.

At the conclusion of the period of performance, all project budget was expended except for $63; however, through obtaining $2,655 more in cost share than originally planned, the project did not expend $2,718 in DOE funds.

Over the course of the project, there were several minor re-allocations of funds (e.g., between one subrecipient and another, as required by changing work requirement and staff availability); however, the project stayed remarkably close to budget throughout.

The project schedule was affected by the expected delays associated with working on projects driven by our utility partners, SMUD and PNM. Both utilities have complex and time-consuming internal program development and approval processes. In addition, PNM in particular had a very long and contentious rate case proceeding throughout much of the CSVP period of performance, resulting in frequent diversion of staff from CSVP activities. The CSVP team adjusted by working more with other members of the Utility Forum, and providing support to PNM when their staff was available. As noted above, the PNM contributions to this Project were extremely valuable, and the longer-term prospects for community solar in New Mexico are bright.

Project Administration and Comments

Tracking of project results must include recognition of the practical management plan, implemented by the CSVP. The project SOPO guided project activities throughout the 33-month period of performance. The Project Officer (John Powers) and Principal Investigator (Jill Cliburn) tracked performance against each milestone with particular emphasis on Go/NoGo decision points. However, with more than 60 individual project milestones, five consulting firms, twelve utilities, and numerous external collaborators and influencers, the CSVP team needed a more streamlined approach to keep the project on track. The team adopted an “event driven” approach to keep all contributors accountable to one another and to the project timeline. This event-driven approach was evident in the SOPO from the beginning, with key workshop events appearing in the Go/NoGo decisions at the conclusion of Budget Period 1.

In order for community solar to fulfill its promise to lower solar soft costs and to expand the market in size and reach, it is imperative to develop new sources of value in community-scale solar projects and program designs. The sources of value targeted by CSVP from the start map onto the tasks stated above, with special importance in strategic solar project design, procurement improvements, target marketing, improved value-assessment strategies, and integration with companion measures. Hence, the project Go/No-Go decision criteria at the conclusion of Budget Periods 1 and 2 were tied to understanding baseline community solar business models and developing improvements, pertaining to the program design process and to these elements.

In the last budget period, CSVP turned attention to supporting SMUD efforts to finish its plan for a community solar program that can achieve results on a major scale. CSVP also turned to supporting Utility Forum members in replicating particular aspects of the high-value community solar model. CSVP also completed final revisions to its innovative GAP process and solar-plus assessment methodology, and it built out its dissemination strategy for achieving high visibility and impact.

No patents resulted from the work performed on this project.

Appendix C: SMUD Presentation of Community Solar Programs and Plans, American Public Power Association, Customer Connections Conference, November 7, 2017

Appendix D: Multiple CSVP Project Deliverables

1. Summary Presentation. High-Value Community Solar: A Brief Guide to Utility Program Design that Makes Community Solar Better. September, 2017.
2. ASES Conference Proceedings. The Right Tone of VOS: Improving the Argument for Local Community Solar. July, 2016.
3. Project Report. Market Research and Market Segmentation for Community Solar Program Success: A Brief for Utility Program Designers. December, 2016.
4. Project Report. Demand Response Companion Measures for High-Value Community Solar Programs: A Guide for Utility Program Designers. April, 2016.
5. Project Report. Solar Plus Storage Companion Measures for High-Value Community Solar: A Guide for Utility Program Planners. September, 2017.
6. Project Report. Community Solar Program-Development Landscape: A Brief for Utility Program Designers. December, 2016.
7. Project Report. Twelve Community-Solar Pricing Strategies from Utilities in the U.S.: A Summary Table. September, 2017.
8. White Paper. Community Solar: California's Shared Renewables at a Crossroads. October, 2017.

High-Value Community Solar:

A Brief Guide to Utility Program Design That Makes Community Solar Better

September 2017

Community Solar Value Project

Powered by SunShot
U.S. Department of Energy

CSVP works with utilities, industry innovators, and community partners. The Project provides demonstration and documentation of four ways to make utility-led community solar better, including:

- strategic design
- target marketing
- procurement and pricing
- solar-plus integration

CSVP is led by Extensible Energy, co-funded by the US DOE SunShot, Solar Market Pathways Program. Jill Cliburn, Project Team Leader, comes from Cliburn and Associates, one of four firms supporting this effort. This report, summarizing the CSVP program-design framework, references more detailed CSVP materials, available on its website. Accompanying on-site training and support are also available, upon request.

Community Solar Value Project

www.communitysolarvalueproject.com/solutions

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Cliburn and Associates, LLC

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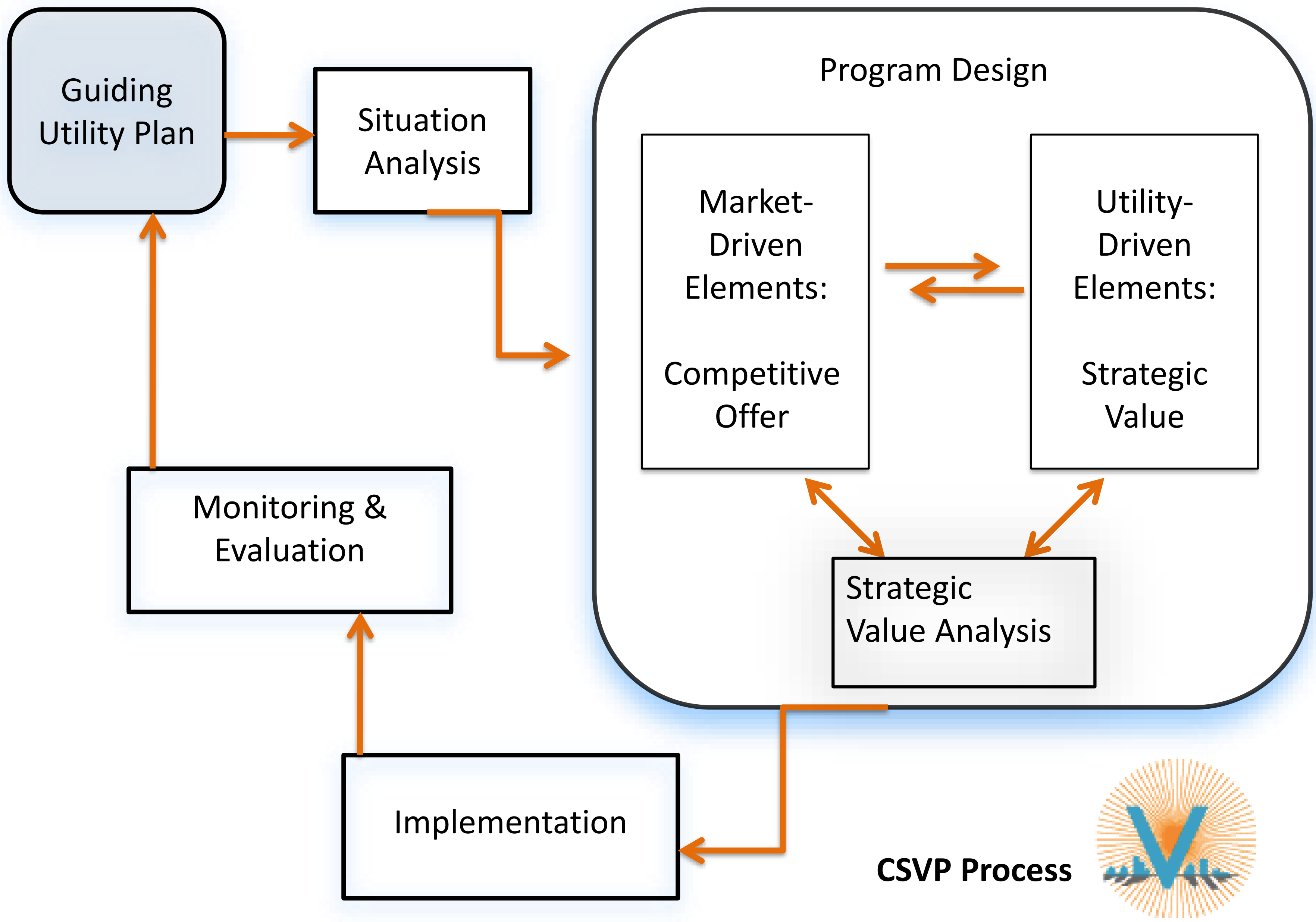
Introduction

On the opening page of the CSVP Solutions Toolkit, we advise, "Avoid casting any program design process in stone."

Nevertheless, we suggest that your team choose a **program design process**, depicted as a flow diagram, to start. This vision of that idealized process will serve both as a tool for unifying diverse team members and as a checklist for your key considerations. The next slide shows CSVP's recommended overall process. Based on best-practice research, it emphasizes collaboration and iterative communications, where customer-driven and utility-driven concerns are given equal consideration. Different steps in this process key to **planning resources** developed by CSVP.

The CSVP web site offers additional planning diagrams, which emphasize different aspects of program design. In any case, be prepared to step "outside the box," to address particular challenges when and how they come up!


Guiding
Utility Plan
Situation
Analysis
Program Design
Market-
Driven
Elements:
Competitive
Offer
Utility-
Driven
Elements:
Strategic
Value
Strategic
Value Analysis
Monitoring &
Evaluation
Implementation
CSVP Process

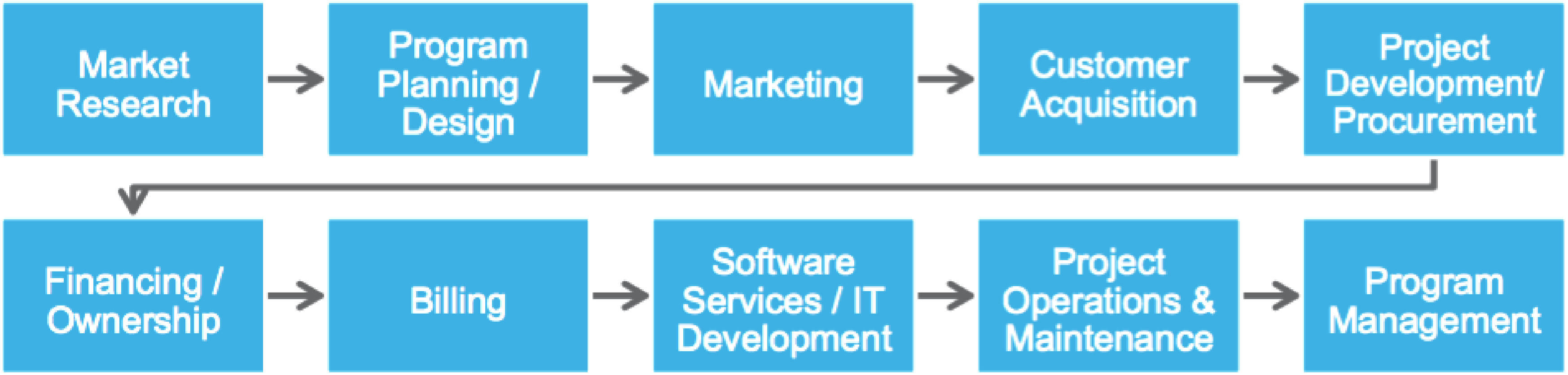
Overview (1): Get Ready

- Utility-led community solar programs should be in sync with the utility's mission and values. First, articulate program drivers, e.g.,
  - *Offer a direct response to customer interest*
  - *Provide a market-based laboratory for 21st C. utility strategies*
  - *Manage the transition to greater use of distributed resources*
  - *Offer more solar choices, including high-value strategies*
  - *Support local government sustainability and economic goal/s*
  - *Equity: broader or universal access to a solar option*
  - *Other*
- Initial "situation analysis" should include
  - *Internal (utility/city) stakeholders: individual views and relationships*
  - *External stakeholders: community and business groups, policy/regulatory*
  - *Market conditions and trends*
  - *Program choices; likely suitability of existing choices; alternatives*

Overview (2): Aspects of the Process

- Program design is iterative; a give and take between customer- and utility- interests/needs
- Market research, including nationally and locally obtained information, leads to understanding customer interests/needs
- Solar- and utility- economics drive pricing, but market based concerns (e.g., competing options; customer appeal) must be considered, too
- The **Program Offer** will be the outcome of about a dozen key decisions, including pricing
- Implementation will include administrative details (e.g., customer application process, billing and credits), as well as short- and long-term marketing campaigns. These elements are relevant whether or not the program is out-sourced.

Early Decision: What to Out-source and Why?



- Developing a community solar program involves a number of stages (not necessarily in this order) involving various skillsets and engagement from different utility departments.
- Utilities can choose to outsource all or some of the stages of the value chain.
- Due to the shift toward the utility-driven business model in some markets, fully integrated providers (e.g. CEC and Sunshare) are now offering to support some stages of the value chain, rather than only to offer complete turn-key services.

Source for Slides 7, 8 and 9: *Key Points to Consider… Outsource and In-House Strategies* (Romano and Cliburn, 2017) on the CSVP Solutions website.

Key Considerations: Expertise + Bandwidth

Program Designer/Manager

Coordinates cross-departmental team
Coordinates external stakeholders
Collects initial research; outlines plan
Works across departments and leads GAP analytics to finalize the program plan
Member of procurement team/s
Leads budget coordination and reporting

Resource Manager

Coordinates with utility resource planners and engineering staff
Provides input for program design
Leads solar project specification; coordinates with procurement staff
Oversees EPC and commissioning
Oversees system O&M

Business and Finance Manager

Advises on business model, financing plan
Resolves cross-departmental budget questions
Coordinates with rates and policy staff
Oversees billing and accounting needs

Marketing Manager

Leads market research & segmentation
Participates in iterative cross-departmental plan
Leads development of program offer/s
Leads development of marketing materials
Develops plans for customer acquisition and care
Leads consumer service and sales training

IT Manager

Develops customer acquisition tools
Supports GAP analysis and other economics
Integrates software to support marketing and billing, including billing system modifications
Reporting and budgetary support

Legal Counsel/CPA Firm

Advises regarding IRS, SEC, and FERC compliance
Advises regarding state policy, guidelines
Reviews procurement plans, contracts
Participates in PPA and offer development
Advises on acceptability of marketing messages

Each utility will be organized differently; these are typical utility roles and responsibilities

Key to Your Decision: Find Your Balance
At Every Step From Program Design to Delivery

Typical Benefits Cited for In-House and Out-Sourced Strategies	
In-House	**Out-Sourced**
• Stronger opportunities to integrate between customer- and technically oriented benefits • May focus on longer term benefits; less vulnerable to cutting corners for profitability • Returns on investment and savings if utilities can own DPV; review balance sheet options • Greater flexibility to change program • Requires cross-departmental team-work; may be a benefit toward integrating operations around tasks, e.g., IT, marketing, procurement • May force system upgrades that will benefit other programs in addition to community solar • Stronger opportunities for savings on site acquisition; leveraging utility relationships with local government and land-owners • Risk management on long-term stability of the solar project • Maintains utility brand identity	• Partners strongly motivated toward success • Likely to be quicker to market • Frees utility staff for other projects • Requires agreement from top-level utility execs; less chance of back-tracking • Mix and match the expertise that is most needed • Regional or national reputation for community solar or specific expertise • Likely to have greater case-study experience • Likely to have a network of other experts to tap as needed • Can put some risks off on the contractor • Third-party developers can tap into tax benefits • Today's agreements can be highly flexible

The Customer-Driven Side of the Equation

Market Information
(Target Segmentation)

Draft Offer

Competitive Test

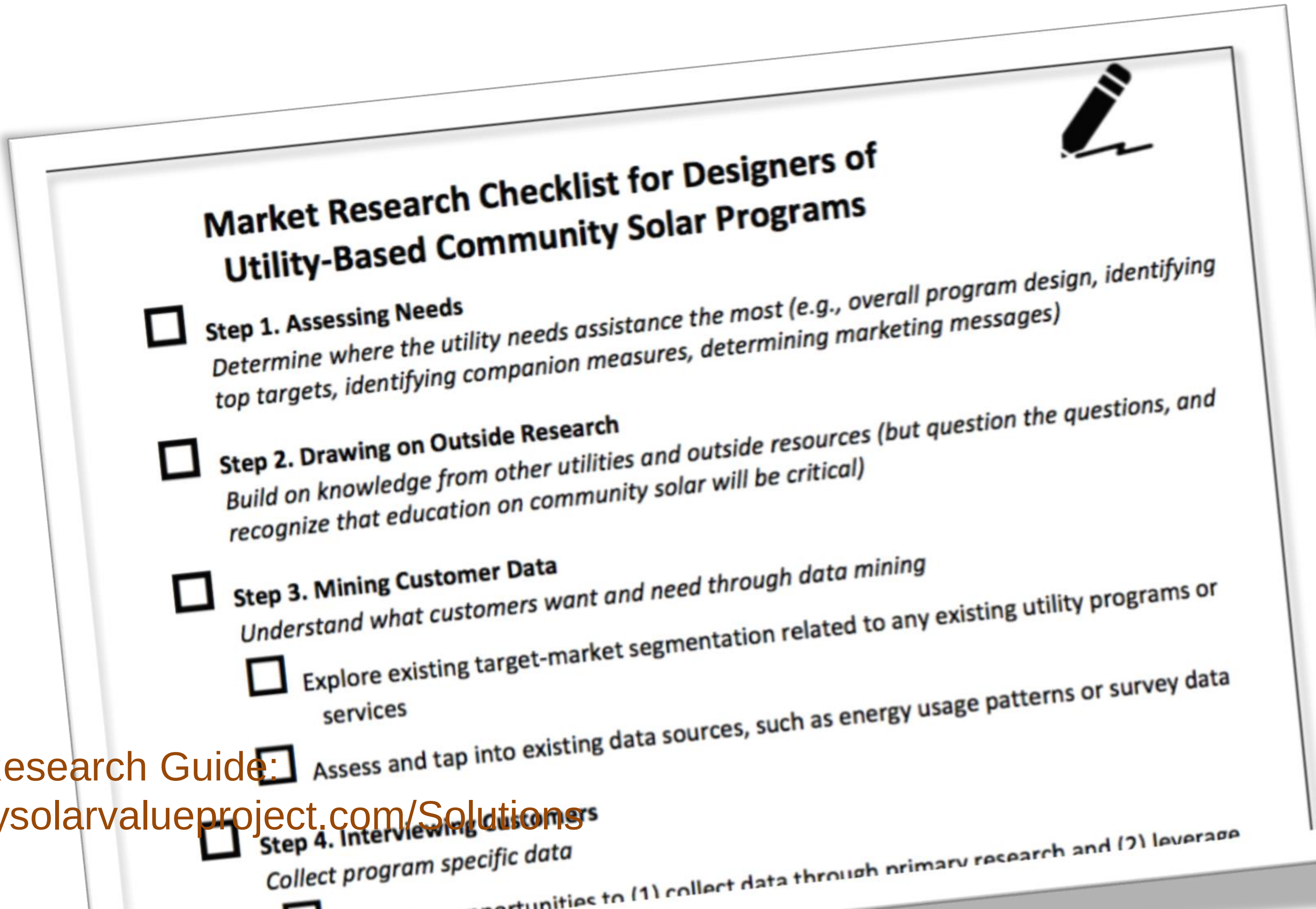
Delivery Approach

Customer Engagement

General Market Information: What We Know

- >60% of residential customers say they want a solar option. Nationally, interest in *community solar* is relatively low, until customers are informed; then interest rises sharply, rivaling interest in rooftop options
- Highly rated community-solar selling points:
  - *Favorable economics*
  - *Environmental benefits*
  - *Community benefits; project sited in the community*
  - *No-hassle, low-risk solar, including locked-in costs*
- Data suggests a premium is okay, if small; economics are impacted by *perception of value*
- Different customer market-segments rank these appeals differently, and different utilities will see slightly different results. *(A lot depends on how you ask your questions!)*

CSVP Recommends a 5-Step Process To Get From National Research Findings to Tailored Local Market Research



Market Research Checklist for Designers of Utility-Based Community Solar Programs

☐ **Step 1. Assessing Needs**
Determine where the utility needs assistance the most (e.g., overall program design, identifying top targets, identifying companion measures, determining marketing messages)

☐ **Step 2. Drawing on Outside Research**
Build on knowledge from other utilities and outside resources (but question the questions, and recognize that education on community solar will be critical)

☐ **Step 3. Mining Customer Data**
Understand what customers want and need through data mining

- ☐ Explore existing target-market segmentation related to any existing utility programs or services
- ☐ Assess and tap into existing data sources, such as energy usage patterns or survey data

☐ **Step 4. Interviewing Customers**
Collect program specific data

CSVP Market Research Guide:
www.communitysolarvalueproject.com/Solutions

“It's really hard to design products by focus groups.
A lot of times, people don't know what they want until
you show it to them.”

— Steve Jobs

Early customer outreach and education can make or break your program’s success!

Common Utility Target Market Segments

- Young Families
- Money Strivers
- Plugged-In Families
- Green Echoes
- Uninvolved Achievers
- Senior Savers
- Green Boomers
- Boomers, Buyers
- Big Toys

These segments are typically keyed to demographics, neighborhoods, lifestyle preferences, and for many utilities, energy-use characteristics. They are further defined by applying Prizm-type micro-segment research.

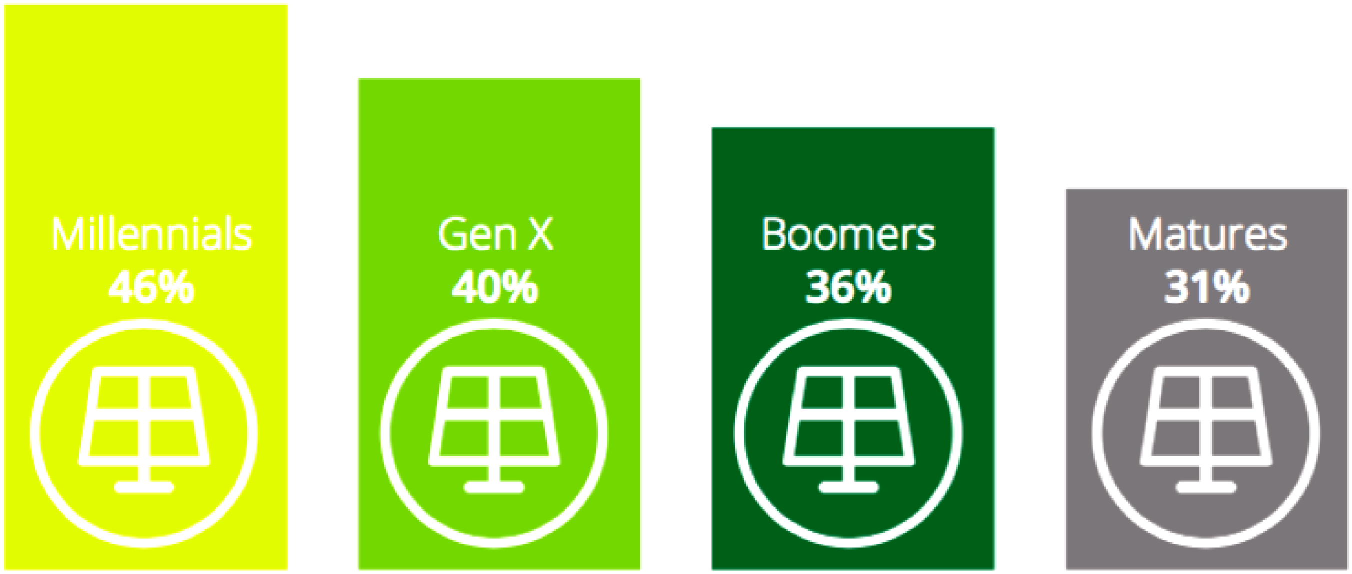
A New Market Opportunity?

Utilities need to move beyond the aging boomer market in order to insure their futures. Millennials are:

- Community minded
- Tech savvy
- Different in spending habits
- Strong in education, earnings
- Already forming families
- Less likely than previous generations to own homes

% Extremely/very interested in community solar

Source: Deloitte Research



SMUD Lesson Learned: Market Research Questions Influence the Findings You Get

- SMUD's original Solar Shares program (2008) asked customers to pay $/mo. for each 1-kW equivalent share
- Provided an incentive and a virtual net metering benefit, for a lower net cost (<$15/mo.)
- Rate was locked in for those who stayed in the program

Early research, including surveys focused on program economics, suggested the program would appeal to renters and working women; *not older women and not retirees.*

But ultimately, the top segments ***were*** "Green Boomers" and "Boomers, Buyers, & Browsers." Why?

Why? 1) Boomers learned the program was highly convenient and predictable—perfect for their needs. 2) Many Boomers were already using SMUD products—and were easily reached with the new offer.

Market Segmentation + Conventional Targeting

Source: Shah, SMUD, 2015

1. Benchmark expectations against other sources of market research, for example segmentation attributes + past customer data, including participation in past programs + building suitability + location, etc.
2. Sketch **Program Offer** based on preferred technology, financing, level of engagement, and check against other market-research information
3. Rank targets, based on market potential and overall benefits.
4. Complete detailed draft offer to suit the targeted sector/s. The offer includes site location, bundled services, pricing/terms, channels, and other elements, based on the sector’s lifestyle values and preferences.

CSVP Worksheet: Research How You Compare

	Your Proposed Plan	Your Competition
Who are the Targeted Customers		
Who are the Enablers		
What is the Offer in a Nutshell		
What is the Solar Design Strategy		
What is the Procurement Strategy		
Where is the Project Siting		
Why is the Offer Compelling		
How Does the Pricing Work		
How Does the Utility Fare		
When—Describes the Utility's Long-Term Benefits		

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Detailed Program-Design Decisions

- Is the program an in-house, outsourced or a hybrid approach? (Note: customers prefer utility as the contact point for the program, regardless.)
- Will customers pay for capacity or energy ($/W, $/kWh) or an alternative, e.g., % of use? Each choice maps onto a business model*
- Sign-up fee. Customers prefer none
- Program length. What happens then?
- Minimum participation term
- Transferability for purchase/lease
- Renewable Energy Credits (RECs)*
- How to cover production risks?
- How to cover unsubscribed energy risks?
- Participation limits (energy, capacity) per customer; other
- Pricing and credit details*

**See CommunitySolarValueProject.com/Solutions for more*

Continued Marketing and Customer Care Insure Program Success

- Information provided early-on influences customer expectations
- Testimonials and neighbor-to-neighbor campaigns are powerful in all solar marketing; for community solar, it may also be helpful to enlist community groups and the utility itself, as trusted resources
- Community solar participants respond to recognition, e.g., door stickers, bumper stickers, logo merchandise… even the chance to sign their panel/s; a program website may also feature participants who help to lead the campaign, as well as real-time performance information
- Marketing may micro-target different program attributes for different customers, via social media or events
- Plan for periodic evaluations and fine-tuning

Nationally, Survey Trends are Clear

Rate Model: Low Probability of Success	Rate Model: High Probability of Success
2-yr. term; option to renew	20-year term; may opt-out
$100 non-refundable "sign-up fee"	No fee or small, refundable deposit
3 to 5 cent premium/kWh	0 to 2 cent premium/kWh
Solar gen from unrelated 3rd parties	Utility owner or co-sponsor
Distant project/s	Local project/s
No real-time production information	Web portal or phone app
11% Support in Survey Testing	**89% Support in Survey Testing**

Source: Shelton Group for SEPA, 2016

The Lesson Here: Double-Check Your Own Research Before You Stray

Panel Model: Low Probability of Success	Panel Model: High Probability of Success
20-yr. term	5- to 10-year term
$595+/panel or share	$395 or less/panel or share
No financing	On-bill financing
Power to grid; no ownership	Ownership of power; even better, of panels
Solar gen from unrelated 3rd parties	Utility owner or co-sponsor
Distant project/s	Local project/s
No real-time production information	Web portal or phone app
16% Support in Survey Testing	**84% Support in Survey Testing**

Source: Shelton Group for SEPA, 2016

Ultimately, You Want to Talk *Price*

- Historic green power approach: Historically, dominated by wind. Yields 2% participation *on average* for ~$0.02/kWh premium.
- *Mass-market* green tariff solar programs are following this model, e.g., Colorado Xcel or California options. Streamlined…many advantages. BUT this model does not meet all community solar program norms. (Often, customers can choose green tariffs *or* shares in a local community solar project.)
- If the program is tied to a local solar project, customers may receive a net rate for solar kWh purchased or if they own or lease a share, a payment ($/kWh) for generation from their share. Options: full retail NEM, modified NEM, or other.
- Newer lease or purchase options offer on-bill financing, shorter terms or provide other ways “out” –Make it *easy.*
- Newer subscription options include the Tucson model of a flat fee, with a built-in incentive for energy efficiency (up to 15%)

Typical Purchase or Lease Program Pricing

<u>Customer Pays</u> Upfront or Monthly for Installed Cost per Share ($/kW)

Price May Incorporate (O&M + Integration + Marketing + Admin Costs)

Plus On-Bill Financing Cost, If Applicable

Customer Continues to Purchase Electricity at the Applicable Rate

Plus Applicable Wires/Service Costs;

Fuel Adjustment Charges Typically Waived

<u>Customer Receives</u>

Monthly Credit for Each Share's Solar Generation to Grid

Also Incorporating Any Applicable Incentives

And +/- the Value of Terms (e.g., REC value incorporated)

Savings Accrue As Utility Rates and Fuel Charges Are Likely To Rise

Typical Subscription-Based Program Pricing

Over the term, the Customer Pays:

(PPA + O&M + Integration + Marketing + Admin Costs)

Minus Utility Levelized Benefits

= Net Cost per Share

$/kW, $/kWh, flat $/month

Plus Applicable Wires/Service Costs

Minus Any Applicable Incentives

And +/- Value of Terms (e.g., RECs, Avoided Fuel Adjustment Charges)

Customer Receives Credit

For Each Share's Solar Generation to Grid

Savings Accrue As Utility Rates and Fuel Charges Are Likely To Rise

Green Tariff Based Program Pricing

The Customer Pays:

(PPA + O&M + Integration + Marketing + Admin Costs)

Minus Utility Levelized Benefits

= Preliminary Net Cost in $/kWh

Adjusted to reflect

Any Incentives + REC Value if Applicable + Credit for Anticipated Generation per Unit ($/kWh) + Credit for Avoided Fuel Adjustment Charge

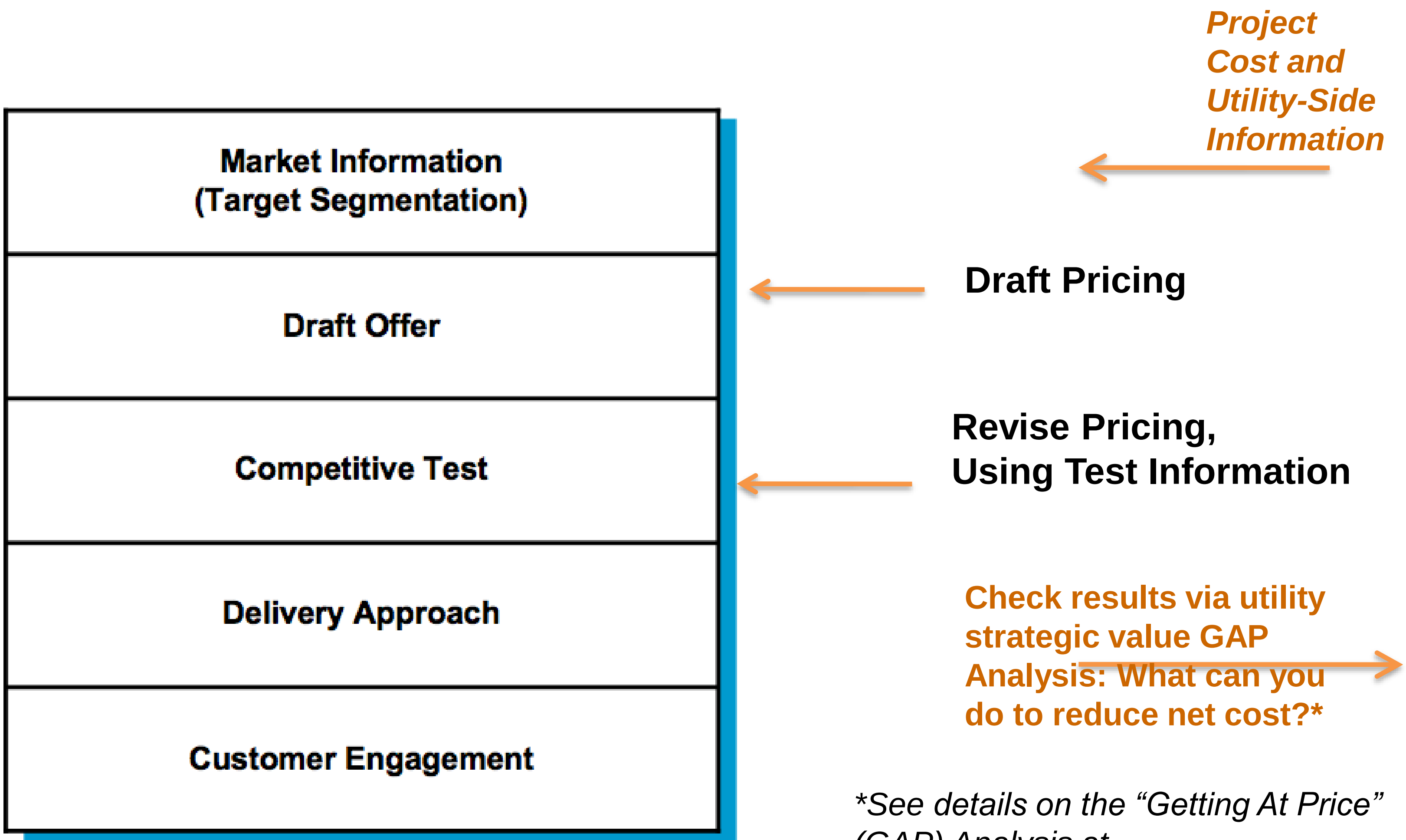
= Total Net $/kWh on Community Solar Tariff

Customer also Pays Wires/Service Costs and Full $/kWh for Electricity Beyond the Share-Size Limit (If Applicable)

Rate May Be Locked in for the Program Term

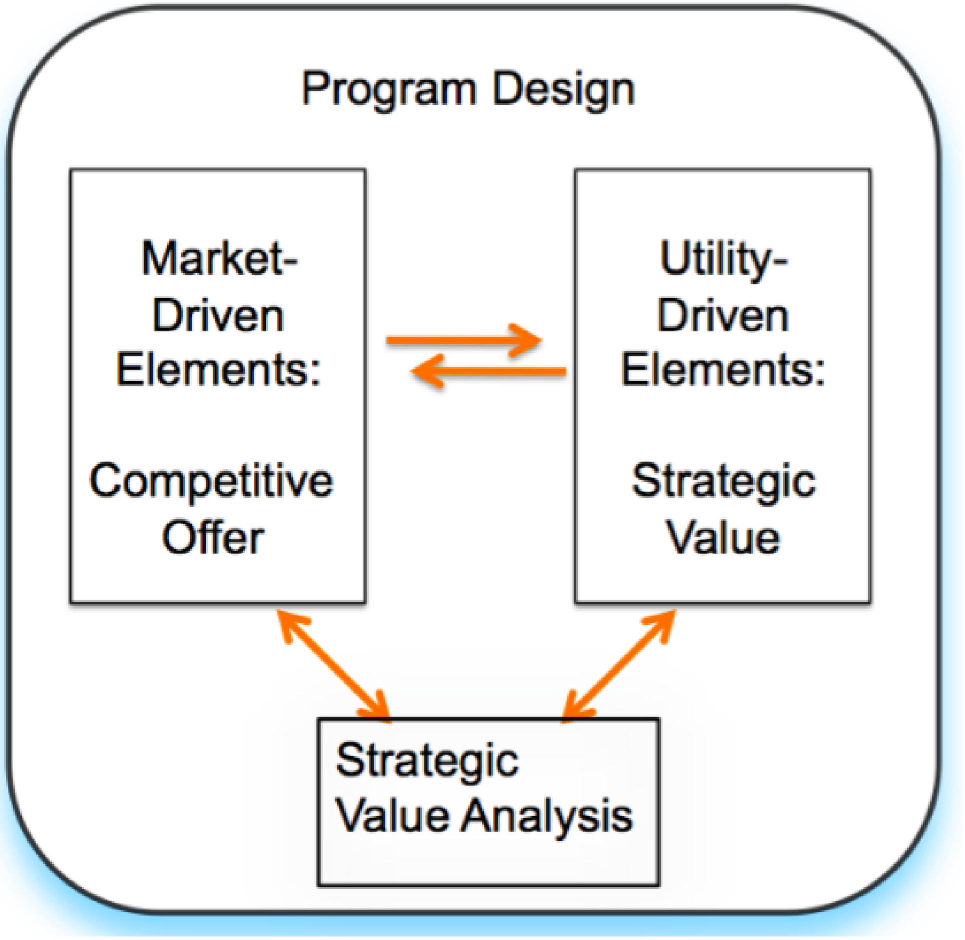
Utility Usually Provides Backstop for Anticipated-Generation Risk

Pricing Must Be
Cost Based and Market Driven



**See details on the "Getting At Price" (GAP) Analysis at* [*www.communitysolarvalueproject.com*](http://www.communitysolarvalueproject.com)

Remember, Market-Driven Elements Need To Work for Utility-Side Planners, Too



What We Will Cover On the Utility Side

- Financing and Ownership vs. PPA Options
- High-Value Solar Project Design
- Procurement Processes
- Fine-tuning Project Economics; the GAP Process
- Stepping Back: How the Full GAP Process Brings Both the Utility-Side and the Customer-Side Together
- More High-Value Options: DR and Storage Measures

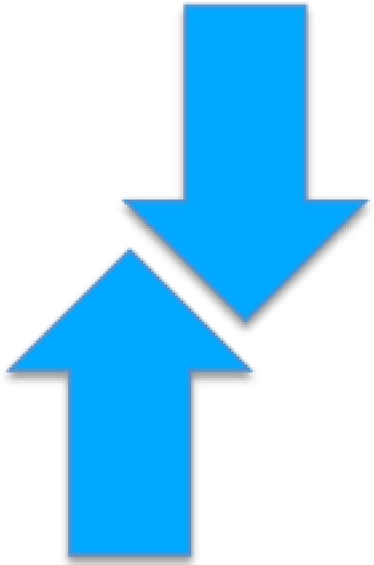
One Path: Working on Financing and Procurement

	Table 2: Comparative Summary of Financing Options Community Solar Programs					
	Utility-Driven Solar Acquisitions				Outsourced Third-party Acquisition	
	Utility Developer	Third-Party Developer; Power-Purchase Agreement (PPA)		Operating Lease	Utility as Prime Point of Contact	Customer as Prime Point of Connection
		PPA	PPA with Flip/Buyout			
Pros	Within regulatory guidelines, utilities can earn a rate of return on the solar asset. IOUs may get tax benefits, though normalization which limits the benefit. Municipalities and POUs have access to municipal bonds and QCEBs; Cooperatives may have access to RUS or CFC and CoBank financing, as well as to programs geared for rural development. Some hybrid models take advantage of both tax-exempt financing benefits and third-party tax incentives.	Third-party can take advantage of ITC and MACRS, and will pass some of this benefit to the utility. Utility does not have to take any of the ownership risks. While the lifetime benefits to the utility are not as great as the ownership option, a PPA generally has a lower utility rate impact.	Third-party can take advantage of ITC and MACRS, and will pass some of this benefit to the utility. The utility also can reap the long-term value of the generating asset, after the tax benefits have been monetized.	Utility can treat the project as an operating expense and leave it off its balance sheet and avoid long-term ownership risk. Under an operating lease, the lessor monetizes the tax benefits and it typically passes some of these benefits along.	Allows utility to roll out a program quickly. In the outsourced model, the utility typically has little role in program design, marketing or program subscription, though the program may be utility-branded. Additional services may include support for virtual net metering and customer information apps. Third-party passes through some of the tax benefits.	Usually policy driven, minimally involving the utility. Utility has minimal responsibility. This model is popular with large customers, especially local governments. Also, some community groups or churches may form small shared solar projects if allowed.
Cons	POUs, municipalities or cooperatives cannot monetize the ITC or MACRS benefits directly; IOU must use normalization in accounting for ratepayers. This spreads the benefits over the useful life of the asset (usually 20 years) and shares the benefits with ratepayers. Ownership risks include long-term O&M, managing long-term warranties, insurance for catastrophic events, and removal if the project becomes obsolete.	Third-party debt may be more costly than utility debt. Utility cannot incorporate project as part of rate base and earn a rate of return. Also, the project typically outlives the PPA (producing for 35 years or more), so utilities forego long-term benefits.	Third-party debt may be more costly than utility debt, so if the utility can monetize the tax incentives it may make sense to own the project from the beginning. The more complicated financing model requires tax and legal support, which may be costly for relatively small projects.	Utility must take risk associated with the solar equipment output, as expected to make lease payment regardless of system production. A buyout may be arranged, but not at the time of the original agreement.	Similar to the drawbacks for PPAs, including third-party debt may be more costly, utility cannot incorporate project as part of rate base and project outlives PPA. In addition, the utility loses some connection with its customers, who deal exclusively with the third-party. Consumer-protection risks possible. Some third-party provider's offer limited customization.	Projects present some technical risks and possibly some equity risks as only a small subsector of customers can take advantage of this model; small customers are involved there may be consumer protection risks. Modeled on net metering programs, with the same risks to the utility.

**See CommunitySolarValueProject.com/Solutions for more*

Working on Solar Design Strategies

- The utility may call for high-value solar design strategies, whether it plans to develop and own the project or to enter into a PPA.
- Some high-value solar design strategies increase first-cost, but bring high-value benefits over the project term
- Other high-value solar design strategies are low-cost, but require planning consideration



Customizing Solar Project Design Strategies

The CSVP GAP analysis taps high-value design strategies that are well-suited to the specific utility/market for each project. CSVP has additional resources available on high-value, community-scale solar. *Depending on the situation*, these may include:

- Strategic Site Characteristics
- Fleet Siting for Geographic Diversity of Multiple Projects
- Single-Axis Tracking Mount
- Optimized Orientation and Tilt Angle of Fixed-Tilt Mount or Carport
- Matching PV Types to Geographic / Site Conditions
- Use of Smart Inverters
- Financing and Business Model Strategies
- Partnerships to Monetize Non-Utility Values
- Solar-Plus Measures

Considerations That Yield High-Value Design From the Project-Procurement Process

- Balancing specification against openness to bidders’ solutions
- Opportunities for economies of scale, without turning to large-scale, remote project siting: aggregating over a build-out, or developing partnerships with other communities
- Careful RFP preparation/issuance and a strong bidder’s list
- Careful RFP evaluation; second round for refinements
- Numerous aspects of contract negotiation; driving for savings without sacrificing quality, timeliness, or risk protection

See www.communitysolarvalueproject.com/solutions for CSVP procurement guides, sample project RFPs, and tips

Procurement Pitfalls

- Jumping into procurement too soon: losing site of the narrative and what matters most to decision-makers
- Assuming that bidders will work from comparable assumptions without instruction
- Assuming that a PPA offer incorporates all costs and benefits that are relevant to your program
- Zeroing out refutable values
- Succumbing to silos
- …
- …

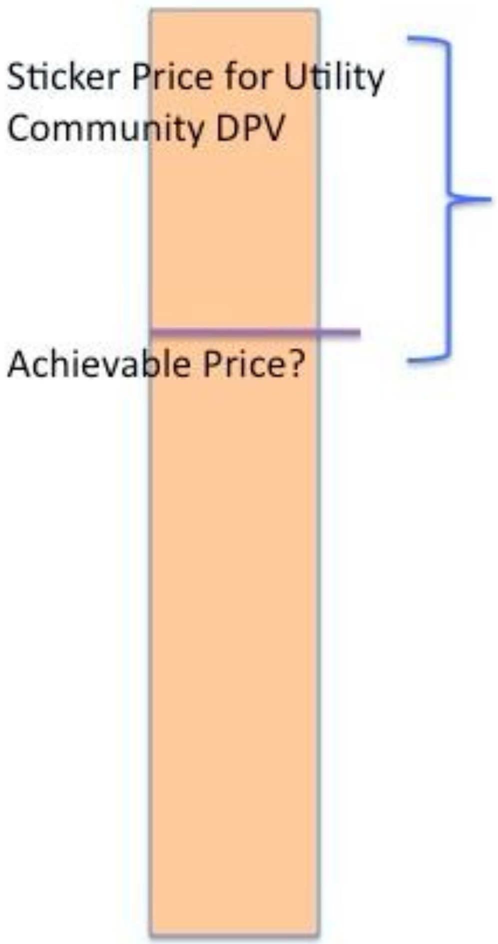
How the CSVP GAP Analytic Process Can Help

Utility-led community solar programs often struggle with the economics and the need for pricing that is both cost-based and competitive. While policymakers work to address fundamental changes to utility rate-design policies, planners still need an internal process to help advance solar projects and programs today.

CSVP's GAP process (Getting At Price) was designed around:

1. Basing the analysis on a program narrative, which concisely describes all the benefits of the procurement and the program;
2. Utilizing the analytic processes as a tool for decision-making, and not as an end in itself;
3. Encouraging the introduction of customized solar design elements that add strategic net value;
4. Including a rigorous solar- benefits analysis, narrowly focused on **achieving the GAP pricing goal**;
5. Adapting familiar rate-design strategies that are cost-based and market driven

GAP Analytics: Streamlined & Goal-Oriented



The GAP analysis is named for need to fill the gap between the baseline "sticker price" on a solar procurement and the net value that the utility can accept, in order to achieve competitive pricing on the program offer.

The GAP analysis is a process to "Get A Price" that reflects strategic DER value, but conforms closely enough to utility norms that it can be achieved and accepted by decision-makers in a relatively short time.

Basis for the Methodology

- One metric often used in evaluating resource acquisition decisions is the Levelized Cost of Energy (LCOE)
- LCOE is defined as the net present value (NPV) of project costs divided by the NPV of kWh output evaluated over the project life
- Traditionally, since most electricity resources were procured from central station projects on the transmission grid, only the NPV of project *costs* were compared
- When considering DERs, it is important to evaluate the *net* LCOE, which also incorporates incremental *benefits* of distributed PV on a levelized basis, i.e., the LBOE
- Even without including every possible benefit, the *net LCOE* analysis provides a more valid comparison of DPV resources

Equations

CSVP defines the LBOE categories as falling into four areas:

- Generation
- Transmission
- Distribution
- Societal

The equations for calculating the net LCOE are:

- $LCOE_{DPV\ NET} = LCOE_{DPV\ GROSS} - LBOE_{DPV}$
- Where,

↖PPA Price ↖DPV Benefits

$LBOE_{DPV} = LBOE_{GENERATION} + LBOE_{TRANSMISSION} + LBOE_{DISTRIBUTION} + LBOE_{SOCIETAL}$

Once the $LCOE_{DPV\ NET}$ is calculated, the utility's non-bypassable wires charge may be included, as usual, for bottom-line CS program pricing.

While some alteration of the wires charge may be warranted, most utilities find that very difficult to achieve. Modifications to support better pricing may be presented as an Adjusted PPA Price or Gross PPA Price + credit.

Generic GAP Analysis Calculation

PV PPA Price ($LCOE_{GROSS}$)	$0.075

Baseline Cost ↗

DPV Value Category (LBOE)	Value ($/kWh)
DPV Benefit Category #1	$0.010
DPV Benefit Category #2	$0.005
DPV Benefit Category #3	$0.005
TOTAL OF DPV BENEFITS ($LBOE_{GROSS}$)	**$0.020**

Aggregated DPV Benefits ↗

PPA Price Adjustment Calculation	Value ($/kWh)
Baseline PPA Price ($LCOE_{GROSS}$)	$0.075
Aggregated DPV Benefits ($LBOE_{GROSS}$)	$0.020
Adjusted PPA Price ($LCOE_{NET}$)	**$0.055**

Cost Minus Benefits ↗

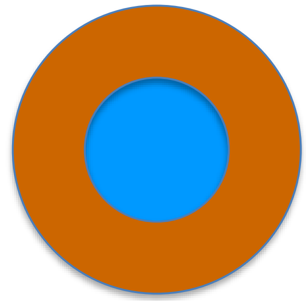
Program Price Offering Calculation	Value ($/kWh)
Adjusted PPA Price	$0.055
Non-Bypassable Wires Charge	$0.045
Community Solar Program Price	**$0.10**

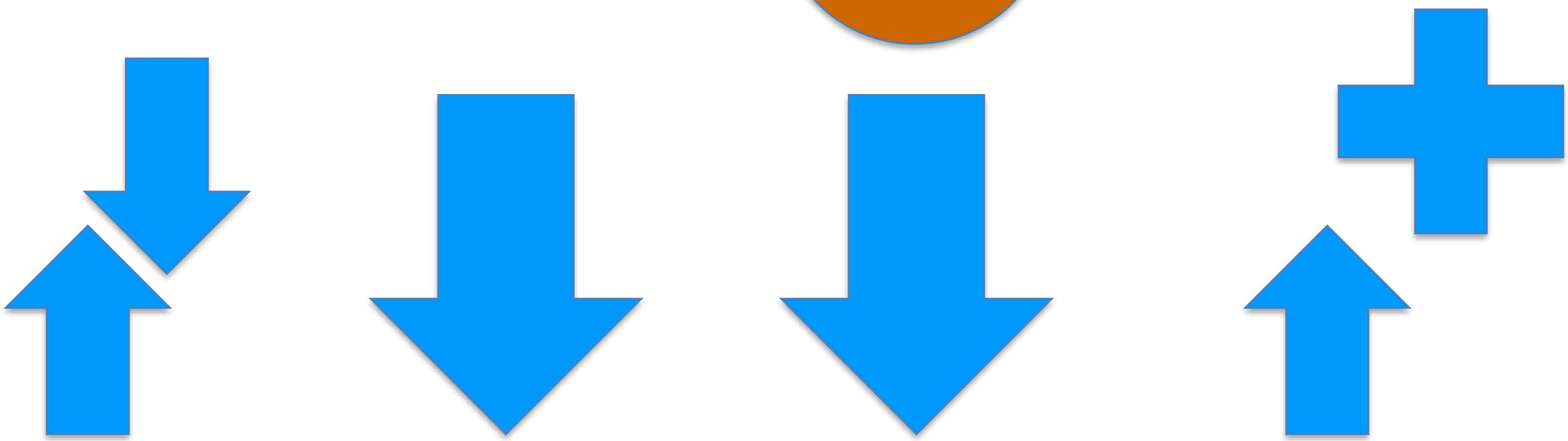
Indicative Pricing Estimate ↗

Summary of GAP Process Findings

- The GAP process is easily adapted to different:
  - Community solar program designs
  - PV system types
  - Utility situations
  - Solar-Plus companion technologies (i.e., storage and demand response)
  - Alternative pricing structures
- CSVP has applied the GAP process to 3 generic scenarios, demonstrating how utilities can make a minimum number of strategic adjustments, in order to add just enough benefit to make a project viable. This is in contrast to a typical value-of-solar (VOS) process, which is more general, and generally more contentious.
- A GAP approach that is streamlined and conservative, yet rigorous in its analytics, can be an effective tool in garnering management support for a community solar program.
- **See the website for reports, sample data forms, scenario results.**

Solar-plus can be one last high-value option





Strategic solar design/specifications

Best-practice project financing/ procurement

Utility-driven target market development & a more customized offer

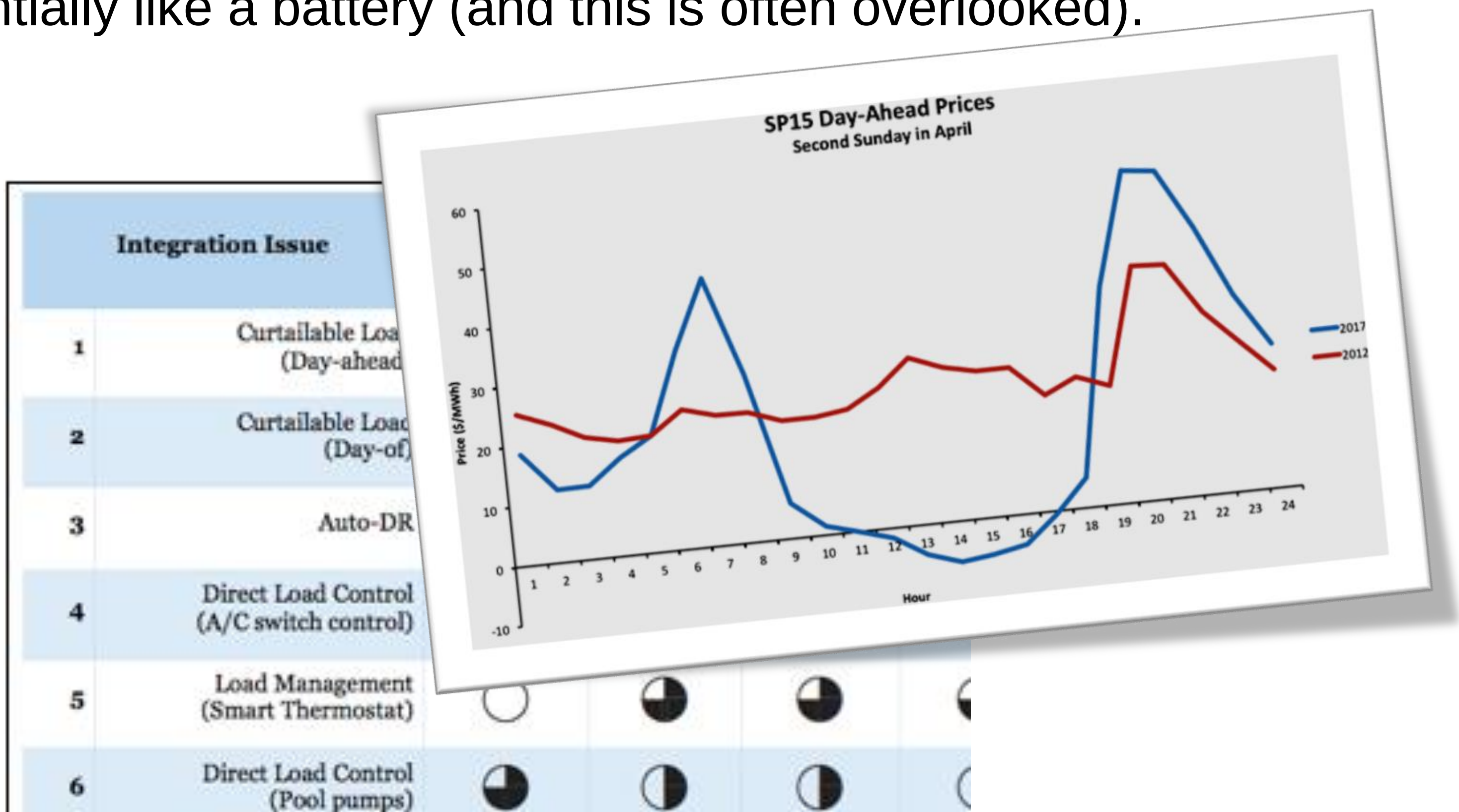
DR and storage companion measures increase net solar value

Solar +
Integration Strategies

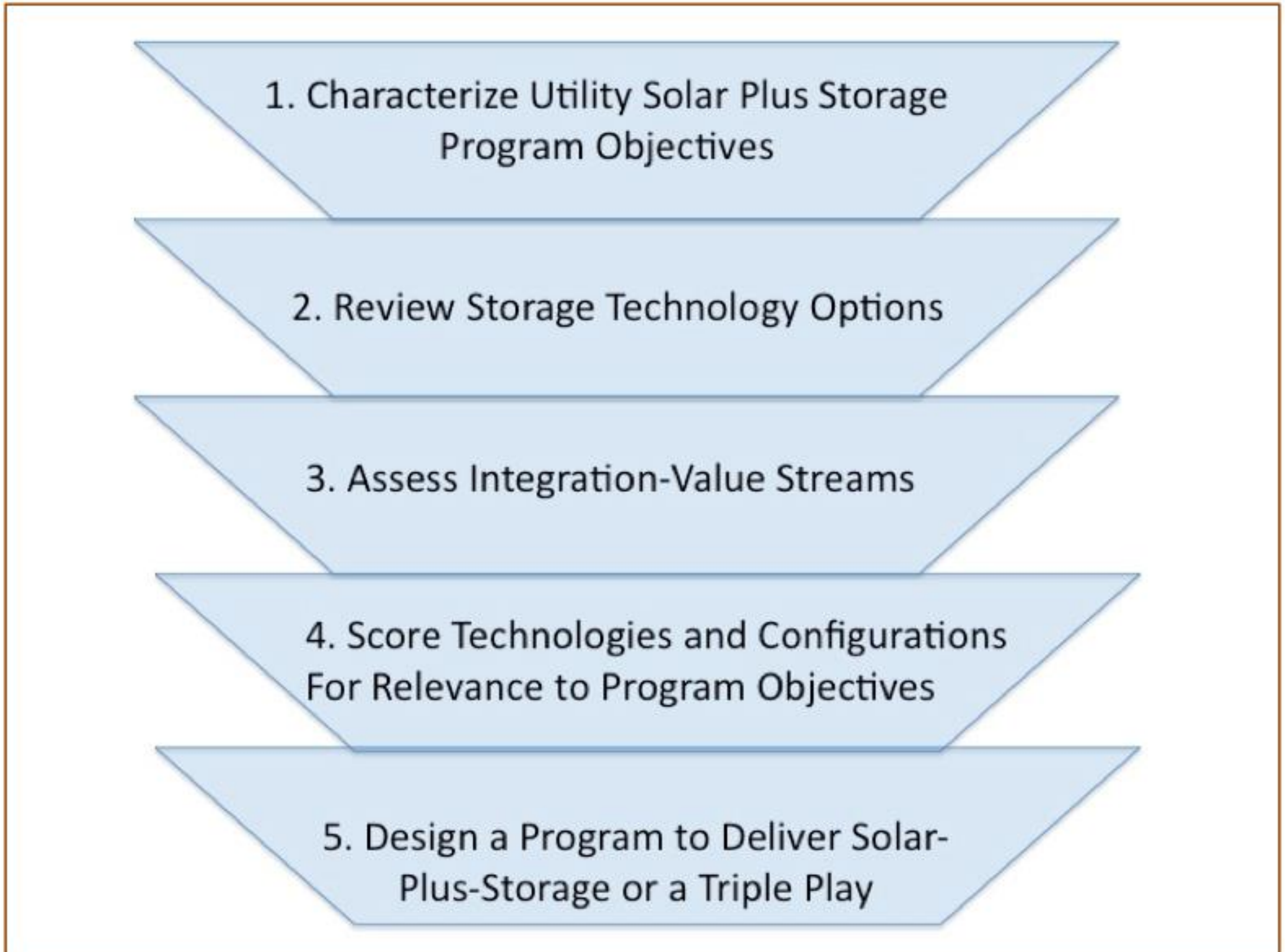
Solar-Plus or Solar Triple Play Strategies defy mass-market research, which puts emphasis on the simplicity of the offer. However, particular market segments seem likely to find that the easy attraction of the solar opportunity makes the more difficult “pitch” for DR acceptable—even attractive!

Integration Measures Follow High-Value Design

- Smart solar project design and smart inverter technologies are first-line tactics
- Solar geographic diversity, with quality forecasting minimizes short-term variability impacts
- Many DR 2.0 strategies, including devices, controls and pricing, work essentially like a battery (and this is often overlooked).



Yes, There is Process for Including Solar-Plus Measure Into Your Plan

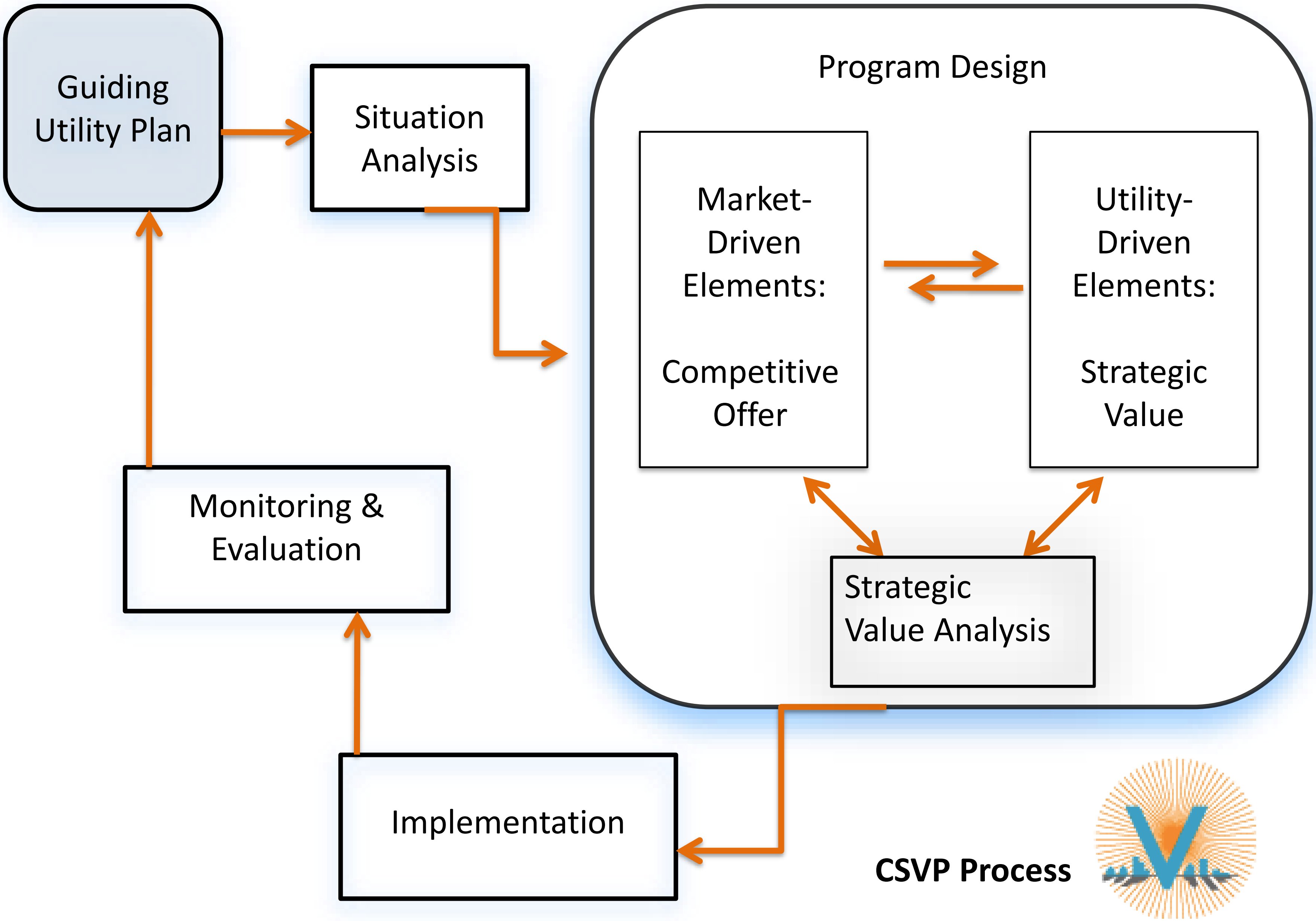


Many Useful Solar+ Technologies

A Solar-Plus Strategy Is Timely for Creating a Market-Based Laboratory

- Using low-cost, customer-side storage, the utility may offer a participation incentive that makes the community solar offer that much more appealing.
- Co-marketing of community solar with DR or storage can lower component-program customer-acquisition costs.
- Introducing community solar with companion measures can engage customers directly with an emerging 21st Century utility model.
- The community solar-plus model offers a scalable opportunity for utility to work with customers and third-party innovators as they all learn to succeed in a fast-changing market.
- Utilities that are not ready to deploy community solar plus storage as an integrated program offer can learn from CSVP's DR and Storage Guides for Utility Planners, as they continue to build out strategic DER portfolios.

Whether or not you go solar-plus, high-value community solar is within your reach.



Final Advice for Program Designers

- Return to the program design process diagram, and adapt it to your own process. Whether or not a utility implements all available high-value options, *a commitment to customer satisfaction and internal collaboration will lead to success.*
- Engage top-level decision-makers early and often:

"Top-level support is the top predictor of program success."*

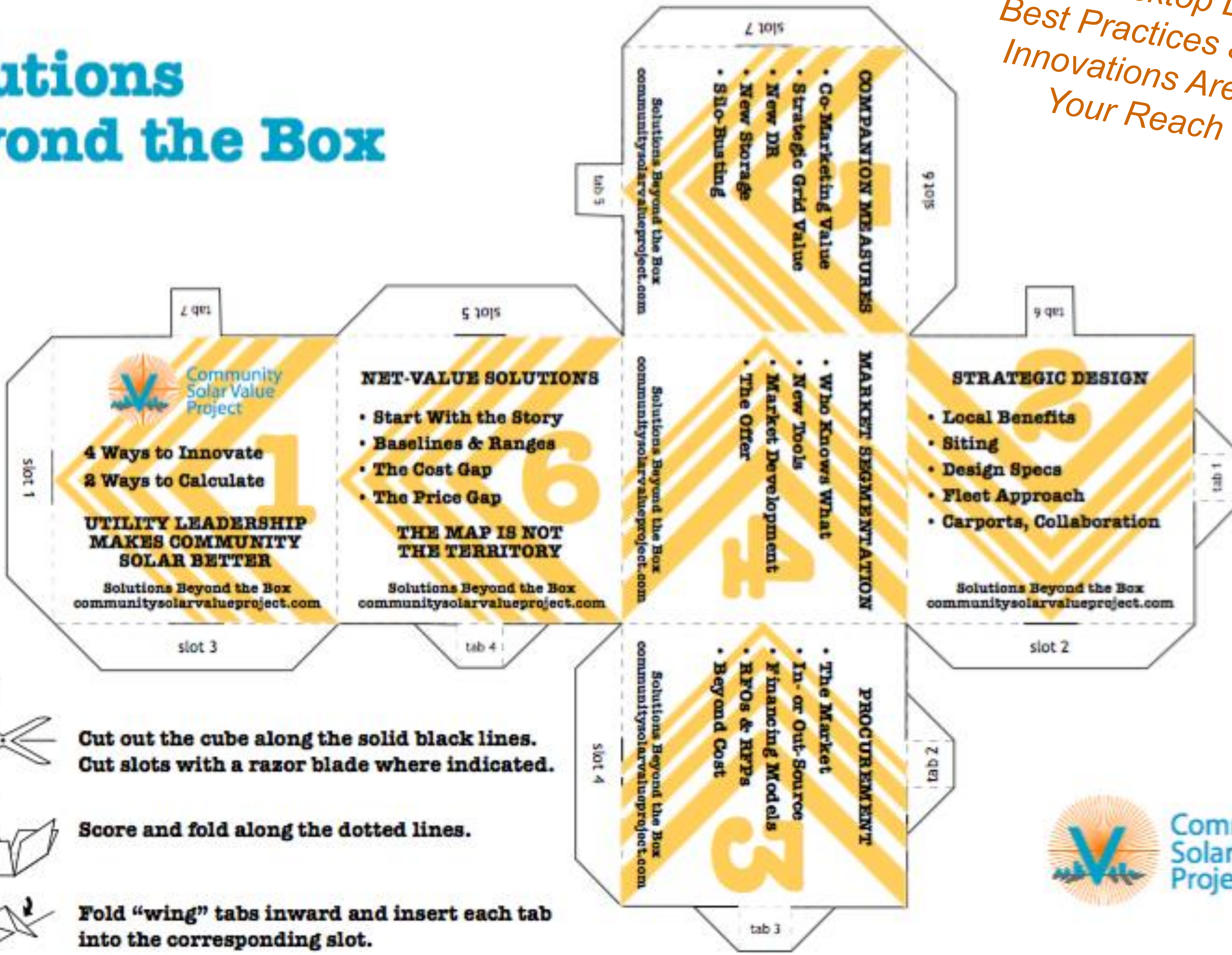
- CSVP's Solution's Toolkit takes planners beyond the assumptions of a smooth-flowing planning process—assuming, instead that planners must think outside the box, in order to address the challenges that come up unexpectedly, but inevitably. See

www.communitysolarvalueproject.com/solutions for details

*Jane Peters, *30 Years of Process Evaluation*, Research Into Action

CSVP Desktop Décor: Best Practices and Innovations Are In Your Reach

Solutions Beyond the Box



Assembly:

(a) Cut out the cube along the solid black lines. Cut slots with a razor blade where indicated.

(b) Score and fold along the dotted lines.

(c) Fold "wing" tabs inward and insert each tab into the corresponding slot.

Community Solar Value Project

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This work contains findings that are general in nature. Readers are reminded to perform due diligence in applying these findings to their specific needs, as it is not possible for CSVP to anticipate all specific situations, to ensure timeliness and applicability of the findings in all cases. Case study and survey research cited herein have been reasonably vetted, but rely in part upon self-reporting by their authors.

Community Solar Value Project

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The Right Tone of VOS: Improving the Argument for Local Community Solar

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Abstract

This paper describes an alternative to the typical value-of-solar (VOS) analytic approach for supporting utility acquisition of local, distributed solar, relative to centralized solar resources. The specific context is resource acquisition for a community-solar program. The utility in this case could acquire (by ownership or power contract) solar from a centralized solar project for a relatively low cost, or it could include a portfolio of local, commercial-scale solar projects with higher "sticker price," but strategic benefits. This case sheds light on the utility's internal-stakeholder debate and on the limitations of detailed bottom-up VOS analysis for some kinds of utility solar decisions. The recommended approach involves building a qualitative, strategic argument, which focuses on relatively few calculated values—three in this case, including strategic-design improvement, reduced transmission costs, and customer-retention value. In other cases, other values or ranges of values might be used. The objective is to apply analytics sparingly, to facilitate better decision-making under highly changeable technology, market, and policy conditions.

Keywords: *Community solar, value of solar, VOS, DER, utility solar, distributed solar, strategic solar*

1. Introduction

The practice of distributed-solar value analysis began in earnest shortly after Small is Profitable (Lovins et al. 2002) cataloged 207 possible values of distributed generation. Today, solar-value analyses, commonly called value of solar (VOS) studies, have become ubiquitous in net energy metering (NEM) policy debates. Less often, these analyses have been adapted to utility-planning proceedings and to support new rates or projects. Rocky Mountain Institute tallied 16 major VOS studies in 2013 (Hansen et al. 2013), and since then, many more have been published. The North Carolina Clean Energy Technology Center (2016) notes that policymakers in 28 states were studying the costs and benefits of NEM or the value of distributed generation in early 2016.

Despite their growing role in state policy-making, current VOS methodologies have practical limitations. For example, Cliburn and Bourg (2013) worked with a diverse panel of NEM stakeholders convened by the Solar Electric Power Association (SEPA) to establish a baseline understanding of VOS and NEM-related issues.

Stakeholders from all sides generally agreed upon VOS terminology and even upon most aspects of methodology, but their different perspectives and assumptions led them to very different conclusions. In addition, we found that current VOS approaches often forced an incomplete or static view of the value of distributed solar (DPV), at odds with increasingly dynamic utilities and markets. In its broad study of methods for analyzing solar value, NREL (Denholm et al. 2014) has envisioned developing a comprehensive VOS methodology, while noting that in the meantime, "there are trade-offs between different approaches in terms of accuracy and appropriateness" to the task at hand. We are reminded that, as the saying goes, that the map is not the territory, and analysis does not necessarily equate with understanding.

2. Methodology

The authors' current work with the Community Solar Value Project (CSVP), funded by the U.S. Department of Energy SunShot program, has suggested the advantages of using VOS analytics sparingly to gain internal utility-stakeholder support for distributed-solar acquisitions. In short, it is the CSVP mission to work with utilities, including a working group that includes Sacramento Municipal Utility District (SMUD), Public Service of New Mexico (PNM), and six other mostly Western utilities, to increase the value of community solar programs. Approaches include strategic siting and design, integration with storage and demand-response, and procurement innovations, regardless of project ownership. Community solar lends itself well to such strategies. Yet, community-solar program design inevitably raises tensions in and among utility departments, where some individuals associate DPV with utility risk and change, and others associate it with risk-management and opportunity.

In working with utilities, the authors have learned that providing a compelling narrative can be more effective—especially early in a program-design process—than providing a full economic analysis. Beginning with a hypothetical case, instead of a specific one, allows individuals within the utility to see past their differences on particular numbers and engage directly in a discussion of strategic possibilities and attainable outcomes. The analytics follow, sometimes as a collaboration involving cross-departmental utility expertise and expertise in solar VOS analytics. In sum, the path for this methodology is marked by four milestones:

1. A sketch of the "realistic hypothetical" solar-program scenario, including relevant problems or challenges;

2. Discussion with utility staff, setting baseline CPV and DPV values (energy, capacity) and identifying a short list of relevant DPV benefit categories, for which net values or ranges of values could be calculated;

3. Selective VOS analysis, to show that the utility could reach the net levelized cost target, which is needed to "close the cost gap" with CPV and justify the DPV investment;

4. Inclusion of additional strategic benefits that could tip the balance if there is still a cost gap between the CPV program resource and a CPV-plus-DPV portfolio option. The overall approach should underscore the changeable nature of technologies, utilities, and markets, and the risk-management value of strategic decisions.

The realistic hypothetical scenario described here involves a generic Northern California municipal utility, which is interested in shared solar, using low-cost centralized solar (CPV) generation, but which also has interest in siting local shared-solar projects. In part, this hypothetical represents a voluntary municipal-utility response to California's Green Tariff Shared Renewables Program, introduced by SB43. In fact, many utilities in the West have been drawn to CPV resources. These resources can supply solar via familiar utility pathways for prices that Lawrence Berkeley National Laboratory (Bolinger and Seel, 2015) has estimated at \$0.05/kWh. Recent news indicates continued price declines, but this paper uses the \$0.05 benchmark for a Northern California project. While projects approaching 20-MW scale could be sited on the distribution grid, tapping in to the CPV cost advantage, the land requirement for such projects (averaging more than 8 acres per MW) is a limitation for most distribution utilities. Thus, the authors assume CPV is transmission-sited. Community-solar DPV is assumed to be distributed on sites that meet a basic grid-hosting requirement (with higher-value siting requirements to be explored later) and an average 2-MW DPV project scale. Designs include 2 MW of fixed-tilt rooftop solar, 2 MW of single-axis tracking (SAT) solar, and 2 MW of flat-roof carport-integrated solar. The latter two designs are modestly strategic. The average cost for this fleet is

$0.075/kWh, based on Lazard (2015) and discussions with other consultants working in the region.

Thus, on the face of it, there is a 2.5-cent per kWh cost gap between the all-CPV and all-DPV options. It is understandable that utility resource planners and program designers might be drawn to the all-CPV solution. The case presented here takes a realistic view of the utility's inclination toward cheaper, centralized resources, and it recalls a solution demonstrated in green-power programs (O'Shaughnnessy 2015), when utilities sometimes combine lower-cost wind power with a smaller amount of solar PV to reach a combined-price target. Here, we suggest a "fleet" approach, beginning with 20 MW of CPV, plus a total of 6 MW of DPV, as described above. The DPV fleet may grow to include more DPV or to add more innovations, as solar costs decline.

Note that the realistic hypothetical scenario should describe relevant problems or challenges. This scenario will address several, but primarily these two:

- A cost gap favoring centralized solar over DPV, despite a preference among many community-solar participants for DPV. Case studies and market research support this customer preference, but the utility sees the higher cost of DPV as a risk, if customers prove to be more driven by savings.
- A pricing gap between utility-based pricing and rooftop solar competitors. The CSVP (Romano 2016) has documented a utility preference for community solar that avoids virtual retail-NEM pricing, in favor of a cost-based $/kWh tariff or a charge per "block" of generation. This approach would reward customers for solar generation, while providing greater utility cost-recovery than NEM-based offers. The challenge is for utilities to keep community-solar pricing within range of third-party competitors. Can utilities achieve this without relying exclusively on low-cost CPV?

2.1 Baseline Values and Target Categories for Analysis

A typical VOS analysis quantifies monetary benefits that accrue to the utility through the deployment of DPV systems and/or project strategies. These benefits typically fall within the following general categories:

- Generation Level
- Transmission System Level
- Distribution System Level
- Societal Level

Within these four categories are numerous sub-categories of benefits. Unlike numerous prior studies, our process does not attempt to document all of the potential VOS benefits up and down the chain of monetizable categories. Nor is the purpose to see how high the benefits of DPV can stack. In working with utilities, the authors have recognized that any stacked-benefit graphic would draw utility stakeholders' attention away from the strategic argument, sparking debates over numerous specific values. An alternative approach begins with relatively straightforward agreement on wholesale energy and capacity values. This includes utility-provided hourly avoided energy and capacity costs for the hours of solar generation. Subsequently, we present a simple categorical listing of possible benefits, including measures that address the utility's strategic problems or challenges, and work to select which to explore. Here, we focus primarily on just three strategic values:

- Strategic-design aspects of the DPV fleet
- Avoided transmission costs
- Customer retention value of local vs. centralized community solar

2.2 Analysis of DPV strategic-design benefits

The approach to this analysis will focus on the levelized cost of energy (LCOE) metric, which is commonly used in VOS analyses and throughout the utility industry to make resource planning decisions. LCOE is defined as the costs of a project (fixed and variable) over its expected life divided by its energy production over the same period, on a discounted basis. In simple terms, the LCOE is the net present value (NPV) of the annual costs divided by the NPV of the project's annualized energy production. Note that the authors also introduce a refinement, specifically identifying a levelized net *benefit* of energy (LBOE) for DPV and incorporating it into the final, fleet net value.

The range of strategic benefits associated with improved DPV project design is great—from the benefits of optimized inverter specification to the benefits of designing for resilience in case of prolonged emergency outages. However, for this hypothetical case, we simply consider how three generic DPV system designs (fixed-tilt rooftop, single-axis tracking and flat-mount carports) impact the need to purchase energy and capacity from wholesale markets or via existing PPAs. Then we derive the benefit of each design, relative to the typical fixed-tilt CPV system. Of course, there was no incremental value associated with the fixed tilt rooftop design, as its design was assumed to be similar to that of the typical CPV system. The flat-mount carport, while generating 12% less energy than a fixed-tilt system on an annual basis, had an incremental avoided cost (0.41-cents/kWh) above the fixed-tilt system. That is because it generates much more power in the summer months, coincident with higher wholesale energy and capacity purchases in Northern California. In fact, this configuration yields 4.2 times the monthly energy production in the peak summer month than in the lowest winter month. Finally, the single-axis tracking system had a higher incremental avoided cost value (1.33-cents/kWh) than the CPV system, since it generates 24% more annual energy on an annual basis than a fixed tilt system of the same size, and its output profile is highly coincident with the highest wholesale hourly power costs.

Combining these strategic-design values in an analysis of the entire 6-MW DPV fleet, the incremental LBOE associated with wholesale power cost savings is 0.64-cents/kWh. In other words, this 6-MW fleet would have avoided wholesale power cost savings that are of 0.64-cents/kWh higher, relative to a typical fixed-tilt CPV project. This savings will contribute to filling the cost gap of 2.5 cents between the CPV-only and DPV-only resource options. Figure 1, below, demonstrates the individual and aggregate generate profiles of the DPV fleet.

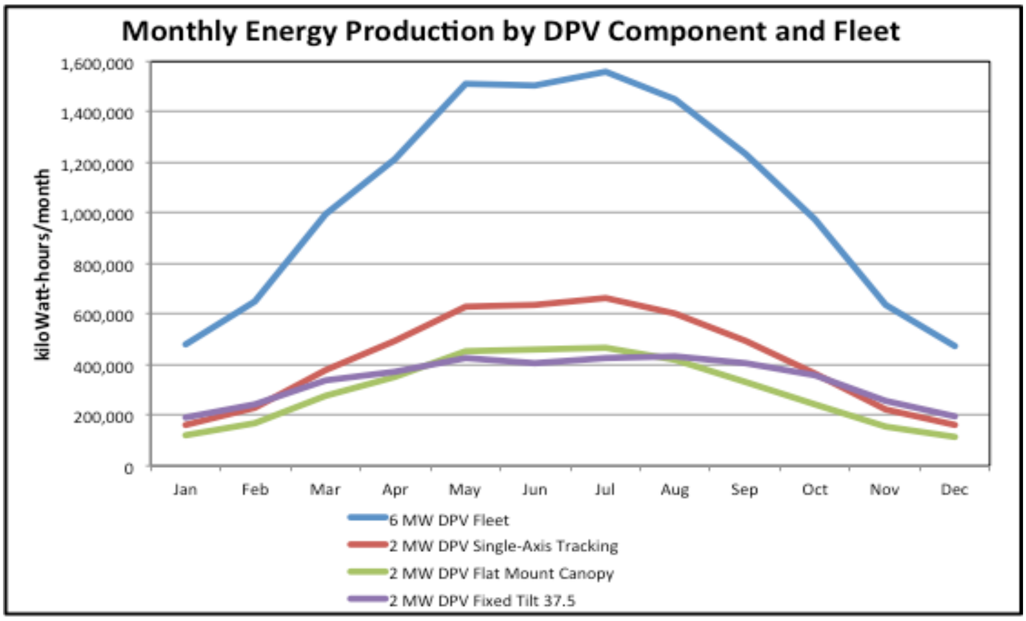

Fig. 1. Monthly energy production by DPV component project-design and by the fleet.

2.3 Analysis of Avoided Transmission Costs

The second category analyzed to fill the cost gap is the incremental value of avoided transmission costs, associated with DPV resources. Avoided transmission cost sub-categories include avoided transmission line losses, avoided ancillary service costs, avoided or deferred transmission capacity investments, and avoided transmission service charges (i.e., firm or non-firm transmission reservation charges). Not all transmission costs are avoided on a 1:1 basis as a result of DPV generation. A robust analytic approach today would require site-specific hourly transmission-cost modeling and additional considerations; in the foreseeable future, researchers at the National Renewable Energy Laboratory and other institutions expect to understand

DER/transmission interactions better and to develop analytic tools to assess DER/transmission values (Palmintier et al. 2016). Yet clearly, significant transmission-related costs would be avoided by DPV, compared to transmission-sited CPV resources.

In order to estimate the potential savings, the authors conducted a literature review. In the literature, transmission-related benefits are treated differently in different studies—often combining transmission system benefits with distribution system benefits as one T&D category, or referring generally to "transmission benefits," when only one benefit, e.g., the value of capacity deferrals from DPV, is being counted. For example, the U.S. Energy Information Administration (U.S. EIA 2015), suggests transmission cost "based on the average cost to build, operate and maintain these systems using a cost of service regulation model" averaging $0.0184/kWh (on a levelized basis) for the California market. EIA does not provide detail on the its transmission costs, but is assumed to be drawn from the "postage stamp" rate—the flat Transmission Access Charges (TACs) in the California ISO market (CAISO) for delivery of energy from the point of generation to the utility distribution system. One study, completed for the California Energy Commission by the Clean Coalition (Clean Coalition 2015), is more inclusive, and estimates transmission avoided-cost DPV benefits on the CAISO market totaling $0.03/kWh. The difference between the EIA and Clean Coalition estimates is the escalation rate of future TACs in the CAISO. Both start at the same 2015 TAC value of $0.018/kWh, but EIA assumes a relatively flat escalation rate in TACs over the next 20-plus years. The Clean Coalition study utilizes the CAISO's projected average future estimate of 7% nominal escalation (5% real) over the next 20 years, to arrive at its levelized value of $0.03/kWh. While this value may seem high, a 7% annual escalation rate is less than half of the historical escalation rate (15%) since 2005. It should also be noted that neither the EIA or Clean Coalition studies incorporate the value of line losses in their TAC-based analyses, underscoring that $0.03/kWh is most likely conservative.

Accepting that arguments for additional avoided-cost benefits can be contentious, the authors note that several other recent sources have found transmission avoided-cost benefits in the same range or higher. For example, the Crossborder study (Beach and McGuire, 2013) submitted to the Arizona Public Service Commission, estimated transmission benefits of DPV in the $0.021 to $0.023/kWh range with an additional $0.015 cents/kWh in savings attributed to ancillary services and capacity-reserve savings, for a total range of $0.036 to $0.038/kWh. A recent VOS study in Vermont by the Acadia Center (Acadia 2015) valued the avoided transmission costs for DPV between $0.027 and $0.030/kWh on a levelized basis. These studies focus on different regions; they are not perfectly comparable. Yet, such robust DPV benefits strengthen the case for considering some significant range of avoided transmission costs..

This paper's suggested methodology has an element of negotiation—posing the question, "What is the likely range of values for this benefit?" Rather than assuming there is one true number, we suggest that there is at least one *better* number, which reflects a better understanding of DPV value under likely technical and market conditions. In this case, we assume a LBOE value of $0.01/kWh for transmission benefits in this analysis—a conservative number from our perspective, but one which can be applied to the DPV portion of this community solar fleet, to help create cost-parity with the all-CPV option.

2.4 Derivation of Revenue-Retention Value

As noted above, this realistic hypothetical case is not intended to be all-inclusive of local solar DPV benefits. The authors are aware of many more benefits that could be added to a considerable stack. However, a first consideration is that, in order to differentiate DPV from this hypothetical utility's low-cost CPV option, we focus only on values that are *uniquely characteristic of DPV*. Thus, for example, environmental benefits that could be monetized from either a DPV or CPV resource are not considered here. There are other benefits that would likely be on the list—for example, locational distribution-grid benefits that could be introduced if strategic siting were part of the community-solar program design.

However, for this paper, we wish to confront a seldom-recognized benefit, which, if included, would help to create a win-win for the utility and the customer. That is, the need to find acceptable alternatives to retail NEM, as it is commonly used today. The aim would not be to limit customer choice, but to introduce an additional choice, with similar bottom-line pricing, other program-defined benefits, and less erosion of utility wires-charge revenue. Even utilities that accept the value of solar have noted how the very rise of NEM could create a utility cash crunch, because solar benefits materialize over the long term of the VOS analysis, while funding for grid maintenance and improvements are needed now. This is especially true in today's solar market, where the amount of residential DPV (mostly net metered) has about doubled in two years, 2014-2016 nationwide, bringing California to a total of more than 3,000 MW of DPV by yearend 2015, according to U.S. EIA. Utilities know they are experiencing impacts of a solar market transformation; many now are focusing less on stopping it, and more on a smoother transition, where community solar (possibly including PPA providers and other non-utility partners) could play a role. Utilities are learning that customers might exit any over-priced community-solar program, and turn to a rooftop lease or purchase, while the utility picks up the remaining years on an under-subscribed PPA. Is there a solution that could slow NEM-related revenue loss, while increasing the amount of DPV and improving community-solar pricing?

Our analysis begins with understanding the hypothetical utility's current residential rate tariff. In this scenario, the residential retail rate is $0.12/kWh. Half of this retail rate represents the value of (standard portfolio) energy, and the other half represents a non-bypassable wires charge. When a customer switches to full-retail NEM for solar on its own property, the associated non-bypassable wires charge ($0.06/kwh) is entirely lost to the utility. By contrast, a tariff-based community-solar model, similar to one that already exists in California, could include a more strategic, lower non-bypassable wires charge, reflecting the benefit of retaining the community-solar customers who pay it.

In practice, it would be reasonable to negotiate a lower wires-charge burden for all community-solar customers, because the net grid-impact per kWh of generation from a community-solar project is likely to be less than the net grid-impact per kWh of generation from randomly sited and variously oriented rooftop projects. That is part of the often-cited community-solar value proposition. However, for the sake of simplicity, we will examine the $0.06/kWh non-bypassable charge before any other value-related discounts.

To set the revenue-retention benefit for this hypothetical case, we first need to assess to what extent customers who choose community solar might alternatively opt for NEM rooftop solar. One can assume that customer-rooftop solar, community solar via a CPV tariff, and community solar via local DPV all draw from the pool 50-65% of all electricity customers, identified by a range of studies, who say they are interested in going solar. According to research (Shelton 2016) for SEPA, about 60% of residential customers are interested in solar power, and about 34% of these are seriously considering options. Before receiving any detailed information about options, the breakdown of that 34% includes about 16% who are primarily considering rooftop solar and 14% primarily considering community-solar (4% not reported). Are these groups interchangeable? Another research track in the Shelton work followed the customer decision process and found that indeed, there is movement in customer preference in both directions. For example, Shelton divided a large group of residential customers interested in solar into those initially likely/very likely to choose rooftop and those not likely to choose rooftop. Then each group was presented with information on actual solar options and pricing, for both rooftop and community solar. After two rounds of polling, 45% of the group initially favoring rooftop switched to a preference for community solar, and 35% of those initially disinterested in rooftop switched to the rooftop preference. Pricing was a major factor, but not the only factor in this shift. Reports from existing community-solar programs also suggest the market is somewhat fluid in both directions between rooftop solar and current community-solar options.

If the community solar option were not available or were not competitive, would as many as one-third of customers, who are currently considering solar, choose a rooftop option? We believe the evidence available today is not strong enough to confirm that. But a significant percentage of customers likely would migrate, and at an accelerating rate in places where rooftop solar (with or without NEM) is near retail parity.

The next relevant question is, Does the customer-retention benefit differ for DPV compared to CPV within a community solar program? Anecdotally, the preference for locally-sited projects is strong, but some analysts have cautioned that early-adopters could be a special group. The recent Shelton work addresses this uncertainty, confirming that customers generally prefer local community solar, meaning "solar you can see on a short drive, in your community." This preference is very strong—even at a higher price. But in the context of subscription-based community solar, Shelton links this preference with other aspects of a competitive program offer, including that any premium should under $0.03/kWh over the retail rate. If other aspects of the program offer are held constant, there is significant value in keeping community solar local.

In this hypothetical case, the authors recommend incorporating a DPV benefit that reflects the impact specifically of local community solar on customer acquisition and revenue retention. Our methodology would ask the utility to review ranges of likely impacts, settling for this hypothetical on an assumption that *at least* 15% of those interested in solar could go to either community-solar or rooftop options, but would choose community solar, so long as it affordable and includes visible, local projects. Thus, 15% of the of the non-bypassable wires charges in the retail rate can be assigned as a customer-retention value for including a significant DPV in the community solar program. Based on the hypothetical $0.06/kWh charge, this results in a first-year customer-retention value of 0.9-cents per kWh and an LBOE of 1.17-cents per kWh when levelized over the 30-year term of the solar investment, using a 6.5% discount rate and a 2.5% annual retail rate escalation factor.

The authors concede that this customer-retention analysis is preliminary. In the discussion below, we suggest ways to improve this analysis, including a call for more detailed market research. We assume any offer—rooftop or community solar—could be made more competitive, with resulting impacts on the market. However, in discussing this hypothetical case with utilities (especially in California where solar growth is strong), we found little resistance to the concept that “there is a significant cost to doing nothing.” The recommended process is effective for engaging utilities on their need to offer a better community-solar product at a better price. Incorporating this fairly conservative local-solar benefit on the DPV 6-MW fleet allows the analysis to fill the cost gap between all-CPV and a fleet with significant local solar.

3. Results

A major goal of this paper is to demonstrate that in selecting solar resources for utility-driven community solar, DPV resources can economically compete with CPV projects. This was accomplished through a simplified VOS-type analysis. Calculations were performed to determine the base-case values for CPV and DPV in terms of their gross LCOE, in simple terms, the levelized “sticker price.” Then, a select few high-value incremental benefits of DPV were analyzed to calculate a net LCOE of DPV resources. arriving at a net LCOE for DPV. This net LCOE accounts for a short list of incremental DPV benefits (three in this case) that are not found in CPV. These are expressed in aggregate as the levelized benefit of energy (LBOE) of DPV, as shown in Equation 2. The focus on select benefits that are uniquely characteristic of DPV is a much simpler approach than reviewing all the values of CPV and DPV, and then subtracting the gross benefits of CPV from DPV to calculate the incremental benefits of DPV.

$LCOE_{DPV\ NET} = LCOE_{DPV\ GROSS} - LBOE_{DPV\ GROSS}$ (Eq. 1), where

$LBOE_{DPV\ GROSS} = 0.64$ cents + 1.0 cent + 1.17 cents (Eq. 2)

$LBOE_{DPV\ GROSS} = 2.81$-cents/kWh (Eq. 3)

Incorporating those benefits, a side-by-side comparison of LCOE values emerges, as presented below.

Tab. 1. Gross Costs for Centralized and Distributed PV, in Comparison With Net Cost of DPV Incorporating Three DPV-Characteristic Benefits

$LCOE_{GROSS\ CPV}$	$LCOE_{GROSS\ DPV}$	$LCOE_{NET\ DPV}$
$0.0500/kWh	$0.0750/kWh	$0.0469/kWh

The results of these analyses show that the difference in “sticker price” between CPV and DPV dissolves into economic equivalence of these resources. The net LCOE of the value-enhanced hybrid solar fleet is virtually the same as the gross LCOE of the baseline CPV plant. As shown in Table 2, the hypothetical 26 MW fleet, including 20 MW of CPV and 6 MW DPV (rooftop, SAT, and flat-mount carports) has a sticker price that is just over one-half cent more than the CPV alone. Considering available market-research on customer willingness-to-pay for local community solar, one wonders whether to increase the amount of DPV in this fleet, since the cost premium, even before counting DPV benefits, would be quite low. Assuming our hypothetical hybrid fleet, with DPV benefits counted (on a net LCOE basis), there is practically no economic difference between CPV alone and CPV-plus-DPV in a 26-MW fleet.

Tab. 2. Economic Analysis for a Hybrid Community-Solar Fleet

20 MW CPV $LCOE_{GROSS}$	6 MW DPV $LCOE_{GROSS}$	26 MW Hybrid Fleet $LCOE_{GROSS}$	26 MW Hybrid Fleet $LCOE_{NET}$
$0.0500/kWh	$0.0750/kWh	$0.0556/kWh	$0.0493/kWh

A second goal for this process was also achieved. These results demonstrate the value of community solar to competitively retain some customers who would otherwise choose to own or lease NEM-based systems. This is shown in reviewing the net LCOE of the community solar fleet versus the LCOE to the utility customer of a NEM system. One California utility consulted for this study indicated that the average offer from third parties to its utility customers for a NEM residential system on a 20-year PPA was $0.1090/kWh with a 2.9% annual escalation factor. This equates to a customer LCOE of $0.1323/kWh. With a hybrid fleet average of the net LCOE at just under $0.05/kWh, the utility has considerable opportunity to recover valid wires charges in community solar pricing, while still offering a competitive product to its customers.

4. Discussion

As noted above, the goal of this methodology is not to build a bottom-up stack of solar benefit values, but rather to work directly with utility staff to build a bridge, to close the perceived cost-gap between CPV and DPV. That goal has been achieved by using only three categories of solar value. The authors could adjust the average LCOE of the fleet either by working with utility stakeholders to count more DPV benefits, or by adjusting the balance between amounts of CPV and DPV in the fleet resource mix. Another option might be for the utility to offer an all-DPV option, keeping the premium within a modest range, as demonstrated by incorporating these three categories of benefits, or by incorporating a subset of other characteristic DPV benefits. One of the main takeaways of this analysis is that utilities have good reason to consider deployment of at least some DPV resources in the community solar resource mix.

In addition to the customer acquisition and retention drivers, there is notable risk-management value in pursuing a diverse resource strategy during these times of change. Risk-management is a key category of strategic value, which our methodology suggests adding to the case narrative, just as prominently as the LCOEs and LBOEs. For example, some utilities are concerned that community solar offers a shorter term for participation and an "easy exit option." What if the declining cost of solar leads to newer, cheaper third-party offers? A project-fleet solution underscores the risk management value of DPV, as projects can be added incrementally, keeping pace with participation and putting downward pressure on average fleet-based pricing. This strategy leads to other technical and socio-economic benefits, too, of a distributed-fleet approach.

In reviewing the results of this methodology, it is important to underscore the importance of facilitating utilities' internal-stakeholder processes and building support for local solar, in order to speed much needed clean energy and grid-flexibility advances. The authors have long recognized the inherent conflicts between utilities and stakeholders, especially regarding solar advances (Cliburn and Bourg 2010). The contributions of non-utility innovators in the changing utility landscape are needed, but they will not fully replace utility functions—or certainly not immediately or without utility collaboration. The necessary change in utility mindset from relying on centralized, remote generation resources to working with centralized *plus* local distributed energy resources (DERs) on an increasingly flexible grid is difficult for anyone coming from established utility culture. By using a simplified, solution-oriented approach to VOS, applied to a realistic hypothetical case, utility groups can feel freer to consider new solutions. As noted above, they would not be pressed into agreement on the one *best* number for each incremental DPV value in the stack; they would only work with a short list of values and agree upon one *better* number for each, representing the range of possibilities and dynamics that they must consider. If a short list of agreeable DPV benefits can close a "cost gap," then implementation of community solar (or other strategic DPV options) can advance quickly, and on a larger cumulative scale.

To be sure, this paper includes preliminary analyses; continued research is needed on several fronts. The scarcity of market research on community solar and on customer preferences among all kinds of PV needs a lot of work. Nevertheless, the authors present what we know so far, because we hope to prompt a more substantive discussion. A hypothetical municipal utility may have the leeway to employ a customer-retention benefit fairly quickly, but we recognize that other utilities could face tough regulatory scrutiny. At minimum, those utilities that cannot monetize this a customer-retention benefit explicitly may be more open to an equivalent sum of other DPV values to help meet the DPV-benefits target. Further, the authors are currently engaged in developing out a more complete pricing proposal, urging utilities, regulators, and advocates alike to advance strategic, significant, and growing fleets of solar DPV.

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6. Acknowledgements and Disclaimers

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The CSVP acknowledges the contributions of various utilities to this effort. Details and updates are available at the CSVP website, http://www.communitysolarvalueproject.com. The authors underscore that the case described is, as intended, a hypothetical, and does not represent specific utility programs or policies.

Market Research and Market Segmentation for Community Solar Program Success

A Brief for Utility Program Designers

Community Solar Value Project

December 2016

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Community Solar Value Project

Powered by SunShot
U.S. Department of Energy

Summary

Market Research and Market Segmentation for Community Solar Program Success is part of the *Community Solar Value Project (CSVP) Solutions Toolkit*. The CSVP is aimed at developing best practices for community-solar programs at electric utilities, including guidelines on how to achieve greater reach and net value by working in four areas: strategic solar project siting and design, project financing and procurement, target marketing and segmentation, and integration with solar-plus companion measures, such as demand-response and storage.

This brief is focused on the target marketing topic area. It guides utility program managers through the market research process, as they design, develop, and market the community solar program offer. By understanding the sub-groups or market segments within the customer base, the savvy community solar program designer can improve customer satisfaction and lower solar customer acquisition and retention costs.

Where does a program designer or manager begin in this effort to understand and act upon their customers' needs? They should start by asking themselves questions that define five key market-research tasks:

1. **Assessing Needs:** Where do I need the most help, in relation to understanding customers' perspectives on community solar?
2. **Drawing On Outside Research:** What can I find out from other organizations that have explored community solar?
3. **Mining Customer Data:** What information does my utility already know about the wants and needs of the targeted customers?
4. **Interviewing Customers:** What additional information can I gather from customers given available resources?
5. **Incorporating Feedback Loops.** How do I collect feedback, then monitor and adjust the program as it moves forward?

This brief explains the process and the resources that are useful at each step along the way. It is particularly sensitive to the realities of working in a utility today, where resources may be available, but are nevertheless hard to find and challenging to interpret. The brief also explains the strengths and limitations of popular new market-research techniques, such as the use of Prizm and other micro-target market segmentation tools.

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Key words: community solar, target marketing, market research, program design, outsource.

About the Community Solar Value Project

The Community Solar Value Project (http://www.communitysolarvalueproject.com) is aimed at developing best practices for community-solar programs at electric utilities, including guidelines on how to achieve greater reach and net value in four areas: strategic solar project siting and design, project financing and procurement, target marketing, and integration with solar-plus companion measures, such as demand-response and storage.

The project is led by Extensible Energy, with support from Cliburn and Associates, LLC, Olivine, Inc., and Navigant Consulting. Utility participants include the Sacramento (California) Municipal Utility District (SMUD), and other utilities nationwide. The project is powered by SunShot, under the Solar Market Pathways program of the U.S. Department of Energy.

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Disclaimer

Contents

Introduction

Utility customers' interest in community solar varies across many variables. Some of these are geographic, related to different policies and access to solar development. Some are demographic, defined by socio-economic indicators such as gender, age, income level, or education. Others are psychographic, defined by similar attitudes, values, and lifestyles. Understanding all these influences can be instrumental to the success of a community solar program. In particular, the study of demographic and psychographic influences are at the core of market research activities, required for successful utility program design and implementation. Utilities can and should draw on existing data from outside jurisdictions, demographic and psychographic data, their own utility customer data, and solar-specific surveys of their customers to help design community solar programs (Figure 1). Collectively, this information can be used in estimating the market potential upfront, understanding the types of products that might be of interest, helping to narrow in on a group or groups that the utility wants to appeal to, and marketing the program to targeted customer segments, in the course of program implementation.

Use Market Research and Segmentation to Understand the Variation in Customer Sub-groups in Advance of Offering a Community Solar Program

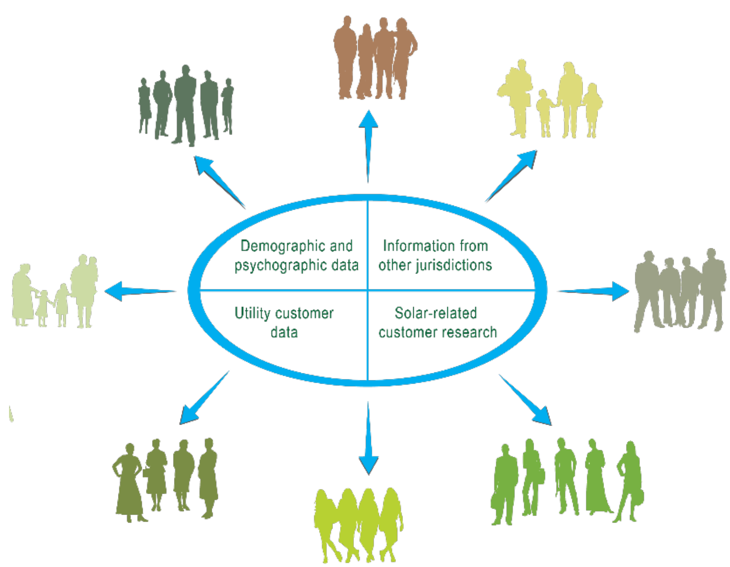

Figure 1. The above figure highlights the use of market research and segmentation to understand the variation in customer sub-groups in advance of offering a community solar program.

Designing an offer with target-market research in mind is critical to the success of any community solar program. This is especially true if the utility desires a program that incorporates companion program measures and "high-value" aspects—e.g., one relying on locally sited projects, which may come at a slight premium, but which bring grid-integration value to the market, along with the solar choice.

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While the exact timing, focus and approach will vary, below we present a checklist of the basic steps to get utility program designers through this process. (See Figure 2 below.)

Notably, some utilities may have the resources to customize each of the research steps for their utility, while others may find it valuable to outsource some steps. Throughout this brief, we mention external resource options where these are available.

Market Research Checklist for Designers of Utility-Based Community Solar Programs

☐ **Step 1. Assessing Needs**
Determine where the utility needs assistance the most (e.g., overall program design, identifying top targets, identifying companion measures, determining marketing messages)

☐ **Step 2. Drawing on Outside Research**
Build on knowledge from other utilities and outside resources (but question the questions, and recognize that education on community solar will be critical)

☐ **Step 3. Mining Customer Data**
Understand what customers want and need through data mining

- ☐ Explore existing target-market segmentation related to any existing utility programs or services
- ☐ Assess and tap into existing data sources, such as energy usage patterns or survey data

☐ **Step 4. Interviewing Customers**
Collect program specific data

- ☐ Determine opportunities to (1) collect data through primary research and (2) leverage cross-departmental resources for gathering data
- ☐ Conduct qualitative research, e.g., focus groups or in-depth interviews, to explore issues
- ☐ Conduct customer surveys to test hypotheses and explore alternative options
- ☐ Analyze all available data to inform the development of the program and marketing plan

☐ **Step 5. Developing a Program Design with Feedback Loops to Monitor and Adjust**
Develop an interactive program-design process, integrating enhancements based on customer feedback with technical concerns, such as project siting and design, pricing, customer sign-up and billing, etc., to create a win-win for both the customer and the utility. Build in feedback loops to monitor and adjust.

Figure 2: A market research checklist for designers of utility-based community solar programs.

Step 1. Assessing Needs: The Value of Market Research and Market Segmentation

Market research and market segmentation can help utilities understand their customers better and allow them to move to a more customer-centric model, improving program success and often lowering overall program costs. In particular, market segmentation can be used to design elements of a program, to identify likely target markets, and to create effective messaging.

1) **Design elements of a community solar offering**[1]. Market research and market segmentation can be used to design or refine a draft program offer by testing and analyzing options for participant terms and payment structures, as well as possible companion measures to community solar, such as energy efficiency, load management or storage. More specifically, to help ensure that the proposed offering meets the needs of targeted segments in the community, utilities can test product bundles among various sub-groups of their population, (such as community solar and a new rate or community solar and a demand-response offer).

2) **Identify likely target markets.** It is important to know which groups of customers are interested in community solar, what is driving local interest, and whether customers are aware of what these programs offer (e.g., savings, bill certainty over time, environmental benefits, etc.). Understanding what customers know and what they want is particularly important if the utility is using community solar to retain a particular segment of customers within the residential or commercial sector, or to identify the right companion measures for marketing with a community solar offering.

3) **Create effective messages** and ways of reaching customers. Market research and market segmentation can be used to understand the best messages and channels for reaching a variety of sub-groups within a population. This can reduce marketing costs, thereby shortening the sign-up process and lowering customer-acquisition costs.

Depending on the utility's needs, these efforts can occur at either the design stage of the program or the marketing stage, in advance of customer acquisition.

Ideally, market research and market segmentation will occur at the program design stage, as well as at the marketing stage; however, utilities with limited resources may focus more heavily on the program design stage to ensure that the offer meets customer needs. That is prerequisite to effective messaging. Generally recommended:

At the Program Design Stage:

- If the utility wants to build a customer-centric community solar offering, including, as desired, identifying appealing companion measures, then research and segmentation are conducted on the front end, both to inform the development of the offer, and to match the offer to a particular customer group.

[1] See http://www.communitysolarvalueproject.com/resources for guidance on the overall community-solar program design process.

At the Marketing Stage:

- If the utility has a good sense of the product that they want to offer, based on what they have seen in other territories and/or what needs to be offered to meet the needs of the grid, then it may be possible to minimize new market research at the front end. Market research and segmentation work that takes place at the marketing stage can provide a good understanding of the best targets for a community solar offer that already is defined. While this "later stage" approach tends to be more utility-centric (i.e., the product is defined by utility needs more than by the customers' needs), it can still provide important insights on customers and improve program success.

The first steps for any program designer involve understanding the value of market research and market segmentation, and determining where the utility needs assistance the most. For example, Does the utility need customer insights for overall program design, for identifying top targets, for identifying companion measures, or for creating marketing messages? The program designer's reflection on such needs, including taking input from internal and external stakeholders, will be an important determinant of later success.

Step 2. Drawing On Outside Research: Building On Knowledge From Other Utilities and Outside Resources

As an early step, all utilities embarking on the community-solar journey should learn from past work in other areas of the country. With respect to understanding customer perspectives on community solar, there is some information available that can start to answer questions, such as: What are the segments that have the most potential for community solar deployment? What are the market drivers and barriers for each of the markets or segments? What are the best channels for reaching customers? However, while some lessons from other regions of the country apply directly to utilities looking to start their own community solar programs, there are also unique aspects of any community that set them apart—such as the cost of electricity, patterns of constrained distribution lines, other geographic aspects that affect project siting, or attitudes among consumers.

Benefits and Drawbacks of Outside Information

Figure 3: The above figures identifies the benefits and drawbacks of outside information.

Local energy markets can vary dramatically, so information from other jurisdictions should be reviewed in the context of: 1) the way the research was conducted (e.g., identifying how customers for the research were selected and whether surveys, focus groups or other methods were used), and 2) the characteristics of this utility territory compared to those of the utility where the research that is referenced was performed (e.g., differences in energy costs, differing customer familiarity with innovations, etc.).

This section briefly describes results from several recently conducted studies, including those from Shelton Group, SEPA, PCG, Hoffman and High-Pippert, Fitzjarrald and Salazar, and the Optimization Group. (The full reference for each study is provided in the References section.) Work by Shelton Group, in partnership with SEPA, is extensively cited here, because it is the most extensive source of national market research on community solar to-date.

The program designer who wants to tap into this wide-ranging research for baseline market intelligence, might focus on two key questions:

- Who is interested in community solar?
- What specific program attributes are they interested in?

Utility-program researchers often draw on national survey work first, because large-scale, nationwide research generally applies to a wider audience. As the utility comes to understand the local market better, the conclusions drawn from national surveys may need to be adjusted. Further, *it important to remember that community solar is in a relatively early stage of market development,* so specific market research data is scant and easily outdated. For example, program scale can have a significant impact on how customers see a program offer—whether customers are asked to become pioneering participants of a small, new program or whether they are asked to join in a similar program that seems expansive and well-established. Moreover, whenever interpreting survey findings from other sources, there are several caveats that the reader should consider. These caveats are presented below, in the context of what today's available community solar market research can tell us.

Who is interested in community solar?

Customers interested in community solar are generally thought to be those who have an affinity towards the environment and solar, but are more cost sensitive than those who buy rooftop solar and/or do not have the option or do not want the burden and risk of installing rooftop solar systems. Notably, Shelton (2016b) found that customer groups most interested in solar leases (i.e., leasing panels or kW shares) are very different than those interested in a community-solar subscription program (typically paying per kWh or kWh blocks); thus, any information describing "who is interested" must be tied to the general type of community solar offer, e.g., subscription or lease. Further, since results are highly sensitive to the customer's education about community solar, it might be useful to ask further, what descriptors of leasing and rate options "connected" with these groups to drive their interest? Within Shelton's survey of 2,000 residential customers nationwide in December 2015, the following target groups emerged:

- **Concerned parents were most interested in solar leases.** This included suburban parents ages 25-44, who are white-collar. This group was most concerned about saving money, the environment, being role models for their children, and time management.
- **Single suburban women over 45 were most interested in solar "block" subscriptions.** Based on the Shelton research, this group included women over the age of 45, most of whom (69%) are homeowners. This group was middle-class with no children at home; they cared about the environment, locking in lower energy costs, and being responsible.

Similarly, CSVP research for this brief included an unpublished study of an early community solar program at the Sacramento utility, defined by a $/kWh subscription offer. Here, 40% of program participants appeared to be middle-income or above (>$75K income); 90% lived in single-family homes that they own, and most were married. The study also found that those participating in the program also had higher than average energy use. Though not identical to Shelton national survey results, these utility-specific findings appear to be similar to the group identified nationally (as described above). Both sources indicate that these programs are currently appealing more to homeowners than renters, and that is counter-intuitive to a popular assumption that community solar is "ideal" for those, such as renters, who simply cannot pursue rooftop solar.

Renters, however, may be the target that utilities want to reach with a community solar program. They have been the target of some other, documented programs, like a SolarCity project in Minnesota that focuses specifically on renters. "To reach them, the company will offer streamlined signup, single-year commitments, and savings of up to 10 to 15 percent off electric bills" (Fitzjarrald & Salazar, 2016). Renters also may be prominent among the group of "millennials" that at least one source has identified as more likely to invest in socially conscious activities (Kopp, 2016).

Education about community solar is critical. Survey findings on interest in specific programs or program elements can significantly shift after some additional information (or education) is provided.

Education about community solar is critical. Generally, customers lack information and familiarity with the term community solar. While the results above point out the groups most interested, several sources also show that respondent interest in community solar changed dramatically, after respondents were informed about what community solar actually is. For example, Shelton (2016b) noted that in one study, interest in community solar among residential decision makers moved from 14% to 47%, after they were informed about what community solar is. However, before interpreting results from outside surveys, it is important for utility researchers to know exactly how the term *community solar* was defined, i.e., what kind of expectations might have been developed, based on the education received (Cliburn, 2016). There are several definitions of community solar, some stressing the financial-savings attributes, others stressing local community spirit or environmental aspects, and still others that stressing the utility- or *non-utility* nature of the program provider. The definition implanted can affect survey results. The definition implanted also can reflect a survey bias, with lasting results.

Interest in community solar should be explored more, as many people are interested, but many are not considering taking specific actions—and even those considering taking action may not be likely to do so. For example, Table 1 below demonstrates how a single survey shows a clear drop in how many customers may participate in a new program, depending on the question they are asked.

Table 1. Example of Difference in Responses Within A Single Survey Based on the Question

Sector	Interested in Community Solar	Currently Considering Community Solar	Very Likely or Likely to Participate in a Community Solar Program
	Single survey, nested questions - asked from left to right		
Residential	47%	14%	Not asked
Commercial	52%	19%	9%

Source: Shelton Group (2016a) and Shelton Group (2016b)

A review of existing community solar market research suggests caution in interpreting survey results from other regions of the country. Surveys (performed via the telephone or online) are often used to help determine interest in community solar. When reviewing outside surveys, it is wise to examine how the questions were asked, and whether they represent the full population or whether they screened for a sub-group that was already pre-disposed toward community solar. In reviewing other research, it is also important to ask, *How similar is this utility to my utility,* and, *Are there multiple studies that show similar results?*

What community solar program attributes are customers interested in?

While there is not a lot known about exactly why customers participate in community solar programs, some research indicates that the preference for community solar over other solar options is largely driven by economics. For those customers who prefer community solar over rooftop options, their rationale is that they cannot afford to purchase rooftop solar (39%), they do not want maintenance costs (39%), they want less risk (28%) and they want more flexibility (24%) (Shelton, 2016b). Some utilities believe that the ability to achieve energy independence is a dominant motivator (Hoffman & High-Pippert, 2015). Other utility program administrators hypothesize that some customers choose the community solar option for "convenience," to "help out" or "do their part" in a community-oriented program (Fitzjarrald & Salazar, 2016).

In reviewing others' research, program designers may ask:
How were their questions prepared?
How comparable are their geographics and demographics?
Are there multiple studies that show similar results?

A study by the Pacific Consulting Group (PCG) found that two of the three most persuasive messages about community solar are ones that emphasized financial factors (PCG 2016). The top three messages were: 1) every homeowner or renter is eligible, 2) there are no start-up cost or investment required, and 3) assuming that offer can deliver savings immediately or over time, that community solar saves you money.

Based on all available studies of customers who are interested in community solar, the customer preferences that are most likely to apply nationwide include:

- **Lower costs, relative to other solar options:** Cheaper options (lower premiums and no sign-up fees for block subscriptions, or lower costs per panel, with financing where it makes sense) have appeal. "Customers tend to respond best to offerings that are priced at a small premium or even a discounted rate, compared to their current bills. (Fitzjarrald & Salazar, 2016)" A popular alternative is to "lock in" the $/kWh for solar generation on a subscription program, so that customers save as typical utility costs rise.
- **Beneficial terms:** Shorter terms for panel-lease programs, and longer terms for subscription programs, but with no penalty for early departure.
- **Real-time information:** Real-time panel production that is visible to customers
- **Local siting:** According to several studies, community solar sited in the community is generally preferred. Shelton (2016a) reported that some customer segments, such as

young families choosing leased-panel options, customers prefer local siting so strongly that they would pay a slight premium for it. However, it is advised that utilities test whether a locally sited solar would add program value (or under what conditions) in working with other customer segments.

Across these four bulleted points, cost is cited as the most important. This might be expected anywhere; however, the best pricing offer for a specific target market, as well as the importance of other terms and options, such as real-time information and local siting, could vary. Further, these attributes may be packaged in many different ways, and specific combinations or variations can affect customer interest. CSVP has documented a proposed offer from one Southwestern utility that promotes likely, long-term savings, but puts more emphasis on a no-hassle, fixed-bill pricing strategy (Cliburn, 2016). Although there can be differences in the type of people choosing among various options (see Table 2 below), the research reveals that people are currently about evenly split between preference for panel leasing or subscriptions. The trend among utility-led programs is to favor the subscription model, so time will tell whether customer interest shifts as the subscription model becomes more refined.

Table 2. Differences in Participant Interests in Community Solar Options, Based on Data From a National Market Survey

	Residential Comparison		**Commercial Comparison**	
	Likely <u>Panel Lease</u> Participants	**Likely <u>Subscription Rate</u> Participants**	**Likely <u>Panel Lease</u> Participants**	**Likely <u>Subscription Rate</u> Participants**
Age	Ages 25-44	Ages 45+	Younger executives (CEO/CFO/COO)	Older – more likely to be owner / partner
Ownership	Homeowner / renter (72%/28%)	Homeowner / renter (69%/31%)	Own their building	Lease their building
Size/ Income Level	$50K+HH	Less than $75K HH	Small to mid-size companies	Small companies
Interest	Want to save money and be a good role model.	Like the idea of locking in lower energy costs, want to be responsible and not waste.	Interest driven by reducing energy costs and being a good corporate citizen	Interest driven by reducing energy costs and wanting more control / independence from electric utility
Geography	Northeast part of the US	Somewhat more likely to like in the Southern part of the US	Midwest part of the US	Midwest or Northeast part of the US

Source: Shelton Group (2016a) and Shelton Group (2016b)

Attributes can be packaged in many different ways, and the specific packages can affect customer interest and participation. This also means that by varying the different program options, utilities can optimize their product or maximize the number of participants. Each utility will have unique results, but utilities can learn from the successes and shortcomings of other, current programs.

Market research can be used to explore program-design trade-offs. It also helps in prioritizing market segments and methods to reach them.

Available market research suggests that developing a customer-centric offer can make a huge difference in program success. This includes attention to characteristics such as the utility serving as point of contact, the proper term of the offer, no/low entry or exit fees, the location of the project, and how well the program communicates about month-to-month generation and value, among other aspects of the offer.

Conversely, there are utilities that are wary of quick program growth and its impact on utility revenues or on solar market penetration. Field experience suggests that adding barriers to customer participation, such as a significant sign-up fee, create more risk than reward for the utility. Community solar program pricing is a particular challenge for utilities, but it is better to introduce a program that anticipates sustained customer retention and steady program growth. (For example, one solution that a few utilities are testing involves fleet pricing. Assuming solar costs decline as the program grows, all participants could see greater savings in future years.)

Utilities may be drawn to the finding that customers prefer strong involvement by the local utility company. However, details on this research question are relatively scant; one might assume that the strength of the response would be related to the utility's other metrics on utility customer satisfaction and trust.

Across multiple studies, the "costs" of participation have proven to be important. One research survey found that people want to lower their electric bill and to have low/no startup costs (Optimization Group, 2013), and another found that interest in participation dropped rapidly beyond a 10-year payback and with the prospect of rising monthly bills. (Hoffman & High-Pippert, 2015) The Hoffman and High-Pippert study also showed a preference for placing community solar projects on brownfield sites or on community assets, such as schools or church roofs, assuming the solar could be sited within their community.

A fourth research study analyzed data from three scenarios[2] and was able to determine a 36% projected market penetration when a program provided a package to include $0 initial investment, a fixed rate for the solar portion of the bill, participation covering 25% of the bill, a month-to-month contract (instead of long-term commitment), and when consumers could expect a 3% immediate decrease in their monthly bill (PGC, 2016).

In addition to this research, actual experience shows that the attribute mix can affect participation. For example, one utility doubled their subscriptions within six months when they changed their design from a fixed monthly payment for 5 years (of $15) to an offering with no fixed payment and an additional 18 years of continued bill credits for the power produced from their panels (SEPA, 2014).

[2] This type of analysis is also called conjoint analysis.

Individual study findings may not map directly onto a particular utility's program design, but multiple study trends suggest that utilities should strongly consider customer preferences when they develop their offers. Further, they should use customer surveys (discussed under Step 4) to look at the trade-offs of various options and how the trade-offs may affect participation.

Take-aways when reviewing outside research

The studies described in this section offer some good information for utilities, but utilities must go further to explore topics specific to their offering, for their specific customer base.

When interpreting the results from outside resources, program designers should:

- Consider how people are asked questions within a survey and the way the questions influence the results;
- Determine whether the results represent the full population, or just those already pre-disposed towards solar or community solar;
- Ask if the utility from which research is gathered is similar to the utility territory where the program will be implemented. If the economic or demographic conditions are very different between the two, customers may respond differently than what the case study describes;
- Look for multiple examples or case studies and see if results are similar. Even absent knowing details about the other utilities in the case studies, when results begin to show up multiple times, a trend arises, and the likelihood of getting similar results increases. One source of case study information is the Community Solar Value Project website, and Utility Forum network: http://www.communitysolarvalueproject.com.

For utilities that do not have the resources to conduct their own literature review and understand the latest research findings in the market, there are research services that can provide insights. A number of energy-focused market research firms offer relevant services. For example, the Smart Grid Consumer Collaborative (http://www.smartgridcc.org) offers research and insights relevant to local solar and integrated DER offerings. E Source, a utility-oriented research and consulting firm, offers an annual research service through its *Solar Customer Project*. This is a subscription-based service that explores residential and business customers' desires, opinions, and likely actions related to solar, so that utilities can incorporate this information into their solar strategies. This product combines new customer research, industry and solar installer intelligence, and marketing and communications best practices to help utilities: 1) develop or refine solar and DER customer strategy, 2) design solar-related customer offerings, 3) develop effective approaches for solar education and communications, and 4) identify opportunities for partnerships and stakeholder engagement. See https://www.esource.com/about-solar-customer-project for more information.

Step 3. Mining Customer Data: Digging Into Existing Data

Mining existing customer data—including digging into utility marketing or corporate-communications knowledge—can tell community solar program designers a lot about the sub-groups, or segments, within their customer base, and each groups' potential to be interested in a community solar offering.

The best way to approach this is to work with the utility's marketing or corporate communications team, as well as related program teams, to fully understand the customer data that are available. This may include energy usage, payment history, preferred communication channels and web-based interactions; details of engagements with utility, as well as any other known behaviors. For utilities that have existing energy-efficiency, demand-response, or low-income energy programs, there may be a wealth of information in those program databases. Often, participant groups fall in certain geographic or demographic categories, or there is rich information on which customers are interested in optional utility rates or services. Examples of the types of information that can be surmised from an analysis of existing data include where to find sub-groups, or segments, that may be more receptive to community solar, such as customers who are:

- **Most likely to engage,** based on customer use of different communication channels and direct participation in related utility programs;
- **Identifying with green communities,** based on which geographic areas have been more active participants in past clean energy offerings, such as energy-efficiency programs or active installations of rooftop solar;
- **More tech savvy,** based on web interactions, interest and participation in smart thermostats, EV rates, etc.;
- **In higher usage and/or price-sensitive groups,** based on usage, usage patterns and participation in TOU rates or online energy audit options, where those are offered;
- **Part of customer groups pre-defined** in national community solar market research.

In the past, this type of data has been spread across multiple databases within the utility and only loosely connected, if at all. Today, however, many utilities are working towards centralizing customer data, so that it is accessible for in-depth analysis of customers. The centralization of data company-wide provides an opportunity for community solar programs; utilities with centralized data can access and use existing information to inform the development of community solar programs.

In addition to these databases, the utility marketing or corporate communications group may already have insights on what customers want. This could range from anecdotal information drawn from discussions between customer account managers and their customer base, to knowledge from past focus groups or surveys, to detailed customer segmentation schemes. Open discussions with those who have knowledge about past communications and market research can provide insights. Moreover, it is important for the program designer to ask whether anyone within the utility has done any work on segmentation, whether it is fully available or in some developmental stage. Segmentation may include broad-based categories that are used for marketing. This is more of a macro-segmentation into 4-6 broadly defined "types" of customers, which may go so far as key demographic characteristics, or more granular sub-groups identified through a micro-segmentation that takes into account their lifestyle characteristics. For example, Figure 4, below describes a segment that is likely to "download music" and "go to zoo." CSVP has found that some community solar program designers were not aware of the richness of customer data that turned out to be available to them, so this type of internal "asking around" is highly recommended.

For utilities already using a segmentation schema for their customers, key areas to investigate include:

- Whether this is available for residential customers only, or both residential and commercial customers;
- Whether the utility uses a pre-packaged or subscription segmentation (e.g., Prizm), or whether it employs a firm to build a more customized segmentation scheme;
- Whether each customer record is assigned to a customer group or not.

Overall, pre-existing utility segmentation schemes can be very valuable to the design of a community solar program. They can help identify the best customers to help achieve broad community-solar objectives, what is important to these customers, the size of the market, and potentially where community-solar projects should be located (i.e., which communities would be more favorable to a community solar product). Often utilities have this information, but program designers or managers from specific technical groups, such as the solar program group, are not aware of it, unless they ask specifically about it.

In general, there tend to be three types of variables used to identify similar residential customer segments: 1) geographic or demographic variables, 2) attitudinal variables, and 3) behavioral or transactional characteristics (Schroeder, 2000). These can be combined in various ways to shed light on customers. Some utilities have designed their own custom macro-segments, while others have used available segmentation resources, such as:

- **Demographic or Psychographic Variables:** Companies such as Experian, Acxiom, or Equifax offer customer data at the zip code level that can be used to go beyond the meter to understand customer's households, preferences, and attitudes. This type of information can be purchased and appended to each utility customer record, and can prove valuable for utilities that are conducting their own segmentation research. However, the information is not always directly applicable to the task at hand; the utility will need to conduct its own analysis using this data.
- **VALs "Value and Lifestyle."** There are also commercially available segments, based on attitudinal variables, such as VALs, which is a segmentation schema created by SRI International, a California-based non-profit R&D firm. VALs is built off the belief that consumers with similar attitudes and psycho-demographic characteristics will exhibit similar behaviors. It was developed based on responses to a battery of questions about risk, status and attitudes and can be useful for identifying or ranking program offers. For utilities, it may be difficult to connect to their geographic region and customer base, since this segmentation is based on values and lifestyles rather than geo-demographics.
- **Prizm.** There are also commercially available segments that are more targeted geographically, such as the geo-demographic segmentation scheme in Prizm. This system was created by Claritas, Inc. and is now provided by The Nielson Company. Prizm is based on the belief that similar households tend to group together by

geography. It tends to be meaningful for utilities because it describes customers in a way that can be used directly in a marketing strategy. Prizm takes all U.S. households and divides them into dozens of segments to provide a granular understanding of customer segments based on household lifestyles, from what people like to eat to where they like to go for recreation, to their use of personal technologies, and more. Segment-identifying information may be appended to each record in a utility's customer database. Prizm has been used for media buys for many years, so market research teams within larger utilities often have access to this or some similar research. If not, they may be interested in getting this type of resource. Prizm is not specific to energy use habits when used in its basic form (as opposed the Nielson/E Source partnership discussed below), so while it provides valuable insights, it will not give direct information on who might be interested in specific community-solar offers.

Among utilities that have segmentation efforts, customized segmentations and Prizm appear to be the most common. Where a segmentation scheme already exists, this can be tapped into to look at who the utility is serving already with existing solar offerings, who might be interested in community solar, and/or who the utility might need to serve. Notably, among the Prizm segments, some utilities have found that groups such as "Movers and Shakers," "Upper Crusts," and "Kids & Cul-de-Sacs" tend to participate in solar offers more than the other groups (Kopp, 2016). The Sacramento Municipal Utility District (SMUD) is one of many utilities that has used Prizm data for many years, along with other types of market research to create more successful, customer-centric programs.

In addition, SMUD and other utilities are beginning to use more customized segmentation products. Nielson and E Source have collaborated to create industry-specific residential consumer groups, created around metrics that are important and relevant to utilities and energy companies, i.e., Residential Energy Segments. The seven key energy-related segments include: 1) Plugged In Families, 2) Recycling and Rebates, 3) Online Pragmatists, 4) Rural Reducers, 5) Thermostat Turners, 6) Young Renters, and 7) Unengaged Owners. These groups are clustered and described based on syndicated research by Nielson and Mediamark Research (MRI), regarding participation in energy efficient behaviors, energy consumption, and energy and environmental attitudes, as well as housing and demographic data. While still not specifically tied to solar preferences, this kind of segmentation can be used as a first attempt to size the community solar market and understand who might be interested in specific program offerings.

Note that among the seven residential energy segments, "Plugged-In Families" tend to have the highest propensity for solar based on their psychological characteristics (Sumner, 2014). See Figure 4 below for a description of this group.

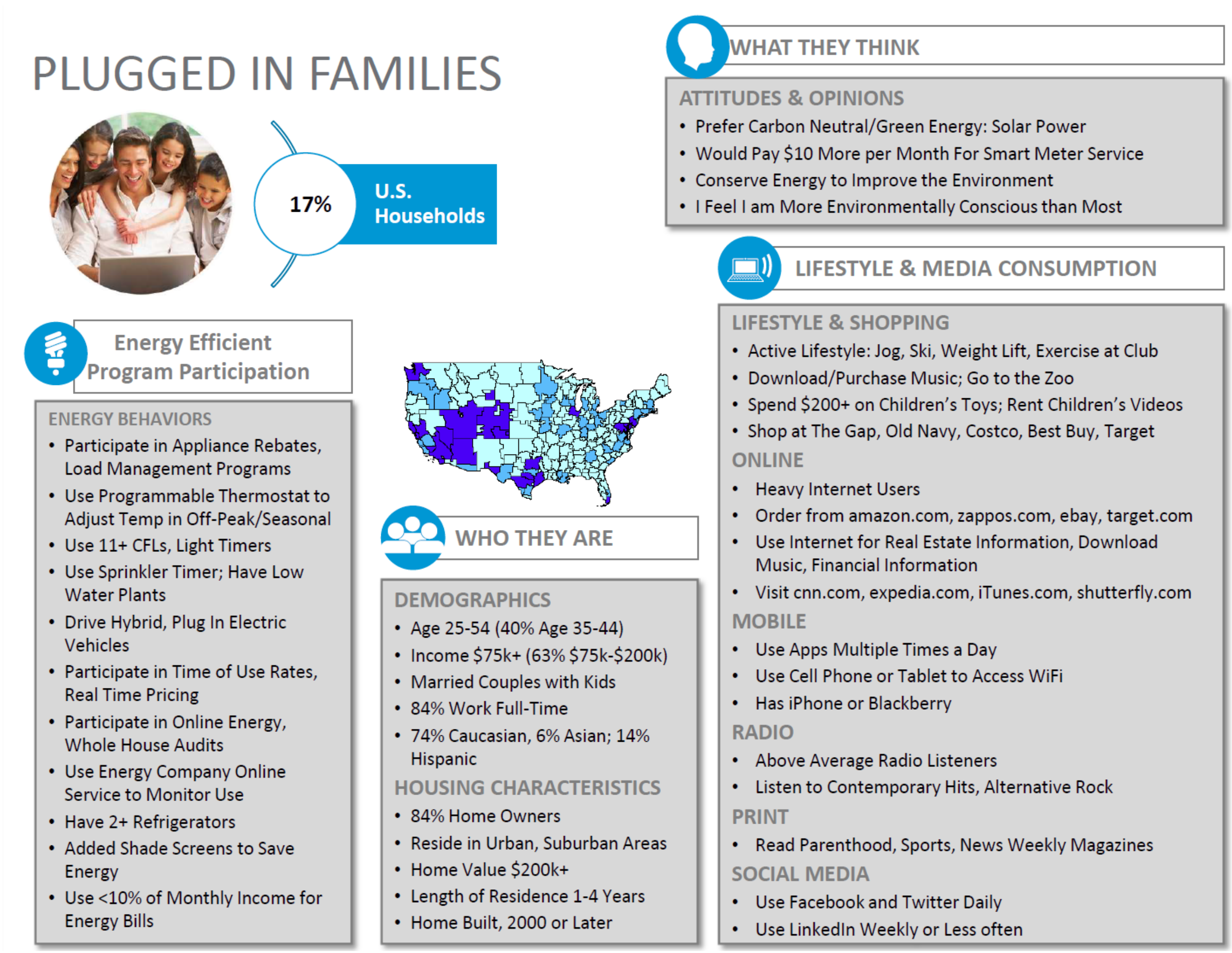


Figure 4: Example of Residential Energy Segment Group with higher propensity for community solar (Sumner, 2014).

Utilities, such as SMUD, have been able to use the data from Prizm and the Residential Energy Segments, as well as data that they collected on their customers, to build a strong foundational understanding of who their customers are. Through a comprehensive data analysis, they seek to design programs with customers' goals in mind. SMUD is taking a utility-wide effort to look at the needs of customers in order to understand who the customers are and design program offers that meets their needs. In fact, SMUD currently has several "SolarShares" program offers for different customer segments; larger utilities may be able to follow suit in that approach (Cliburn & Powers, 2016) Specifically, they looked at known data, e.g., from Prizm/E Source and their own customer data, to understand their various customer groups, and then they rank-ordered their segments, based on which groups might be interested in programs such as community solar. This allows them to estimate the size the potential market and design customized program approaches (Kopp, 2016).

Leverage existing data collection efforts to gather basic information on customer needs and wants, related to the new program

SMUD also took the analysis one step further, to incorporate a proprietary framework developed by Strategyzer, called the Business Model Canvas (www.strategyzer.com). This tool look at whether the existing offerings line up with what customers are looking for. This step was followed by utility-specific research, including focus groups, surveys, etc., with customers, to understand specific wants and needs. All of this is being used as an input to the utility's community solar (SolarShares) program design and marketing (Kopp, 2016).

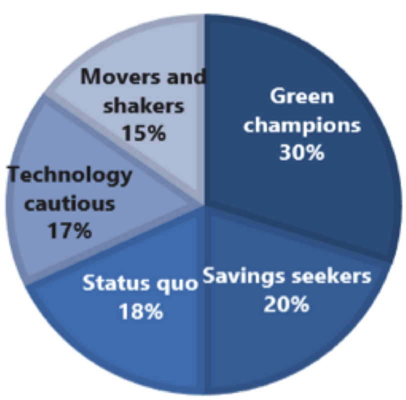
Overall, when designing a community solar program, the program designer should assess and tap into existing data sources within the organization and explore existing market segmentation efforts. This will help size market and explore options. More general data should be coupled with specific data, to hear directly from customers, if at all possible.

Types of Segmentation

Macro-segmentation divides a population into groups, while micro-segmentation divides the population into smaller groups or individuals. Micro-segmentation is a targeted approach for reaching select customers, and in the case of utilities, can be tied to individual records within the customer database so that it becomes more actionable for the utility. However, micro-segmentation does require more resources (both financial and analytical) to implement a broader macro-segmentation effort.

Macro-segmentation

- 4-6 groups representative of population
- Segment has similar characteristics
- General approach for reaching



Micro-segmentation

- Smaller groups, or individualized
- Tied to individual records within customer database
- Targeted approach for reaching select customers

Figure 5: Types of segmentation (Sumner, 2014).

Step 4. Interviewing Customers: Data Collection and Analysis Specific To Community Solar

Because each utility has its own needs, there are a few questions that a specific utility program designer should consider before beginning new, utility-specific research. Considering a few driving questions can help to define the specific research sample and questions for any community solar research effort. The questions below are followed by likely steps in the specific process of collecting program research.

- Why am I running this program?
  - E.g., To retain certain groups of customers or reach customer groups we haven't been able to reach through other program offerings; to reduce costs of renewables integration, or to fill another specific customer need?
- Is the program focus on residential, commercial or both?
- What options do I want to explore with customers?
  - E.g., Price points and terms, visibility/importance of local siting, importance of real-time information, desire for recognition?
- Do I have a sense of the program name and marketing messages?
  - What messaging options are we considering (good for planet, lower energy costs, independence from utility, take your kids to see your solar array, avoid hassle, affordability, you can be part of the solution)?
  - Do customers need education about what community solar is, or on technical terms, or on what type of information is needed to persuade them?

1. Determine ability to collect data through primary research and leverage cross-departmental resources for gathering data

For organizations with limited resources and/or organizations hoping to develop a step-wise effort to understanding customer needs before fielding a larger-scale survey effort, there may be an opportunity to leverage cross-departmental resources to gather information about customer interest. For example, many utilities have:

- **Existing market research panels**, that is, a group of customers that answer a short online survey on a monthly or bi-monthly basis,
- **Annual customer satisfaction surveys**, or
- **General population surveys** for evaluation efforts or other reasons.

While these existing survey efforts have other purposes, there may be an opportunity to add one or two questions to specific to interest in community solar. When coupled with the existing demographic data, which these surveys already collect, one or two more questions about interest in community solar or about aspects of this program offering, could be useful.

2. Conduct qualitative research, such as focus groups or in-depth interviews, to explore issues

When the program designer has resources for a multi-step research approach, qualitative research on the front end can allow the program to test various options for offerings. This is particularly useful for a complex program—like community solar—that people may be unfamiliar with. Among utilities that have conducted focus groups before designing their community solar programs, they often have a difficult time getting respondents to understand the topic. The qualitative interactions in a focus group allow one to provide more information on the products than in a traditional survey. Focus groups can help refine how to succinctly ask about community solar, and give feedback on terminology that might be difficult for customers to understand. Focus groups also can help narrow options when there are too many options to test through a survey.

However, in focus groups, the information that customers receive from the utility or from each other can shape the research outcome. Customers can influence each other through the group dynamic, and results cannot be extrapolated to the larger population, whether because of small sample sizes and the fact that these groups tend to screen for those with some inclination towards solar. As such, coupling focus group findings with a survey effort is very important.

Use focus groups to test understanding of program terminology, to learn about effective messaging, and to identify options for further research.

If targeting business customers, in-depth interviews may be more efficient, or the utility could use new methods of web-assisted, in-depth interviews to show information while discussing a topic. For utilities that do not have robust resources for market research, they may be able to draw on customer service representatives, or others who interact with customers day-to-day, to understand customer needs.

As an example of research customization, San Antonio-based CPS Energy, which has advised the CSVP, conducted focus groups. It found that focus group participants initially felt all solar programs, including community solar, were for higher income customers. Because this utility wanted to structure its program to be available to all customers, they used the results of the focus groups to understand general acceptance and attitudes toward community solar, and then they adjusted their customer-education and marketing to make sure that the offer would appeal to a broader group (Wagner, 2016).

3. Conduct customer surveys to test hypotheses and explore alternative options

The best information to understand how to design the program, and potential uptake of a community solar offering, may come directly from customers. Customer surveys can explore:

- Upfront cost compared to monthly premiums
- Preferred contract length
- The importance of geographic location
- Optional companion offerings

- Key motivations for investing
- Messaging
- Trade-offs between the factors above

Surveys can be fielded by email, phone, or both, depending upon the availability of contact information and the targeted group that the programs wishes to reach. Web-based surveys are often lower cost, and can allow for more sophisticated trade-off analyses, but the researcher should be careful to make sure that any web-based group is somewhat representative of the groups being targeted. For example, if using lists of customers who already engage with utility through internet to pay their bill, it is important to consider how representative this is of the full population (e.g., do 10% of population have e-mail addresses, or closer to 60% of the households or businesses?), and who might not be represented (e.g., non-tech savvy customers).

Be aware that one key finding of the SEPA/Shelton research on community solar was that most customers know very little (if anything) about community solar at the outset. Survey findings may be of limited use unless this information gap can be addressed. According to some program designers (Cliburn, 2015), use of predictive market-segmentation research on customer lifestyles is a valuable complement to survey work, in order to better predict customer interests in this new product offer, which may be hard to describe. If the program designer's utility can sort by market segments, then one could sample by targeted groups, or cross-reference a general-population survey by identified segments. For community solar, there also may be a desire to sample geographically, for areas where the program anticipates siting the solar project.

Ultimately, the best approach will depend on the targeted group/s and available budget, but regardless of the approach, any program survey should be designed with the end point in mind.

4. Consider best approach given budget and needs for expertise

Some utilities may find that they need external help from a consultant or subscription service. There are several private research companies and membership groups that can offer assistance. For example, E Source's PV Predictor can help utilities examine their customers' propensity to go solar. This is a "predictive analytics propensity tool" to help identify utility customers with the highest propensity to go solar. It is part of a customer-centric approach to predicting customer interest in solar, based on proprietary E Source research on customer interest and behaviors. It can provide 1) a propensity-of-adoption score for a customer segment and/or individual customers; 2) projected total adoption (in MW) across the service territory; 3) actionable recommendations on the most effective solar-related targeted marketing and communication approaches. Note that this tool has been developed primarily for rooftop solar programs, but that it may be adapted to community solar needs (Schofield & Garrett, 2016).

Other consultants offer similar services, both more or less detailed. The utility program designer may opt for expert assistance in pulling various sources of market research together and providing recommendations for several reasons, such as 1) practical issues, such as deadlines requiring focused attention, 2) the opportunity to get a "second set of eyes" that are unbiased by internal utility culture, 3) the opportunity to increase customer trust in findings.

Community solar program managers that tap outside support are still wise to work closely with other utility departments, in designing the program and determining a marketing plan.

As they assess their capabilities and needs, utility program designers may find that they identify with one of two groups:

- **Limited Resources - Leveraging**: For a program designer who has limited resources—that is, minimal existing data on their customers, and not a lot of resources available to field market research, or to specifically interpret the needs of the customer base with respect to community solar. There are usually options for these program designers to work across departments to leverage other data and data collection, as well as to look for outside support.
- **Robust Resources**: The program designer who works in a utility that has already transitioned to a customer-centric approach, or that is considering shifting more broadly to that approach. This program designer may integrate many sources of existing data and segmentation work into the program design and marketing stages. This will help target the program, reduce customer acquisition cost, and/or appeal to certain market segments to retain customers. Those program designers in this group may be ready to succeed with larger or more complex community solar programs, such as those that include companion offers related to demand response, energy efficiency, or storage. Yet, as they break new ground, these program designers also may identify specific needs for outside support.

Step 5. Developing a Program Design With Feedback Loops That Allow It To Monitor And Adjust

Once the utility program designer has gathered the research needed to understand potential program customers, this information should be integrated with technical information, such as project siting and design, pricing, customer sign-up options and billing etc., to create a win-win for both the customer and the utility. From the market-research perspective, it is important to build in information feedback loops, so that any program can be continuously monitored and adjusted as necessary. For example, as the program rolls out, programs managers should look at who is participating and whether it aligns with the expected segments, and then tweak the marketing plan as needed.

It is critical in this final step of monitoring and adjusting to determine the best information to track (e.g., enrollment costs, take rates) for the chosen marketing plan. If designing a program for customer retention, program designers should look at customer participation and/or turnover within the targeted group. If the utility aims to lower customer acquisition costs, program designers should look at the costs of reaching out to and getting a participant for this program, versus for other utility programs. Many utilities also find it valuable to test various options to compare products or outreach methods to understand uptake, retention, and customer acquisition.

This final step also involves working with a cross-departmental group of utility stakeholders. For example, if early-stage inquiries about the program suggest problems with proposed project siting, then there may be time to make change—if not in siting, then at least in messaging. If customer acquisition seems hindered by a complicated pricing structure, then staff charged with pricing might make some adjustments. Likewise, if a recommendation of early market research proves difficult for technical staff to implement, or if customer-recommended terms prove unworkable, then the project team can adjust accordingly.

The five steps for using market research and market segmentation, as summarized earlier in this brief (Figure 2), will help program designers to develop a more customer-centric community solar program. Using a customer-centric approach that draws on market research and market segmentation can help build towards a successful, scalable, and more cost-effective community solar program offering.

For more information on the CSVP project, and additional resources to help design community solar projects, go to http://www.communitysolarvalueproject.com.

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Demand Response Companion Measures
For High-Value Community Solar Programs

A Guide For Utility Program Designers

Community Solar Value Project
April 2016

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Summary

Demand-Response Companion Measures for High-Value Commumity Solar Programs: A Guide for Utility Program Designers is geared to assist utility solar program designers and managers in including demand response (DR) measures for co-marketing with distributed solar, and particularly in utility-driven community solar programs. The Guide also may be useful to DR program managers, utility planners, and others who wish to understand how different applications of traditional DR are evolving to address new high-value opportunities in renewable-energy integration.

The CSVP updated the name of this document, which was first released as, **Incorporating Demand Response Into Community Solar Programs** in April 2016. The document is essentially unchanged, and therefore we retain the original publication date and authorship.

This Guide takes a practical approach, assuming an introductory understanding of issues related to rising distributed solar market penetration. It focuses on how adaptations of traditional DR can help to address these issues. The Guide reviews existing DR options found in utility programs throughout North America. Four categories are discussed, including curtailable load programs, automated DR (Auto-DR), direct load control, and pricing strategies. Specific examples are drawn primarily from CSVP's work with a Northern California utility, but options, including thermal storage, that are suitable in other regions are briefly discussed. The Guide presents a scoring method to quantify and classify the attributes of particular options to solve a variety of integration-related issues. Case studies from relevant utility programs are included. Information on costs for DR options is provided in an appendix.

This volume is a companion to **Storage Measures for High-Value Community Solar Programs: A Guide for Utility Program Designers,** released in fall 2017. Together, the two volumes show how community-scale and distributed solar may be designed to increase program net value, including grid-integration value. This work was funded in part by the Solar Market Pathways Program, powered by SunShot, in the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, an agency of the United States Government, under Award Number DE-EE0006905.

Key words: distributed solar, community solar, demand response, solar-plus, program design.

About the Community Solar Value Project

The Community Solar Value Project (http://www.communitysolarvalueproject.com) aims to increase the scale, reach, and value of utility-based community solar programs by using strategic solar technologies, siting, and design, and by integrating suitable companion measures, such as demand-response (DR) and storage into broad program designs. Such measures can address grid impacts of rising solar penetration and increase solar net value. Market development for this model also is being addressed. The project is led by Extensible Energy, LLC, with support from Cliburn and Associates, Olivine, Inc., and Navigant Consulting. Utility participants include the Sacramento (California) Municipal Utility District (SMUD), Public Service of New Mexico, and other utilities nationwide. The project is powered by SunShot, under the Solar Market Pathways program of the U.S. Department of Energy.

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Disclaimer

Contents

Introduction

The Community Solar Value Project (CSVP) aims to increase the scale, reach, and value of utility-based community solar programs, primarily in four ways: strategic solar siting and design, best-practice procurement, well-targeted offers and pricing, and suitable companion measures, such as demand-response (DR) and storage, integrated into program designs. The inclusion of DR and storage (also known as solar-plus or "triple play" strategies) in community solar programs is possibly the most innovative—and most important—aspect of the CSVP agenda. Community solar provides a unique market-based laboratory for utilities that need to know what distributed energy resource (DER) business models mean to them and their customers. Community solar provides the opportunity to attract customers who want to be part of a clean energy future. As a community solar program manager, you can engage in a dialog with customers about all the elements of DER, even as you demonstrate internally how DR and storage can ease the impacts of rising solar market penetration.

The timing for starting an enhanced community solar program could not be better. Most utilities do not face a need for full-scale renewables integration strategies today. Yet utility industry leaders concur that the future will include more renewables and DER, and that future is at hand. According to a recent report from the Smart Electric Power Alliance (SEPA), six states are actively engaged with integrated DER planning and market testing (Coleman, February 2016). And those six states include some of the largest in the nation. Their commitment to renewables integration has inescapable consequences for the industry.

The CSVP Utility Forum, a group of program managers from eight utilities that reviewed this document before publication, discussed the rise of DR, in particular, as a renewables-integration strategy that is emerging in integrated resource plans (IRPs) for significant build-out within five to eight years. Given that timeframe, the demonstration of DR as a companion measure for community solar is right on time.

There is a growing body of literature on the value of DR and storage for renewables integration. CSVP provides an updated sampling of those resources on its website. This DR-measures Guide takes a more practical tack. We assume that the reader has some foundational understanding of renewables integration and of community solar. Thus, this Guide delves into the questions that utility solar program staff or their counterparts in DR and resource planning would ask during early-stage program design.

The overall integrated community solar program-design process is illustrated in Figure 1. In relation to this volume, the selection of DR companion measures for community solar would take place in the highlighted box in Figure 1, referred to as "utility-driven elements." At the same time, we note that the DR screening and selection process for community solar program design is scalable. It could be applied to community solar programs of any size or it could be applied utility-wide, as utilities get their virtual hands around what flexible grid operations mean on the local as well as regional level.

In Section 1, this document introduces the variability issues associated with solar photovoltaics (PV). In Sections 2 and 3 summarize how DR can help to address these issues. In Section 4, the discussion moves to a description of existing DR options, found in utility programs throughout North America. Next, Section 5 discusses the scoring approach used to quantify and classify the attributes of these particular options to solve a variety of integration-related issues. We explain how DR for renewables integration differs from typical DR options and how many existing options may be adapted to capture integration-value opportunities.

Section 6 offers case studies of innovative integration strategies. Finally, this document concludes with a summary of the key points.

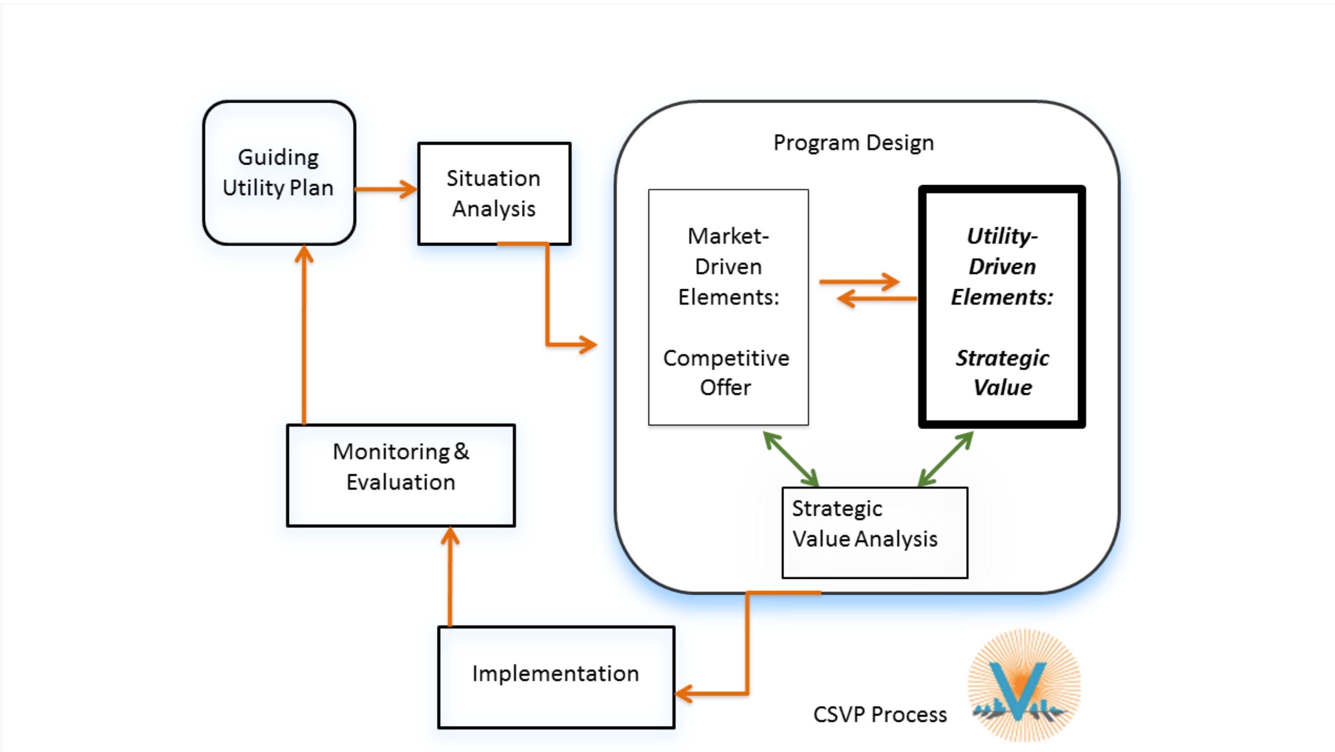

Figure 1: CSVP Process Map - The above figure highlights the location of the DR assessment and selection process within the overall process for community solar program design.

1 The Challenge of Solar Variability

The output of any photovoltaic (PV) system is inherently variable; power output varies by season, time of day, and over much shorter intervals due to intermittent clouds and shading. In each of these time domains, output variability can introduce grid planning, operation and stability issues that may require mitigation.

Very short-run variability is a relatively local issue, as geographic diversity across multiple solar sites greatly reduces the cumulative swings in production and their impacts on the utility system (Perez, 2009). However, diversity alone cannot compensate for all short-run effects. The type of variability that has garnered the most attention is the intra-day variation in solar output. Specifically, the fact that solar output naturally drops as load rises in the late afternoon and early evening has led utility planners to worry about the “duck curve,” explained further below. Even with best-practice strategic solar design, which may include southwest-facing installations, single-axis tracking, and advanced inverters, the issue of a rapid late-day ramp in customer demand affects utilities that have significant amounts of solar on the grid.

As more distributed energy resources are integrated into the grid, variability can be offset by a range of technologies and programs, including battery storage on either side of the customer meter, thermal storage, and DR. Combinations of these options are often most effective to mitigate variability and raise the utility value of distributed solar fleets.

2 Demand Response Applications

The use of DR to aid in renewables integration is still a relatively novel concept. Traditionally, DR programs have been designed to help distribution utilities meet peak load requirements, alleviate local distribution system constraints, or to mitigate grid emergencies. Each of these applications allow for a relatively generous response time, and each would be dispatched infrequently. Traditional DR relies upon notification by the system operator, so that customers or aggregators will reduce the load, providing relief for a variety of system problems. This has been referred to by some as "DR 1.0" (Martini, n.d.). These programs operate across varying time horizons, using different technologies and incentive structures (Federal Energy Regulatory Commission, 2010).

The incentive structure for these programs includes capacity payments for customers available to reduce load a specified number of times within a given time horizon. Often, such capacity payments stem from resource- or generation-adequacy credits that the operator may claim for DR programs. The signal to reduce load provided by the distribution company to the customer is known as an event or dispatch. Some programs provide additional energy payments based on how much load was actually reduced. Effectively, these programs are seen as replacements for generation since they can alleviate issues within the transmission and distribution system and/or avoid the need for additional peaking resources (Nolan, 2014).

2.1 Demand Response in Central Markets

Central markets (ISOs and RTOs) have run peak-shaving DR programs for more than a decade; at PJM alone, the portfolio of DR programs provides a resource of more than 10,000 MW (McAnany, 2016). Central-market programs can deliver peak load reductions in response to system emergencies, high wholesale prices, or both. One of the key benefits of DR is the potential for wholesale-market price reduction. Since electricity supply is fixed, the supply curve gets quite steep as it reaches system peak capacity.

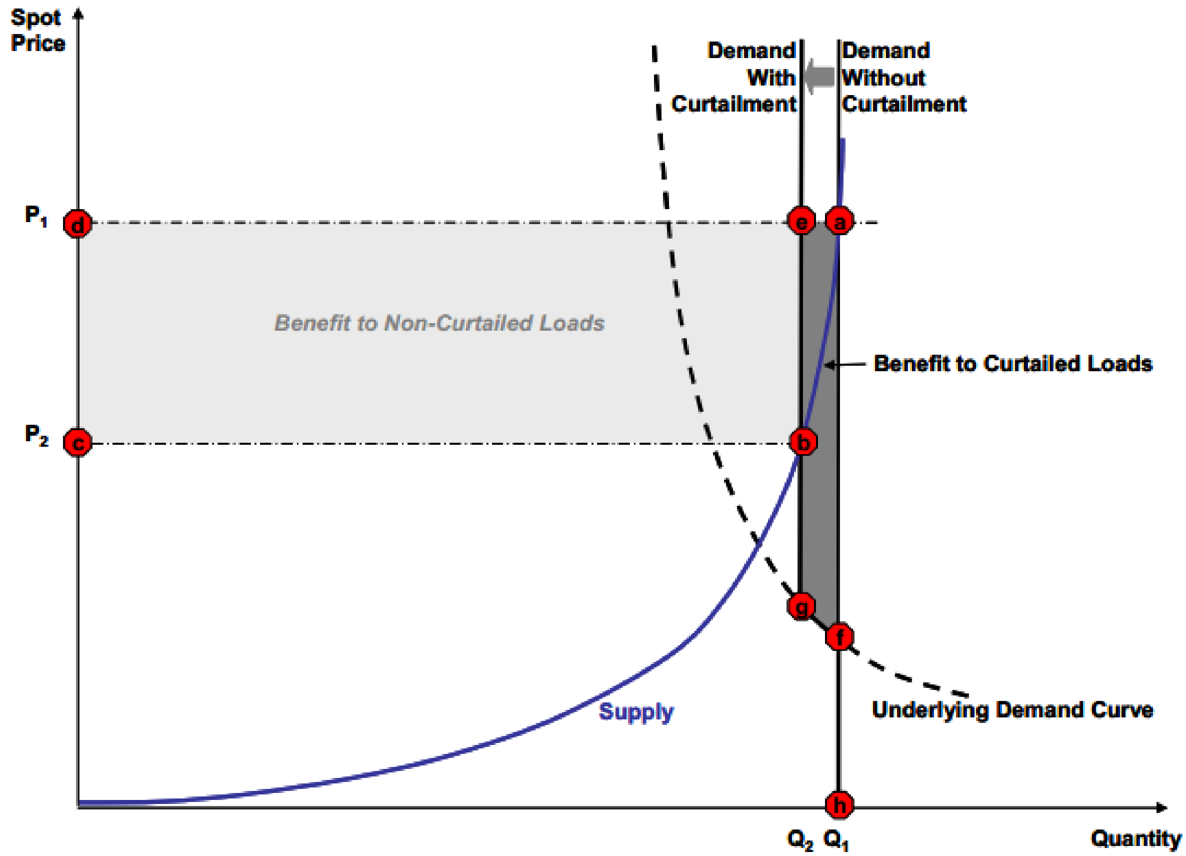

Figure 2: The above figure highlights the location of the potential surplus from DR participation in wholesale markets (Brattle Group, 2007).

In Figure 2, P represents the spot price of electricity in an organized market, while Q represents the quantity of electricity. In a scarcity or peak situation, the price and quantity rise to P_1 and Q_1, respectively. DR directly reduces load consumed and the quantity of electricity demanded from Q_1 to Q_2. As a result, the price decreases from P_1 to P_2. By virtue of the fact that the supply curve is so steep at it nears peak capacity, the difference between P_1 and P_2 is significant.

The obvious impact of movement along the supply curve is that everyone–the utility and all its customers—will benefit from the lower spot price. An important side effect of this dynamic is that the resulting price decrease from DR results in a net transfer of the surplus benefit from generators (or producers) to consumers (or "non-curtailed loads"). That is, producers who were selling peak power at much higher P1 * Q1 must now settle for P2 * Q2. If the difference between P1 and P2 is as significant in practice as the results of economic theory would indicate, the resulting transfer could be large.

There are many additional considerations that would help indicate whether this transfer or savings actually would occur in a real-world market scenario, and these are being documented. However, the above economic model has been compelling enough to policy makers, so that DR has become widely accepted. For most of the county, the potential benefits have been substantial enough to warrant further proof through implementation.

2.2 Renewables Integration at the Local Level

DR holds great potential for use in renewables integration. On the most basic level, it may be used to modify system loads at peak or during the steep afternoon ramp, to conform better to solar resource availability. However, to access their full potential, DR options must respond faster and more frequently than they have in the past. This evolution is often designated as DR 2.0. These advanced strategies also may work bi-directionally, providing not only load reductions but also load increases as needed.

The benefits of a DR 2.0 approach may be realized at the ISO level, but they also may be realized locally. Distribution utilities that integrate DR into community solar programs are driven to maximize many DER benefits that are not visible at the regional level. These range from less exposure to market risks, to lower distribution system costs, to emerging benefits, such as greater local resilience and clean electrification. Some communities believe managing solar plus DR strategies at the local level helps them to strike a better balance between self-reliance and interdependence. This document uses the terms DR 2.0 and simply DR, but intends consideration of DR 2.0 attributes whenever DR is used for renewables integration.

3 Demand Response Options

In order to develop a cohesive framework for evaluating DR 2.0 options, we must first classify them. Fortunately, a broad spectrum of literature has attempted to do just that (Rocky Mountain Institute, 2006). The following discussion provides an overview of five distinct classes of DR options: 1) Curtailable Load, 2) Automated Demand-Response, 3) Direct Load Control or Load Management, 4) Pricing Strategies, and 5) Residential Load Curtailment.

This is not intended to be a comprehensive review of existing DR options. Rather, this Guide takes a broad first cut at some of the most salient features common to each of the five categories selected, with emphasis on applications. That is because specific applications, in specific contexts, determine the right path for utility program implementation.

3.1 Curtailable Load

Curtailable load DR programs encourage customers to reduce load at specified times of the day by offering capacity payments and often, energy payments. Many of these utility-administered demand response programs are Day-Ahead (DA) and or Day-Of (DO) programs, in which the utility must notify each customer, either on the day before or on the same day as the required load reduction. These programs are typically designed for medium/large commercial and industrial (C&I) customers that have the potential to respond to dispatch signals before an event. Customers are paid monthly incentives based on the amount of capacity they commit to provide. These commitments—often called nominations—allow a customer or aggregator some flexibility to tailor responses, based on fluctuating operational characteristics.

The Pacific Gas & Electric (PG&E) Capacity Bidding Program (CBP) is an example of a curtailable load program. Several enrollment options provide curtailment events of one to six hours, which can be called between 11 a.m. and 7 p.m. For participants in the Day-Ahead option, notification is provided by 3 p.m. the day before; participants in the Day-Of option are notified on the morning of the same day as the event. As such, 20-26 hours advance notice would be required to dispatch the Day-Ahead program, while 3-5 hour advance notice is necessary to dispatch the Day-Of program. Capacity payments range substantially from $2.17/kW-month to $24.81/kW-month depending on the option selected by the customer, as well as by the time of year. Higher incentives are paid during the high demand summer months. Additionally, there are energy payments based on how much reduction was achieved by the participant during an event window. Energy measurement is calculated against a baseline.

3.2 Automated Demand Response

Automated demand response (Auto-DR) creates a direct loop between the operator and technologies that can reduce load on certain end-uses through automated notification and control. As the response time for Auto DR is much shorter than in the curtailable load programs mentioned above, there is well-documented potential to use these technologies to support flexibility on a variety of time scales (Watson, Kiliccote, Piette, & Corfee, 2012). In fact, some authors maintain that fast-response, demand-side resources that can provide ancillary services are an absolute necessity in meeting flexibility needs under a 33 percent renewable portfolio standard in California (Masiello, et al., 2010).

Given that Auto-DR represents a variety of automating technologies, the costs per customer are greater than those associated with traditional (often manual) demand response. As such, Auto-DR is often a more attractive option for larger C&I customers that can invest in sophisticated control technologies. Even with this expense, Auto-DR may make control of customer end-use equipment more cost effective than battery storage in certain applications.

3.3 Direct Load Control or Load Management

Direct load control (DLC), or load management programs install simple control technology on space-conditioning units or electric water heating systems that the program or system operator controls directly. This Guide characterizes four such options according to end-use (A/C switch control, smart thermostats, pool pumps, water heaters). In these examples, operators directly control the device, taking the customer out of the loop. One-way programs of this nature have been used by hundreds of utilities for the past 30 years, with millions of end use devices controlled. Approaches incorporating more sophisticated two-way communication (particularly in conjunction with communicating thermostats) have been tested in pilot programs by many utilities in the last few years. Much work has demonstrated that such automation increases load reduction potential significantly (Nolan, 2014). Moreover, many DLC programs such as the SmartAC in California allow for as many as 100 hours of operations per season. If configured appropriately, DLC programs among residential customers have tremendous potential to aid in renewable integration (Cappers, Mills, Goldman, Wiser, & Eto, 2011).

3.4 Pricing Strategies: Critical Peak Pricing and Time-of-Use Rates (TOU)

Price-responsive DR can trigger participants to modify load voluntarily, in response to higher-than-normal prices. The most straightforward example is a time-of-use (TOU) rate. TOU rates include tiered pricing schemes, which become more expensive during peak times or whenever the marginal cost of electricity generation or procurement to the utility is high. These rates are often have seasonal adjustments to match shifts in utility load.

Load reductions from these rates are voluntary; the prime incentive to the customer is saving on the monthly utility bill, not a direct payment. Compared with the programs described above, the yield is lower, on average (Faruqui & George, July 2002). Yet TOU rates can be helpful in addressing longer-term net load curve modifications; indeed, they can help match intra-day solar variability by encouraging users to shift typical daily electricity usage into off-peak periods. However, additional measures are often necessary to deal with specific days or hours with unforecasted changes in solar generation.

Critical peak pricing (CPP) adds an adjustable component to a flat or tiered rate structure. When triggered, the CPP event entails much higher than normal prices for a period on a specific day. CPP events can be triggered at the discretion of the utility, due to distribution needs or abnormally high wholesale market prices. Events are often limited to a certain number of times per season. The timing for notification of an event is individually driven by the utility, but tends to fall into the same Day-Ahead or Day-Of timeline as curtailable load programs (Rocky Mountain Institute, 2006).

3.5 Residential Load Curtailment Programs

Load curtailment programs that rely on customer behavior are particularly challenging to catalog because they are often designed and operated by third parties. However, the general feature is the reduction of any end-use loads by the customer upon receipt of a notification signal. Participants have flexibility around which appliances or end-uses they reduce. There is often an administrative split between the utility and third-party aggregator in this scenario. Since there is a less structured reduction strategy in a program like this, that the load reductions are more variable and less dependable, though this is ultimately driven by the particular end-use, the particular third party, and the program design (Federal Energy Regulatory Commission, 2009).

4 Scoring Analysis

4.1 Purpose

In order to help utility program planners quickly assess DR options and select those best suited for inclusion in a community solar program, this Guide offers a scoring system based on analysis of the various DR options. Using this methodology, a utility analyst would be able to pick out and identify a set of key measures to evaluate for a proposed program. To achieve this, the next section presents two tables of information about candidate DR options.

In Table 4-1, we build upon the previous descriptions of DR measures, defining each according to a set of key program attributes, such as enablement costs and average load impact per unit. These criteria, distilled from a broad research effort, contain important information for a utility program designer who wishes to quickly assess which DR options match their particular target audience.

Table 4-2 takes this analysis one step further, asking, "Considering the program criteria we have defined, what specific types of solar variability could a given DR option address?" Each program-type is then rated, according to its ability to address these characteristics.

4.2 Introduction to Table 4-1: *DR Opportunity Assessment*

Table 4-1 reviews a catalog of 11 DR options. As mentioned previously, some options require detailed program design, while others, such as Auto-DR, may be implemented with minimal program support. All of the options, although based on information garnered through looking at representative examples, are genericized to a certain extent. Each row provides a "median" value for each criterion presented and thus represents multiple similar programs of each type. In some cases, examples of specific programs are provided. The end goal of Table 4-1 is for a utility program planner to be able to assert a planning outcome, such as, "For a typical direct load control program employing A/C switch control, we can plan to spend $47/kW."

4.3 Definition of Terms in Table 4-1 and Appendix

Yearly Cost Planning Estimate ($/kW)	This figure is an estimate of the total yearly cost associated with running a program of this nature. It is composed of enablement and incentive costs: 1. Enablement costs are associated with purchasing and installing the end-use devices and control systems, which will be used for load management or reduction. Note that for options without any automated, pre-specified technology there would be no direct enablement costs. 2. Incentive costs are either one-time or ongoing payments (capacity/energy) made to the customer during the program cycle. *The calculus used to generate these figures and references for the input amounts are reviewed in detail in the Appendix.*
Average Load Impact per Unit	This metric provides a benchmark regarding the average load reduction per participant.
Seasonal Availability/Impact	This category is driven by the program window of availability, as well as the end-use in question. Most programs are operated during a single season (winter or summer) or year-round.
Events Feasible per Season	This column provides an estimate of how many times a dispatch may be called for a generic program of this type.

Signal-to-response Time	This is the time between sending a signal to begin a change in load and the onset of that load change by the customer or equipment.
Duration of Impact	This is an average measurement of the length of the load reduction period for the program
Target Customer Class	This column characterizes the general class targeted by such a program classification: Commercial/Industrial (C&I), or Residential (Res)

Table 4-1: DR Opportunity Assessment (Options 1-7)

DR Option		*Yearly Cost Planning Estimate ($/kW)*	*Avg. Load Impact per Unit*	*Seasonal Availability/ Impact*	*Events Feasible per season*	*Signal-to-response time*	*Duration of Impact*	*Target Customer Class*
1	Curtailable Load (Day-ahead)	$198	Depends on end-use	Most effective during peak season	Frequently limited to less than 50	20-26 Hours	2-6 Hours	C&I
2	Curtailable Load (Day-of)	$228	Depends on end-use	Most effective during peak season	Frequently limited to less than 50	3-5 Hours	2-6 Hours	C&I
3	Auto-DR	$265	Depends on end-use	14% of peak load winter; 16% for summer	Depends on program	5-15 Min	5 min–1 Hour	C&I
4	Direct Load Control (A/C switch control)	$47	0.37 kW -2.06 kW	Warm months only	~100	2-10 min	2-4 Hours	Res
5	Load Management (Smart Thermostat)	$85	.67 – 0.86 kW	0 .61-1.079 kW-	~30	2-10 min	1-4 Hours	Res
6	Direct Load Control (Pool pumps)	$38	N/A	Year-round	~Often	2-10 min	30 min–4 Hours	Res
7	Direct Load Control (Electric water heaters)	$38	0.65-0.69 kW	Year-round	~100	2-10 min	30 min–4 Hours	Res

Table 4-1 (continued): DR Opportunity Assessment
(Options 8-11)

DR Option		*Yearly Cost Planning Estimate ($/kW)*	*Avg. Load Impact per Unit*	*Seasonal Availability*	*Events Feasible per season*	*Response time to signal*	*Duration of Impact*	*Target Customer Class*
8	Critical Peak Pricing	Costs typically borne by utility	5-17% load reduction (manual); 20-60% (automated)	Year-round	~100	2-10 min (RMI)	30 min–4 Hours (RMI)	Any
9	TOU Rates	Costs typically borne by utility	4–17% load reduction	Year-round	N/A	N/A	N/A	Res
10	TOU w/ CPP	Costs typically borne by utility	N/A	Year-round	~8-30	~20-26 Hours	Often 4 Hours	C&I
11	Residential Load Curtailment (Behavioral)	Costs typically borne by utility	N/A	Year-round	Depends on third-party design			Res

Sources: Killiccote, Piette, Wikler, & Chiu, 2008; Rocky Mountain Institute, 2006; Haeri & Gage, 2006; Fenrick, Getachew, Ivanov, & William, 2014; Portland General Electric Company, 2004; Lopes & Agnew, 2010.

4.4 Introduction to Table 4-2: *Ability of DR Options to Address Integration*

Table 4-2 describes key attributes of a variety of DR options. To select options directly applicable to a particular community solar program, an additional step is required. Table 4-2 takes the characteristics from Table 4-1 as a starting point to ask, "How well could a particular option address a specific variability concern?" Assertions of this nature depend crucially on the specifics of the program, as well as the particular nuances of the variability concern. With that in mind, the scoring methodology is simple, assigning a value from zero to four (presented as ○ ◔ ◑ ◕ ●) to characterize the ability of each option to meet a particular variability concern. This approach can be extended by applying weights to each variability concern (or column) in Table 4-2, according to each concern's importance at any utility.

The specific terms of these variability criteria are defined below.

4.5 Definition of Terms in Table 4-2

"Duck Curve"	This measure determines whether the DR option can help mitigate steep evening hour ramps from 4-8pm in Spring and Fall when mid-day net loads are low. This dynamic is further explained in the context of Curtailable Load Programs.
Intra Hour Fast Ramps	This category examines whether the DR option can assist with un-forecasted steep ramps that occur anytime throughout the day because of cloud cover within a 30-minute to two-hour time frame.
X>2 Hour Forecast Error	If the DR measure generally has the ability to be dispatchable within 2 hours to meet forecast error, this category will be labeled High.
X>24 Forecast Error	If the DR measure generally has the ability to be dispatchable within 24 hours to meet forecast error, this category will be labeled High.
Peak Load Reduction	For this column, we assess the potential of the DR option to contribute to system peak load reduction, especially as net system load shape changes due to the mismatch between gross system load shape and solar output.

Table 4-2: Ability of DR Options to Address Integration

	Integration Issue	*"Duck Curve" Issues*	*Intra Hour Fast Ramps*	*X>2-Hour Forecast Error*	*X>24-Hour Forecast Error*	*Peak Load Reduction*
1	Curtailable Load (Day-ahead)	◑*	○	○	◑	●
2	Curtailable Load (Day-of)	◑*	○	◑	◑	●
3	Auto-DR	●	●	●	●	◕
4	Direct Load Control (A/C switch control)	○	◕	◕	◕	●
5	Load Management (Smart Thermostat)	○	◕	◕	◕	●
6	Direct Load Control (Pool pumps)	◕	◑	◑	◑	◑
7	Direct Load Control (Electric water heaters)	●	●	◑	●	◑
8	Critical Peak Pricing	◑	○	◑	◑	◑
9	TOU Rates	◑	○	○	○	◕
10	TOU w/ CPP	◑	◔	◑	◕	◑
11	Residential Load Curtailment (Behavioral)	◔	◔	◑	◑	◑

● = High ◕ = Med. / High ◑ = Medium ◔ = Low ○ = None

*Assuming ability to operate during shoulder seasons

5 Discussion of Scoring Analysis

Note that for each of the categories of DR Programs discussed below, program cost estimates will be an additional consideration. This Guide does not focus on costs, as they differ greatly based on program size, technical requirements, and other factors. A brief review of DR program cost estimates is included in the Appendix of this Guide.

5.1 Curtailable Load Programs

Before considering any DR program, it is important to recognize the role of forecasting. Regional and system load forecasts are now routine and generally are accurate for traditional-DR time domains (seasonal or day-ahead and sometime finer). The need to forecast variable generation resources when using DR for renewables integration presents a different, but generally achievable challenge. In particular, solar generation forecasting has been shown to reduce integration costs significantly (Perez, 2013), thanks to readily available advanced solar forecasting tools. This is especially true for geographically diverse distributed solar fleets, which naturally mitigate "passing cloud" variability. The CSVP recommends taking a fleet perspective and balancing against the system load (or at minimum, a circuit load), rather than against a specific project site, to engage diversity benefits on both the generation side and the load side. Yet, some forecasting errors occur, especially in shorter time domains, and these can be costly. For example, if actual solar resources are greater than predicted, DR could be dispatched unnecessarily to deal with renewable integration. In general, this dynamic renders Day-Ahead and Day-Of DR programs to be somewhat blunt instruments for renewables integration on time scales finer than the hourly level.

Nevertheless, curtailable load programs have quite a bit of potential to address a variety of integration issues. Below, we summarize impacts of operating curtailable load programs on two specific integration concerns: 1) Summertime peak load reduction, and 2) duck curve issues.

Consider the following stylized example of the impact of DR on net load during a hot summer. Solar production comes online around 10 am. In effect, the net load is thus lower than system demand. However, as solar production begins to wane due to decreased sunlight (Hours 19, 20 in the graph below), the net load, in effect bounces back up and hovers closer to demand. Demand, during the hot season will not diminish until far later in the evening when temperature has cooled significantly. DR programs of this nature, can play a vital role at coming in right as solar production begins to drop off, thereby driving down net load. This dynamic is illustrated in the figure below.

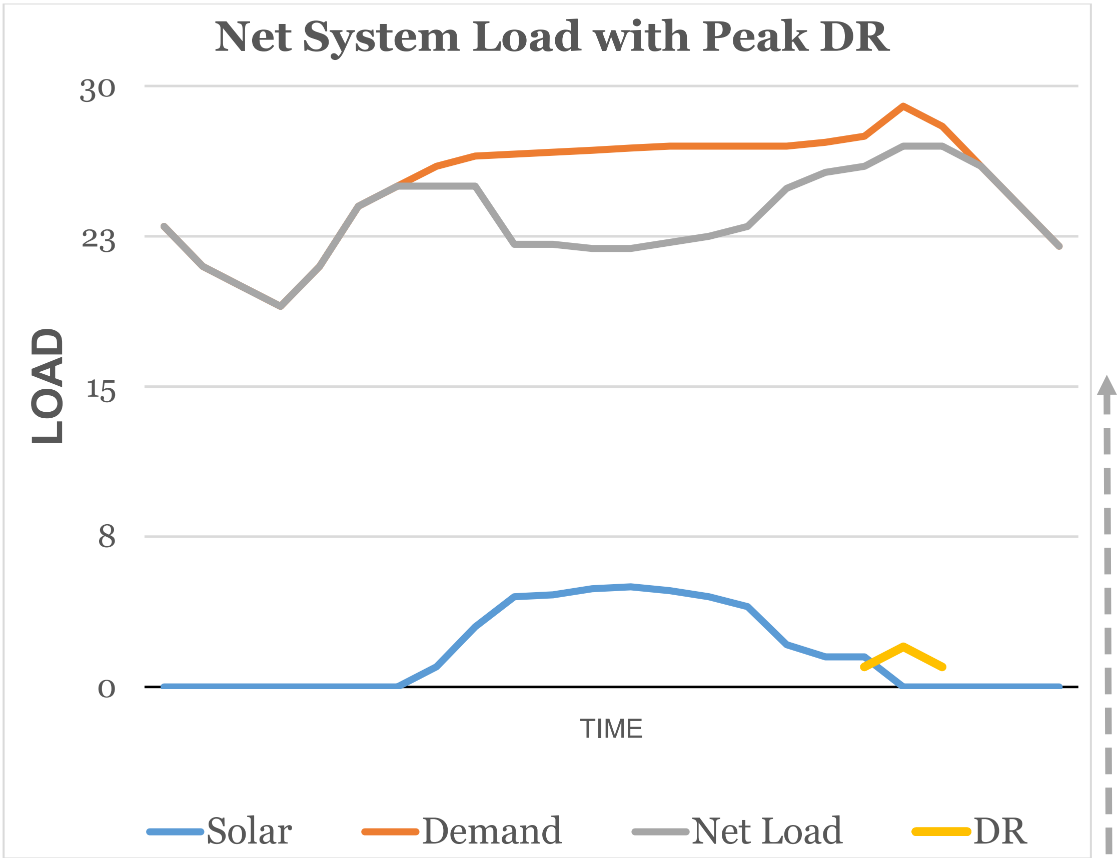

Figure 3: Example Net System Load w. Curtailable Load DR: The above load curves demonstrates the effect of utilizing DR on demand & net system load during hot season.

In addition, certain programs of this design can play a role in addressing a related but distinct issue: the duck curve. During shoulder months (spring and fall), solar generation peaks earlier than system loads and falls off when system loads peak, causing a steep increase in net demand. Curtailable programs can be operated during this window to help with overall system needs of this nature, provided they are available on a year-round basis. The load curves shown below demonstrate the general effect of this on net system load (California Independent System Operator, 2013).

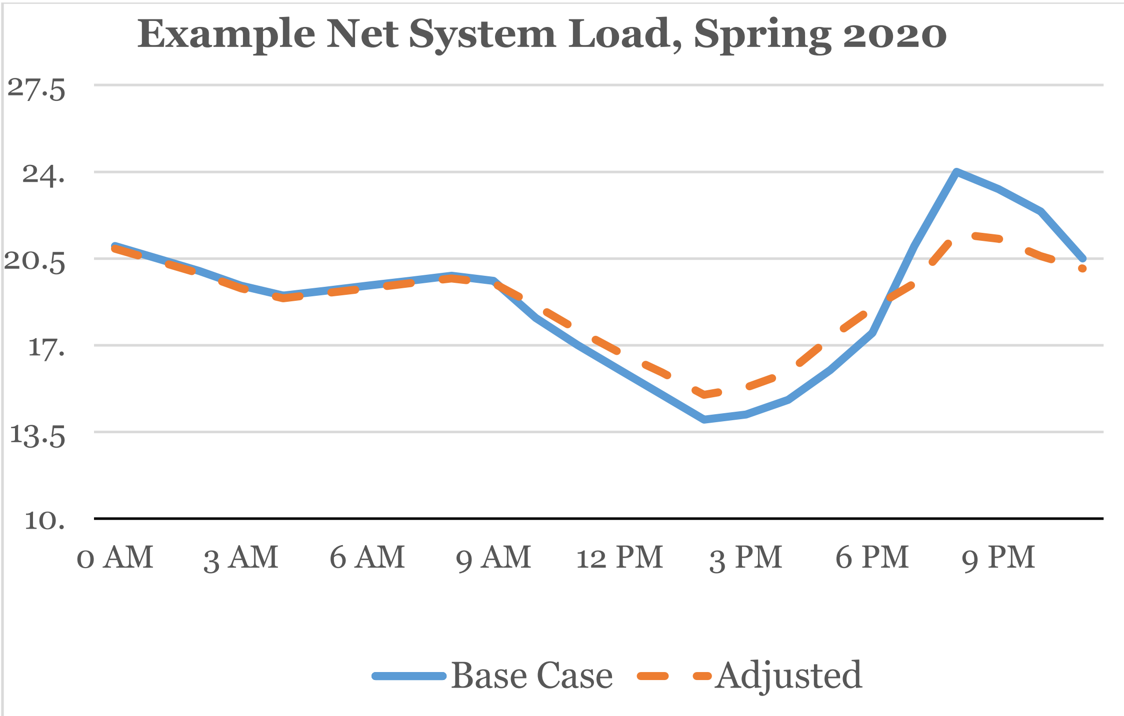

Figure 4: Example Net System Load 2020.

Depending on when program event windows are set up, these types of programs could help mitigate some of the variability driving the evening ramp, leading from the base case (blue), to an adjusted case (orange). For this to occur, programs would be triggered during evening hours (e.g., 4pm-8pm). Aside from the fact that some programs might not be dispatchable over this time period, an additional constraint is the number of times each program can be dispatched per season. Since distribution utilities and customers have come to expect using these programs on an infrequent basis, they may need significant changes to address the duck curve issue. More suitable companion measures might involve a permanent load-shift, through a time-of-use rate, or technology enabled measures, such as battery or thermal storage.

5.2 Automated Demand Response (Auto-DR)

With short notification timelines and the ability to accommodate frequent dispatch, it is clear that the technical potential of Auto-DR to address all variability concerns listed in Table 4-2 is high. The following diagram indicates the interplay between automation, notification timelines and frequency of dispatch for the main categories of DR options. Not surprisingly, Auto-DR leads the group.

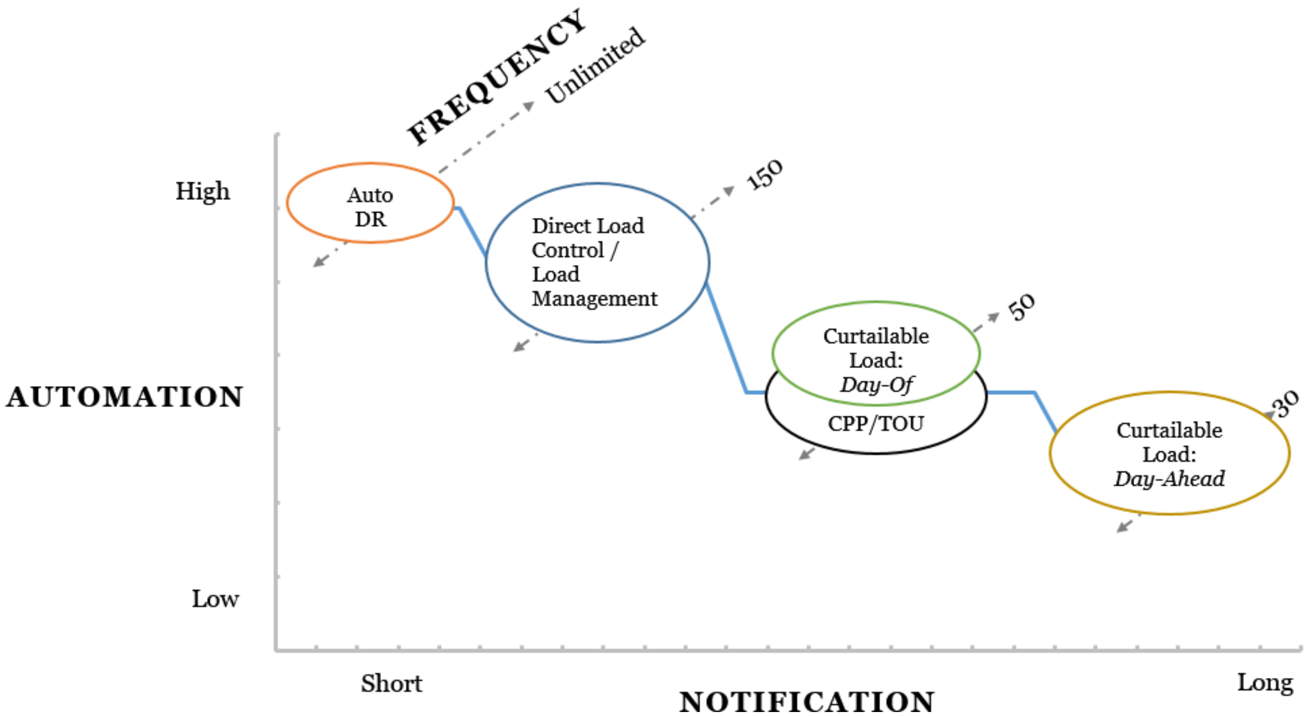

Figure 5: Notification and Automation: The above diagram illustrates that increased automation will impact notification timelines as well as the potential frequency with which the resource may be called.

Although ripe with potential, the underlying ability of Auto-DR to fulfill variability needs may varies across geographical regions due to other factors, beyond technical capability. Even in California, often assumed to be one of the more developed markets, there is likely not enough capacity in Auto-DR to meet the overall system needs that will result from the 2020 Renewable Portfolio Standard (Watson, Kiliccote, Piette, & Corfee, 2012). In the PJM market, fast-responding DR resources play a significant role in the wholesale market, comprising roughly 36 percent of all Tier 2 synchronized (spinning) reserves provided in 2012. However, a policy of infrequent, contingency-only dispatch, by definition limits the value of this option.

One potential bright spot in using Auto-DR for integration is in the Midcontinent Independent System Operator (MISO) region. Automated load response has been providing ancillary services to MISO for a number of years. An aluminum smelter plant in Warrick County, IN, operated by Alcoa, has been consistently providing between 10-15 MW of various ancillary services into MISO after significant investment starting 2009, meeting a large portion of overall regulation needs. Since then, the Warrick plant has moved into providing spin, energy and spinning reserve services through interruptible load. (Todd, et al., 2009).

The high potential of Auto-DR should be weighed against availability and other practical constraints. Still, it may be a cost-effective opportunity for integration, especially when smart-grid technology is already in place.

5.3 Direct Load Control

In line with much of the research reviewed, the scoring analysis indicates that direct load control (DLC) programs offer tremendous potential for renewables integration. The main channel by which this flexibility can be delivered is through extremely short signal-to-response times. The diagram below illustrates the correlation between signal-to-response and the suite of integration issues. In sum, although peak load reduction can be addressed using all of the measures listed here, the faster the ability to respond, the more applicable the DR measure is to solving ramping and short duration (2-hour) forecasting issues.

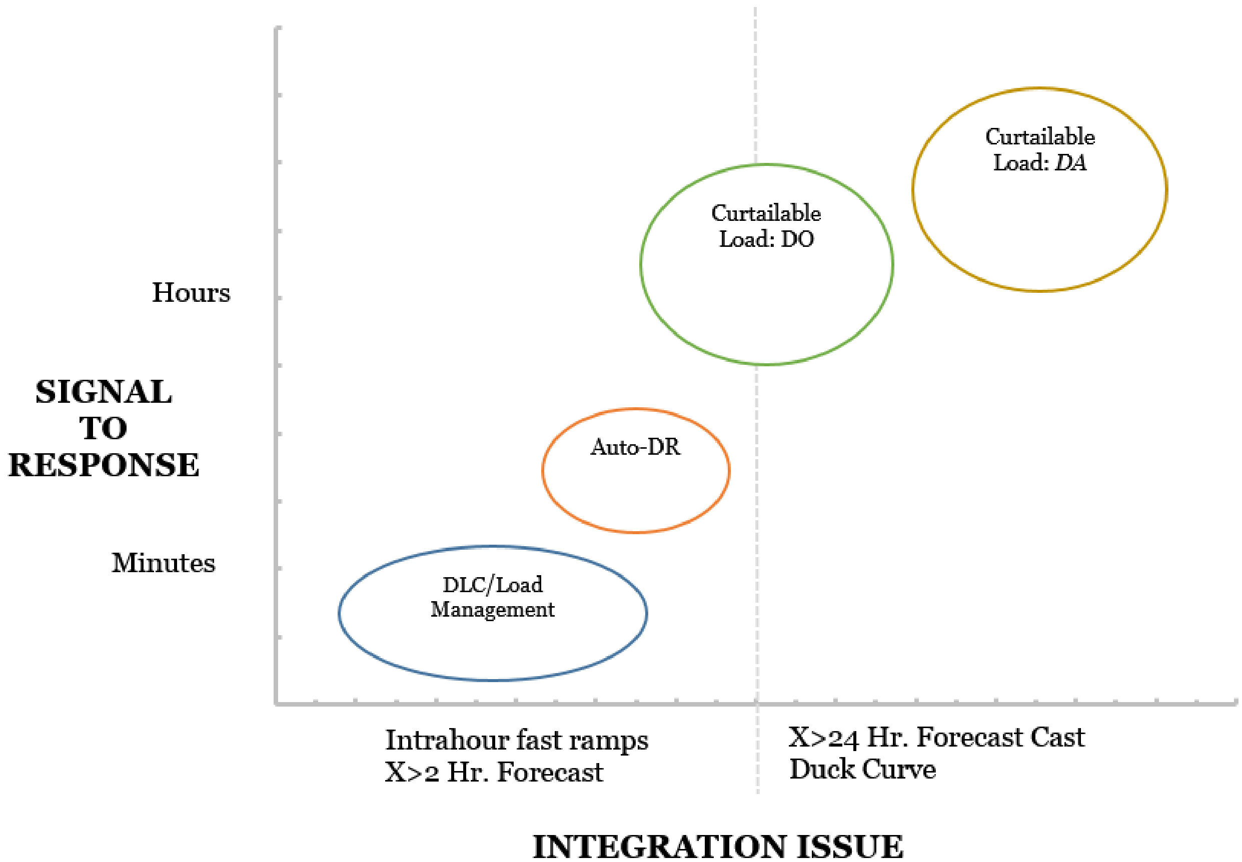

Figure 6: Signal-to-response / Integration Issues: The above diagram illustrates that lower signal-to-response times allow for the ability to address a different set of integration issues.

Resource magnitudes for DLC/Load Management programs generally tend to be the smallest of the DR options surveyed here. This is not necessarily be a drawback. For the distribution utility, there may be great value in commanding a fleet of smaller locations, insofar as it translates into the ability to geographically target grid areas of need with greater precision.

As factors such as these illustrate, the applicability of the potential for DLC programs depends on some key on-the-ground factors. For example, PG&E's SmartAC-Residential program which had 125,057 service accounts in April 2015 currently has no near-term plan for partial (granular) dispatch. Clearly, dispatching the entire portfolio of customers across various geographic regions comes with certain inherent costs and complexities. This may limit the potential application of this program to a smaller subset of integration issues.

The granular dispatch issue has been addressed by many other utilities. For example, with 710,000 participants delivering 1,000 MW during normal operation, Florida Power & Light has operated one of the largest and most popular residential DLC programs in the country, "On-Call," since July of 1986. The On-Call program cycles air conditioning and heating loads, turning them off for 15 minutes out of every 30 minutes for 3 hours. It also offers participants bill credits on a yearly basis. As Florida is not part of an ISO and the program can be dispatched on a highly localized basis, this program plays a critical role in addressing both local and system-wide needs (Malemezian, 2003). The considerable differences between the On-Call and SmartAC programs underscores the fact that while DLC holds tremendous potential, programs must be carefully structured—and, in some cases, restructured—in order to fully unlock the potential that best complements variability needs.

5.4 Pricing Strategies: Critical Peak Pricing and Time of Use

The pricing strategies represented in rows 8-10 of Table 4-2 pose an interesting scenario. Within a Day-Ahead or Day-Of time domains (dependent on the notification period), pricing can be used to target specific integration issues. In fact, there may be more flexibility in this time threshold to address certain integration issues than would be present in a typical curtailable load program. While a DR event may be called for a four-hour block of time, it suffers from discrete dispatch so that if a customer needed to return to normal load levels at some point during the event they would have no economic signal to aid in the decision of which hour to choose. Rates and tariffs can be created and implemented address that need. Each individual hour of the event period could be priced according to specific system need. In this way, the utility can set up a rate structure that incentivizes load reduction behavior within the Day-Ahead or Day-Of time frame, which is more flexible than what a typical curtailable program could achieve.

However, the distinction between programs designed for bill savings rather than direct payments add complexity to this comparison. Research on past DR programs showed that on average, customers on dynamic rates do not reduce load as much as those on automated or DLC programs (Faruqui & George, July 2002). There also could be significant regulatory hurdles to instituting a new rate to target solar integration over the simple retooling of an existing DR program. One final concern is that these rates are limited primarily to the subset of integration issues that can be addressed within the Day-Ahead or Day-Of time frames. Given the fact that large numbers of customers are often placed on TOU or CPP, most of these customers cannot be expected to have access to advanced load-management technologies.

These considerations produce relatively low scores in this analysis of rates and tariffs for renewables integration. However, broader adoption of these rates with new design elements in coming years, could offer new, highly-ranked solutions.

6 Case Studies of DR Integration with Renewable Resources

Distribution utilities that have worked to maximize smart grid capabilities have begun to see DR in combination with distributed generation, including wind and solar. The following case studies relay different approaches to addressing renewable variability concerns. These studies portray the cutting edge of what utilities might do to merge the two worlds of demand-side management and renewables integration.

6.1 Oklahoma Gas & Electric-SmartHours Dynamic Pricing (2013-Present)

Oklahoma Gas & Electric's SmartHours dynamic pricing program utilizes peak-hour pricing from 2-7 pm. This program has been developed to help aid in the integration of the wind resources, which are now at 7 percent of the utility's total resource mix (Oklahoma Gas & Electric, 2014). The program is projected to grow with new transmission in Western Oklahoma, connecting the utility with additional wind resources (Walton, 2014). Like the Steele Waseca program described in detail below, this program has the utility interfacing directly with customers. The objective is to help manage the utility's peak load and to maximize the benefit of renewables on the system. This is sometimes characterized as a "smart distribution utility" approach to renewables integration, since pricing and devices used together to help manage system load, independent of the ISO/RTO.

6.2 Arizona Public Service-Solar Pilot Project (2010-Present)

Driven by a state mandate for 15 percent renewables by 2020, Arizona Public Service (APS) filed for a pilot project in 2010 to install utility-owned solar arrays on roughly 200 homes, including solar water heaters in 50 homes and small-scale stand-alone wind turbines, in Flagstaff. With funding from the US Department of Energy, the project is highly localized in one electric distribution area. It delivers 1.5 MW of distributed solar. The key distinguishing feature of this project is the goal to balance demand and supply within a small geographic footprint. As discussed below, this approach has been avoided in some other case studies for reasons that are further detailed in the PowerShift case study below. Nevertheless, it is a precursor to some micro-grid oriented solar-plus projects.

6.3 Bonneville Power Administration"Non-Wires Solutions" (2002-Present)

The Bonneville Power Administration has taken a pre-emptive approach to addressing ongoing transmission and distribution concerns. It launched an initiative in 2002 that sets up a "Non-Wires Solutions" assessment, looking at viable energy efficiency and demand response options before launching any T&D upgrades. This creates a formal process by which alternatives to new wired projects are evaluated, with an initial screening to be considered. Any construction project goes through this analysis if it will cost at least $5 million and will be undertaken at least eight years in the future (Neme & Sedano, 2012).

6.4 Steele-Waseca Cooperative Electric Sunna Project (2015-Present)

Steele-Waseca Cooperative Electric (SWCE) is based in Owatonna, MN, and serves nine districts in a territory of roughly 900 square miles. The co-op serves about 60-MW of peak load. As a member of the Great River Energy G&T, SWCE gets 15 percent of its energy from wind resources. With water heating representing between 13 percent and 17 percent of residential energy consumption, the shifting of this load has tremendous potential to aid in renewables integration and to raise the effective net value of wind (and eventually, of solar) generation (Troutfetter, 2009).

The Sunna Project community solar program operates on a familiar co-op community solar model. The solar project serves the distribution grid, overseen locally by SWCE. Members of the co-op may subscribe to one 410-Watt solar panel for one-time fee of $170, so long as they agree to join a water heater load control program as well. (For those who opt out of the water heater program, the cost of the solar panel increases to $1,225.) An equivalent amount of kWh production is deducted from the participant's electric bill each month, in a form of virtual net metering. SWCE's 16-Hour Water Heater Program provides willing members with a new 105-gallon electric storage water heater at no additional cost. These water heaters are outfitted with mixing valves, which allow the unit to store water at a higher temperature than needed for domestic use. The hotter water is mixed with cooler water as it exits the tank, so there is no noticeable difference from standard water heating. The main control strategy employed by the utility is to shift the water heating load from on-peak to off-peak hours (Walton, Why one electric co-op is offering their solar customers free water heaters, 2015).

The solar project is just one source of variability on the co-op system, so the water heaters balance against the system load instead of the community solar project alone. The program utilizes the significant flexibility for charging the water heaters to work at night time, when net system loads are low (typically due to high availability of wind power). This approach takes advantage of lower electricity prices, and can help the utility avoid over-generation. As such, there is no direct coordination between the charging of the water heaters and the availability of renewables, except via the intermediary of the grid itself. The configuring of the DR measures to grid conditions, rather than directly to the production profile of the renewables themselves is a recurring theme across best-practice case studies for renewables integration.

6.5 New Brunswick Power PowerShift Atlantic (2010 – 2014)

PowerShift Atlantic was an innovative research and demonstration project led by New Brunswick (NB) Power, which spanned Canada's three Maritime Provinces–New Brunswick, Nova Scotia and Prince Edward Island. This demonstration project was the basis for program development work, which is ongoing. Together, these provinces controlled a hefty 675 MW of on- and off-shore wind power, which is about 13 percent of peak system load (Natural Resources Canada, New Brunswick Power, 2014). The PowerShift strategy relied upon year-round, bi-directional load response. It stands in contrast to many traditional DR programs, as well as to the Sunna Project model, which trigger peak load reductions over pre-specified times of day. The demonstration was highly successful and led to ongoing efforts.

As designed, the program had a tiered structure, with NB Power acting as program administrator. At the top of the operational hierarchy, a Virtual Power Plant (VPP) system created by Leidos,[1] received forecasts of net system load from the system operator. The VPP also interacted with five DR aggregators, each controlling their own aggregations of customers. Aggregators provided the VPP with forecasts based upon the operating parameters of their individual customers. The VPP operator calculated energy targets that were sent back to the aggregators every fifteen minutes. In turn, the aggregators were expected to send control signals out immediately to end-use loads and devices in a continuous feedback loop of responsive load.

[1] Leidos (formerly the Science Applications International Corporation) is a Fortune 500 American defense company headquartered in Reston, Virginia, that provides scientific, engineering, systems integration, and technical services.

It is noteworthy that even though the overarching program goal was renewable integration, program administrators learned that it was better not to have the VPP optimize the load response against the wind forecast alone. This lesson was learned by examining what could happen on a peak day. Depending on when large wind resources came online during the evening and how they coincided with overall system peak, the VPP could signal for loads to shift directly into peak hours. This could result in aggregators increasing the load beyond grid capacity. Instead, the VPP set out a load trajectory on a 24-hour basis, to best smooth the forecasted net load shape (load minus wind) that was received from the system operator. This way the VPP reduced the strain on conventional generation, shifting loads to reduce the effects of the variability of the wind generation, not the generation itself.

Downstream from the VPP optimization, aggregators relied primarily on end-uses with some kind of storage component. One aggregator utilized pre-cooling, controlled electric water heating, and manipulation of pump timing, while another focused on optimization of pumping system loads from industrial processes.

NB Power had a unique benefit to aid in the success of PowerShift: a high degree of trust from its customers. This was due in part because the project was promoted as a Canadian national demonstration, invoking public support. Successful marketing also played a key role. The program was able to recruit a high number of participants, and most of the control equipment belonged to customers, who did not receive incentives to participate. Reportedly, public support for the region's wind resource has been a major driver.

NB Power has leveraged some of the infrastructure and networks developed through this project in the Reduce and Shift Demand (RASD) program, which aims to create an innovative smart grid framework through smart communicating thermostats, energy smart appliances, self-serve options for energy shifting, energy usage dashboards; and thermal energy storage.

6.6 Pacific Gas & Electric Intermittent Renewables Management Phase 2 (IRM2) Pilot (2013 – 2014)

As in many other locations, the influx of renewables is rapidly changing the shape of California's load curve (Lazar, 2014). The Intermittent Renewable Management Phase 2 Pilot (IRM2), a PG&E project administered by Olivine, was conceived as an integrative model for how distributed energy resources (DER) could be dispatched economically to address short term system needs related to variability. The program ran from February 2013 through December 2014 and was open to commercial and industrial customers of PG&E.

IRM2 brought demand-side resources, including DR, directly into the wholesale market as a supply resource, similar to a generator, becoming part of the economic bid stack and affecting wholesale spot prices. Through the daily optimization of market offers, these resources met needs that are directly driven by the generating characteristics of renewables.

Critical to IRM2 are the must-offer obligations (MOOs). Load Serving Entities (LSEs) are required to contract for capacity above their load requirements in order to meet reliability requirements and ensure adequate capacity is available if needed. Contracted generators bid MOOs into the wholesale market, to be available for dispatch if needed. Although there is little DR currently integrated into the wholesale market, policies and procedures are now being implemented to use DR to meet resource adequacy requirements and compete for these contracts.

One of the lessons of IRM2 was that participants who were able to meet pilot participation requirements demonstrated an increased level of operational sophistication and the ability handle dispatch events often. Many of the parties who inquired or enrolled relied on innovative demand-side technologies, and few had previous experience with traditional utility-program DR. Applicable resources included storage batteries and even modulated Electric Vehicles.

Through the daily optimization of market offers, these resources were able to effectively demonstrate their benefits, such as reliability and flexible ramping, for replacing the need to use gas peaker plants to address intermittency.

An integral component of the IRM2 was the fact that these DERs were part of the small group of resources that have participated in the wholesale market outside of distribution utilities' minimal program integration. Utility and CAISO market systems to support DER were still in the early stages of development during the program. IRM2 shed light on real-world challenges, as this market grows and expands to address renewable-resource intermittency. Since completion of the IRM2 the CAISO's Flexible Resource Adequacy Must Offer Obligations guidelines have been modified and approved by FERC to include DR resources. California regulators now have launched a statewide Demand Response Auction Mechanism (DRAM) Pilot to test the viability of procuring DR for resource adequacy purposes, which would carry the MOO, through an auction mechanism with a standard contract.

Conclusion

In addition to the practical comparisons of DR measures for use in renewables integration, this Guide offers at least two key takeaways. First, if DR is to aid in the integration of renewable resources, accurate forecasting (particularly of net system load) is critical to setting DR-for-integration targets. In the PowerShift and Steele Waseca projects, it was demonstrated that forecasting overall grid needs, as opposed to the output of any single renewable facility, can be effective and helps avoid unintended consequences. Second, there is a need for a variety of fast-responding, flexible DR options to aid in renewable integration. As all the above case studies suggest, new end-uses must be recruited, which ideally offer bi-directional load shifting, i.e., load reductions and load increases.

Although traditional DR lessons apply, distribution utilities may find it better to create new DR programs for renewables integration, or to create specific new messaging about modified program offerings, to ensure that all the criteria for flexibility are met. Advanced DR programs for renewables integration, sometimes called DR 2.0, are best-suited to newer, smart grid technologies. In the context of community solar marketing, DR companion programs also might leverage new third-party provider capabilities. Ultimately, the creation of multiple options for customers with innovative DERs (on both sides of the meter) would help to assure not only the viability of significant community solar fleets, but ultimately the path towards a lower-carbon future.

The development of DR programs to address renewable resource variability need not compete with traditional DR programs, nor erode their value in addressing seasonal peak load. Nascent experience shows that customers who are eager to adopt and embrace solar PV in particular represent a new target market, willing to consider other options as well, to address the impacts of variability. They are likely to speed the use of new technologies, such as DR 2.0, thermal storage, storage batteries, and EV charging. While not necessarily suitable for longer DR events, many of these work frequently but quickly, and with little or no customer inconvenience. Innovative DR program design and targeted customer recruitment can extract value that complements the challenge of increased solar market penetration.

Community solar program design is a new area; most utilities do not have robust community solar programs yet. Incorporating DR options into such programs adds a layer of complexity to be sure. However, customer enthusiasm for solar and solar-plus strategies and the pace of change in the solar industry should not be underestimated. As the community solar market rapidly grows, it is appropriate for utilities to incorporate measures needed to support growing solar penetration. The grid will look very different in just a few years than it does today. As the percentage of variable generation increases, responsive load will become increasingly valuable.

The CSVP sees opportunities for utilities to combine utility-driven community-solar business models with DR options–and ultimately with DR plus storage as bi-directional sink and source options–to address variability in net load. Today, such value would be difficult to capture with other solar projects (e.g. customer rooftop, or remote utility-scale power plants). Solar program designers need to embrace such opportunities to ensure that customers have access to the power choices they want, while utilities can maintain grid stability as renewable penetrations increase.

Appendix: Planning Cost Estimates

The following table was used to calculate values for the Planning Estimate Yearly Costs introduced in Table 4-1. For all rows the values in Enablement and Incentive costs were taken from literature review. "All-in Monthly Cost" was calculated by taking the Enablement Cost divided by the program period, then adding the monthly $/kW incentive cost. We assume a 5-year program period. The "All-in Monthly Cost" was multiplied by 12 to calculate with the "All-in Yearly Cost."

		Input Costs						**Totals**						
	DR Option	*Enablement Cost ($/kW)*			*Incentive Costs ($/kW)*			*All-in Monthly Cost ($/kW)*		*All-in Yearly Cost ($/kW)*		*All-in 5 year Cost ($/kW)*		*Avg Yearly Cost ($/kW)*
		Low	*High*	*Term*	*Low*	*High*	*Term*	*low*	*high*	*low*	*high*	*low*	*high*	
1	Curtailable Load -Day-Ahead (Navigant Consulting, Inc., 2015)			One-time	$2	$30	Month	$3.00	$6.25	$36	$75	$180	$375	$56
2	Curtailable Load-Day-of (Navigant Consulting, Inc., 2015)			One-time	$2	$35	Month	$3.00	$6.25	$36	$75	$180	$375	$56
3	Auto-DR (Ghatikar, Riess, & Piette, 2014)	$125	$300	One-time	$2	$35	Month	$4.08	$40	$49	$480	$245	$2,400	$265
4	Direct Load Control - A/C switch control (Haeri & Gage, 2006) (Rocky Mountain Institute, 2006)	$70	$150	One-time	$100	$150	One-time	$2.83	$5.00	$34	$60	$170	$300	$47
5	Load Management - Smart Thermostat (Haeri & Gage, 2006) (Rocky Mountain Institute, 2006)	$200	$400	One-time	$100	$150	One-time	$5.00	$9.17	$60	$110	$300	$550	$85
6	Direct Load Control - Pool pumps (Haeri & Gage, 2006)	$55	$75	One-time	$100	$150	One-time	$2.58	$3.75	$31	$45	$155	$225	$38
7	Direct Load Control – Electric water heaters (Haeru & Gage, 2006)	$55	$75	One-time	$100	$150	One-time	$2.58	$3.75	$31	$45	$155	$225	$38

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Solar Plus Storage Companion Measures For High-Value Community Solar

A Guide For Utility Program Planners

Community Solar Value Project

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Summary

This guide to **Solar Plus Storage Companion Measures for High-Value Community Solar** is a companion to an earlier Community Solar Value Project (CSVP) publication, **Demand Response Measures for High-Value Community Solar Programs**. Both guides can help utility solar program planners in creating compatible distributed energy resource (DER) programs, and especially in bringing greater utility value into community-scale solar, by adding companion measures. The CSVP is focused on community solar as the likely solar program model, but, in fact, any solar resource or aggregation of solar resources may be matched with complementary storage and demand response (DR).

This guide also may be useful to utility strategic planners, resource procurement specialists, DR program managers, marketing program managers, non-utility vendors and others who wish to understand current and emerging storage opportunities and storage measures on both sides of the customer meter.

The authors assume an introductory understanding of issues related to rising distributed-solar market penetration. As a framework for early-stage program planning, this guide presents a five-step process:

1. Characterize Utility Solar Plus Storage Program Objectives
2. Review Storage Technology Options.
3. Assess Integration Value Streams.
4. Score Technologies and Configurations for Relevance to Program Objectives.
5. Design the Program to Deliver Solar Plus Storage and/or Demand Response.

The range of storage technologies covered include those suited for deployment on the utility side of the meter and on the customer side of the meter. The use of stationary batteries for energy storage has become the center of industry attention today, and this guide provides summary information and resources to help facilitate their practical use. However, this guide gives equal attention to thermal storage options, such as grid-interactive water heating (GIWH) and controlled ice storage systems, which are most likely to be aggregated through a customer-focused program. A number of other options are also discussed, including emerging controlled electric vehicle charging and bi-directional vehicle-to-grid (V2G) strategies. A sampling of utility programs and references for more information are included in each technology discussion.

Value streams are discussed from both the utility perspective and the customer perspective. Value is derived from using storage and DR to meet the utility system's integration needs along different time horizons, from addressing seasonal generation and load-curve characteristics to instantaneous needs for frequency response and voltage stability.

The market structures needed to explicitly monetize these values are just emerging, and for some utilities and customer groups this will be a limitation. Yet programs available to most distribution utilities can provide benefits today. These programs can solve some

integration problems close to home and minimize exposure to the eccentricities of external markets.

The CSVP has developed a simple scoring approach to help utility planners in assessing choices among storage technologies and deployment configurations. The approach presented here precedes more technically refined methods, which are currently under development by the U.S. DOE Grid Modernization Consortium and other advanced engineering groups. In working with utilities and stakeholders today, CSVP recognizes a pressing need for elementary understanding of renewables-integration problems and solutions, which could be implemented in the market today. The CSVP's recommended model is a community-solar program, co-marketed with storage companion measures. Several relevant demonstrations of this approach include the local community solar plus storage program at Steele Waseca Electric Cooperative, in Minnesota, implemented with the co-op's power supplier, Great River Energy. In other cases, solar thermal energy storage or customer-side batteries have been offered to address increasing integration needs, but without specific reference to a community solar offer. The CSVP's work with its primary utility partner, the Sacramento Municipal Utility District (SMUD) in California, also has contributed to that utility's understanding of solar plus storage program options, with new product offers anticipated in the next two to three years.

This guide concludes that there are many ready opportunities for utilities and their customers to benefit from solar plus storage program options. Solutions to relatively straightforward problems, such as the need to smooth the "duck curve," can and should be introduced today, so utilities, customers, and third-party innovators can gain experience working together to solve integration problems. Their timely efforts can prepare utilities on pace with the potentially skyrocketing growth of renewables and especially distributed energy resources (DERs). Because of their inherent flexibility, many storage solutions introduced for load-shifting today could be applied to more sophisticated integration problems as markets evolve and change.

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Keywords: distributed solar, community solar, energy storage, battery, thermal storage, storage water heater, ice storage, ancillary services, grid services, solar-plus, program design.

About the Community Solar Value Project

The Community Solar Value Project is aimed at developing best practices for community solar at electric utilities, including guidelines on how to achieve lower costs and greater value in five areas: optimal siting and project design, procurement, pricing, target marketing, and matching the solar offer with companion measures that attack solar-integration challenges. The project is led by Extensible Energy, with support from Cliburn and Associates, LLC, Olivine, Inc., Millennium Energy and Navigant Consulting. Utility participants include the Sacramento (California) Municipal Utility District (SMUD), and other utilities nationwide. The project is powered by SunShot, under the Solar Market Pathways program of the U.S. Department of Energy. See http://www.communitysolarvalueproject.com

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Disclaimer

Contents

1 Introduction

The Community Solar Value Project (CSVP) aims to increase the value and reach of community solar programs and community-scale projects through improvements in five challenge areas: strategic project siting and design, procurement, pricing, target marketing and matching the solar offer with demand response (DR), and storage companion measures that add solar integration value.

Before turning to a detailed exploration of storage as a promising challenge area, some definitions can help to set boundaries for the discussion. First, the focus of this guide is on the role of the local utility, which is most likely to drive solar generation on its own distribution system. The term *distributed solar*, thus refers to that local, community-scale PV resource, as well as to customer-sited PV. We use the term as broadly inclusive for solar on the local grid.

The term *integration* is used in many different contexts when discussing renewable resources, and especially solar. For this guide, we consider integration primarily as a set of strategies that compensate for variable generation from solar projects, at intervals ranging from a few seconds to a few hours, as well as to the seasonally shifting characteristics of PV generation. Integration issues are relatively inconsequential at lower solar-resource penetrations, but as penetrations rise, diurnal and seasonal variability creates a mismatch between utility generation and load. Often, this is a first-line challenge, which storage or DR or both can readily address. But systems also experience imbalances of much shorter duration, and these are more challenging to address. This guide explores how storage, along with DR and control technologies, apply to the range of integration challenges: which configurations work best for utilities today, and how practical issues, from cost to market and policy pressures, affect the utility's decisions about what kind of storage to use, and where and how in the market today.

The term *energy storage* itself needs some definition, in the context of this guide. Obviously, the context is storage to support electric utility service. At that, the choices for product selection, scale, placement and operation are many. For the most part, we focus on options that complement community solar program design. As such, customer-side options are highlighted; thermal storage is especially highlighted for its relatively low cost and accessibility. Customer-side battery storage is also discussed. Utility-side battery options are discussed primarily for their value in strategic-use applications. For interested readers, we include references to the full range of storage approaches in another CSVP publication, *CSVP Resource Links for Solar Plus Storage* (Cliburn, Halberstadt, & Powers, 2017). We also provide references for the special case of local resiliency, which is a potentially great value stream, but which is not covered in depth here.

While storage is rarely used in community solar programs today, some storage programs complement community-scale solar portfolios or address the wholesale-market impacts of renewable-resource variability, through an approach of "solving the problem near the source." This approach has benefits that limit utility exposure to the risks and costs of responding only to wholesale market conditions.

One final note: When storage is deployed on the customer side of the meter, the storage measure may be implemented under the utility's DR or load management or broader energy services program, often in collaboration with solar and resource planning managers. This guide does not provide detail on implementation strategies. CSVP's earlier guide to *Demand Response Measures for High-Value Community Solar Programs* (Huffaker & Powers, 2016) goes into more detail and provides case studies. CSVP also has addressed important challenges of cross-departmental collaboration in its community solar design guide and other publications. This guide to *Solar Plus Storage Companion Measures* offers a five-step process for setting the course toward implementing a successful solar-plus strategy, but these are early steps along a path that utilities are beginning to walk, together with their partners in market innovation.

1.1 Market Trends for Distribution-Scale Solar

The U.S. solar market grew by nearly 14.8 GW of capacity in 2016, nearly doubling its 2015 growth, according to the Solar Energy Industries Association (SEIA, 2017). Most of this growth was in the utility sector (10 GW). The total 40.4-GW capacity of the U.S. solar market in early 2017 was dominated by large, centralized solar projects, owned by or under power-purchase agreements with utilities. This has pushed the solar fraction of total U.S. generation from near-invisibility to 3.2% of net summer capacity and 1.4% of annual generation nationwide—a 73x multiplication market scale since 2006. Of course, the impact of solar generation is much greater in some states than in others. But the rapid growth of the solar market is occurring far beyond California. Rising solar states, with strong market growth in 2016, included Utah, Georgia and North Carolina. Utilities nationwide recognize that a solar transition is underway.

The growth of solar on the local distribution grid is an important subset of overall solar-resource growth. Distributed solar includes the widely recognized residential market segment and a non-residential market, which may—due to shifting approaches to categorization—include a significant number of utility-driven projects, as well as a growing number of corporate projects that exceed typical non-residential scale. The total market that is generally classified as *distributed solar* has been growing by about 5-GW annually (Margolis, Feldman, & Boff, 2017).

Whether growth in the local solar sector dramatically accelerates depends in part upon whether integrated distributed energy resource (DER) strategies take hold. Local solar is the cornerstone of most DER strategies, including those supported by policies in California, New York, and other states. Beginning in 2016, growth in the non-residential solar sector picked up, due in part to interest in DERs. This includes utility-driven community solar projects and utilities working to meet specific key-account, corporate customer needs.

According to Rocky Mountain Institute (RMI), utilities could add significantly to overall distributed solar growth. According to RMI, "Community-scale solar represents a substantial untapped market that could powerfully complement existing utility-scale and behind-the-meter solar market segments" (Brehm et al., 2016). The majority of these new, utility-driven projects would be in the 0.5 to 5-MW range. RMI believes this market potential could total 30 GW by 2020.

While the terminology can be confusing, RMI's definition of community-scale solar includes distributed solar developed for community solar programs *and* for the utility's overall resource portfolio needs. According to many sources, community solar program development presents opportunities that are especially strong. The Smart Electric Power Alliance (SEPA) reports that the market for community solar took off in 2016, topping 300 MW installed, with more than 300 MW in the pipeline. Over 170 utilities reported that they had active community solar programs by late 2016 (SEPA, 2017a). GTM Research, an arm of GreenTech Media, concurs: 2017 is seeing dramatic growth in community solar. GTM has predicted 400 MW of community solar in 2017 alone. Further, it cites statements from the National Rural Electric Cooperative Association (NRECA) that co-ops alone could account for more than 480 MW of community solar in the near future, outpacing GTM's already bullish market estimate (Trabish, 2017b).

The reasons for the dramatic growth of local, community-scale solar are varied. One driver is the growing segment of businesses that want to express their commitment to clean energy in a visible way. Another driver is a growing interest in broader solar access—e.g., using community solar in particular to extend the benefits that early adopters of rooftop solar have enjoyed to a broader cross-section of customers. And there is also a growing understanding of the strategic value of DERs, including solar plus storage and DR, to add integration value. Some commercial customers already grasp the benefits of using solar plus storage and DR to minimize demand charges on their bills. Utilities are responding, introducing incentives that insure more upstream load management and integration value—a utility/customer win-win. There is no single reason behind local solar market growth, but the numbers show a significant shift.

1.2 Solar Variability

The output of any PV system is inherently variable: Generation varies by season and time of day, and over much shorter intervals due to passing clouds and other weather effects. In each of these time domains, the variability of a growing solar resource can introduce grid operations, stability, and planning problems that require mitigation. Yet it has only been in the past five years or so that a significant number of utilities have been working to deploy better solutions than the "15 percent rule." By that outdated rule, utilities would arbitrarily close any distribution circuit to further solar development, once it reached 15 percent solar penetration.

Experience in growing solar markets shows that PV variability is not a major challenge at low penetration. Even at moderate levels of penetration, PV often claims capacity credit for reducing a portion of peak demand. This is especially true in regions where the peak is driven by daytime commercial air conditioning. Even as solar penetration rises, there are basic, proven ways to mitigate variability impacts. For example, geographic diversity—encouraging a wide distribution of solar installations rather than a few large systems in one place—greatly reduces the cumulative short-term swings in production and their impacts on the utility system. Better solar forecasting has a strong impact, not on changing solar variability, but on reducing the cost of dealing with it. Advanced inverters also have integration capabilities that barely have been tapped (Perez, 2016).

The type of solar variability that has garnered the most attention is the daily variation in solar output. The fact that solar output drops as load typically rises in the early evening has led utility planners to worry about a mismatch between generation and load during the day, especially as it occurs in the spring and fall, when solar generation is great but air conditioning loads are small. This mismatch is called the *duck curve,* based on a graph (Figure 1) in an early analysis by the California Independent System Operator (CAISO). Even with best-practice strategic solar design, which may include single-axis tracking and advanced inverters, the challenge of a rapid late-day ramp in customer load affects utilities that have significant amounts of solar on the grid. A related problem is the possibility that solar generation may be over-abundant in midday—especially during shoulder seasons of the year, when daytime loads do not reach peak conditions. As solar market penetrations rise, the duck curve is becoming a real, though surmountable challenge.

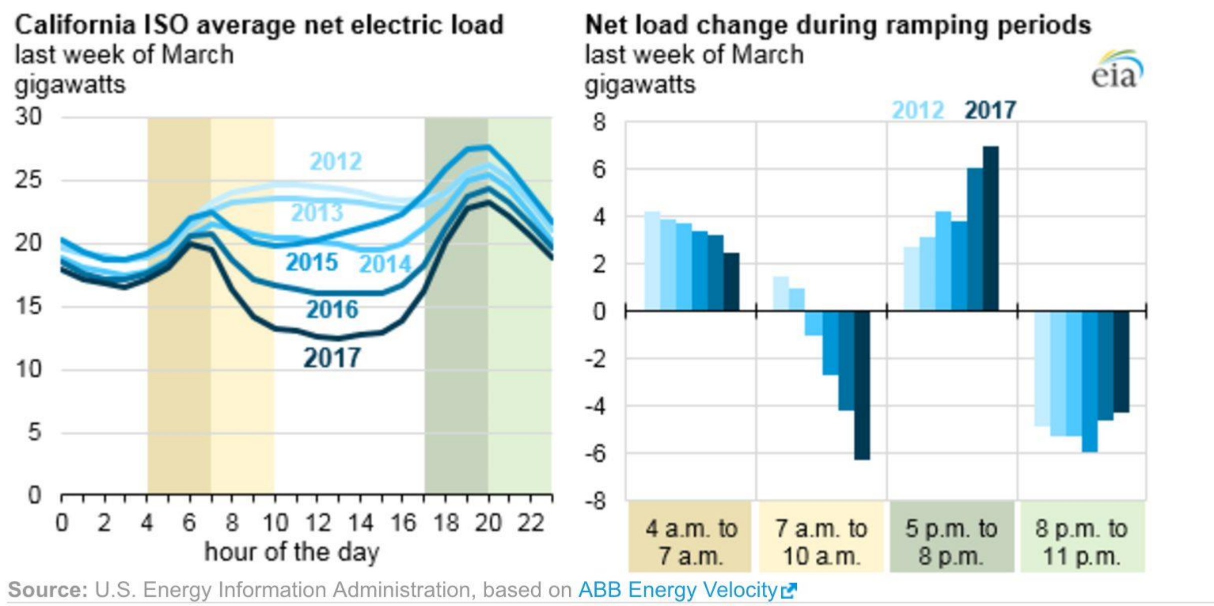

Figure 1. California ISO "Duck Curve" Documented by U.S. EIA, Spring 2017. Source: U.S. EIA, 2017.

As renewable energy penetration rises, the job of meeting customer loads—which are themselves variable—is becoming a complex series of trade-offs. Utilities wish to tap the value of solar and wind when available, while meeting the practical requirements of conventional generating systems and modulating loads through a growing range of technical, operational, policy, and customer-engagement tools.

Unless your utility is in a high solar-growth region—such as California, Hawaii, Massachusetts, New Jersey, North Carolina and Arizona—concerns about solar integration may not crystallize for some time. And even in these states, responsibilities are often shared with regional power markets. However, regional markets are already recognizing that the cheapest, surest way to avoid regional grid imbalances is to solve some integration problems *closer to the source*—at the distribution level. Solving integration problems locally is good for operations and risk management—and ultimately for improving customer satisfaction. The advice from utility planners who already have walked this path is clear: It is better to start early, to be ready when the inevitable need for integration solutions become urgent.

1.3 Storage in the Context of Community Solar

Community solar provides utilities with many benefits over typical customer-owned rooftop installations. Community solar projects are installed on the utility side of the meter. They are planned and built in close collaboration with utility resource planners, and their generation characteristics are fully visible to the utility. These facts alone offer the utility more flexibility in how to offset the variability of such installations. In addition, the utility can research the level of interest in community solar, long before construction and enrollment; hence, the utility can design the PV strategically and offer solar-plus companion measures, including storage, to add grid-integration value. Further, by promoting storage and DR along with a popular community solar offer, the utility can lower customer-acquisition costs for each offer and double or triple the value of each customer contact.

Community solar provides considerable economies of scale when compared to most rooftop-scale solar installations. With utility involvement, community solar planning also may be coordinated with the development and use of storage technology on the utility side of the meter, extending economies of scale to the storage proposition as well. Such solar-plus facilities may be planned to minimize interconnection expenses and delays and—sometimes—to add specific grid benefits such as enhanced reliability or upgrade deferral.

Behind-the-meter, customer-side storage may be supported by community solar. Opportunities for customers, working alone, to install storage and recoup their investment are limited. By contrast, a full-scale, utility-run behind-the-meter storage program can combine customer benefits (e.g., avoiding high time-of-use rates) with utility benefits (e.g., storage for emergencies or for more frequent load-control) and change the economic proposition from red to black. Customer-side storage technologies include options from thermal storage to small battery banks, which can be readily economic.

In these ways, local community solar programs represent a market-based laboratory for advanced solar integration strategies. Customer participation is voluntary, attracting the same customers who are interested in the range of technologies needed for the 21st-century clean-energy grid (Smart Grid Consumer Collaborative, 2015). A well planned community solar program can provide relatively low-risk benefits to customers, while reserving the likelihood that there will be lessons learned before storage and specific solar-plus options are rolled out at full market scale. In the context of a community-solar program, technical and program improvements are relatively easy to make. Well-reported news of progress only builds customer loyalty and interest in doing more. Community solar offers opportunities for meaningful customer engagement, technical and operational learning, and dialog with policy-makers about just where the path to the future should go. This guide will support utilities in any type of local solar-plus-storage planning, but the authors generally assume a community solar program context.

2 Solar Plus Storage and the Solar Triple Play

Energy storage and solar-plus have grown into a complex and promising industry in recent years, with technologies and investors ready to address a range of problems. According to GTM Research (GTM Research and Energy Storage Association, 2017), the conventional energy storage market, defined primarily by batteries, is set to grow 11 times over between 2016 and 2022—to about 2.5 GW. Leading states in the storage market include California, Arizona, Hawaii, Massachusetts, New York, and Texas, but this may change with shifts in policy emphasis, corporate leadership, and regional market demand for resilience. Dramatic price drops, characterized by a drop of more than 60% in lithium-ion battery costs since 2012 (SEPA, 2017b) continue to impact the market. Behind-the-meter storage is seeing a sharp rise, and may represent at least half of the storage market in coming years. Utilities are more likely to seek win-win solutions—working with customer-side storage—than they are to fight the trend.

Further, utilities realize that even with dramatic market growth, battery solutions alone may not may not be the answer. A DER approach—including generation and storage options that include batteries and more, with advanced control technologies and price signals for DR, plus energy efficiency and infrastructure improvements—holds the greatest promise for utilities that face high-renewables penetration in the foreseeable future. CSVP's market-based laboratory approach presents practical first steps for utilities to approach this complex and fast-changing market.

Beyond the option of working toward an integrated community solar plus storage program roll-out, utilities may see the entire distribution system or any operational subset (e.g., circuit) as their test bed for solar-plus-storage and triple play solutions.

Readers of CSVP's 2016 publication, the guide to *Demand Response Measures for High-Value Community Solar Programs* (Huffaker & Powers, 2016), will recognize that there is an overlap between strategies for energy storage and DR. Indeed, many DR programs have made use of some type of energy storage for many years, and many storage technologies rely on the same control options as DR. In practical terms, it is beneficial that some storage measures that use DR controls have already passed regulatory review, allowing their costs to be monetized. Notably, some storage resources are distinct from those typically used in DR programs, and there are intriguing approaches for combining such resources into a solar-plus-storage-plus-DR configuration. CSVP has called this the *solar triple play*.

CSVP favors a triple play strategy because combining solar, storage, and DR allows each of these resources to be put to its best and most economic use. In addition, new synergies emerge.

This guide gives relatively little attention to the most obvious solar-plus configuration: a large bank of batteries sited at or near a solar installation, which together serve a community solar-plus program. Field experience suggests that batteries are best used for purposes beyond smoothing the output from a single PV installation, so the benefits of taking a micro-grid or "virtual micro-grid" approach would be limited. Utilities that have co-located battery storage with solar so far have operated the storage components separately from any community solar offer that might exist.

One utility-led alternative: The solar-plus-battery installation could be operated to ease the peak-load burden on an entire circuit, taking into account supply and demand characteristics beyond those specifically tied to a particular solar plant. A circuit-scale design and operating protocol would be especially smart if the feeder were slated for a relatively near-term upgrade. In that case, the solar triple play also could provide grid benefits and possibly defer the upgrade. Moreover, if front-end cost were a consideration, program planners could eliminate the utility-side battery altogether, relying instead on customer-side batteries or other customer-side options.

A study recently completed by PNM Resources for CSVP (Hawkins & Sena, 2017) modeled a solar triple play scenario on a PNM feeder that needed voltage support. As modeled, the triple play strategy would not only resolve voltage problems, but it would also drive more cost-effective load-management, support local solar development, and open the way for the utility to promote clean electrification.

CSVP anticipates other program-design innovations, too, around this dedicated solar-plus-storage configuration. Yet these would most likely emerge from a customer-driven or third-party-driven effort to tap unique value streams—resilience benefits, near-zero energy development benefits, etc.

3 Utility Planning Process for Solar Plus Storage or a Solar Triple Play

The focus of this guide is a five-step process for designing a solar plus storage program. As noted above, this process applies whether or not the solar resource is presented to customers as a community solar program offer.

Figure 2 summarizes the steps recommended in planning a utility-driven solar plus program. They are comparable to steps in any utility program-design process, in which the early steps involve defining needs and opportunities, and the later steps involve ranking and then customizing viable solutions.

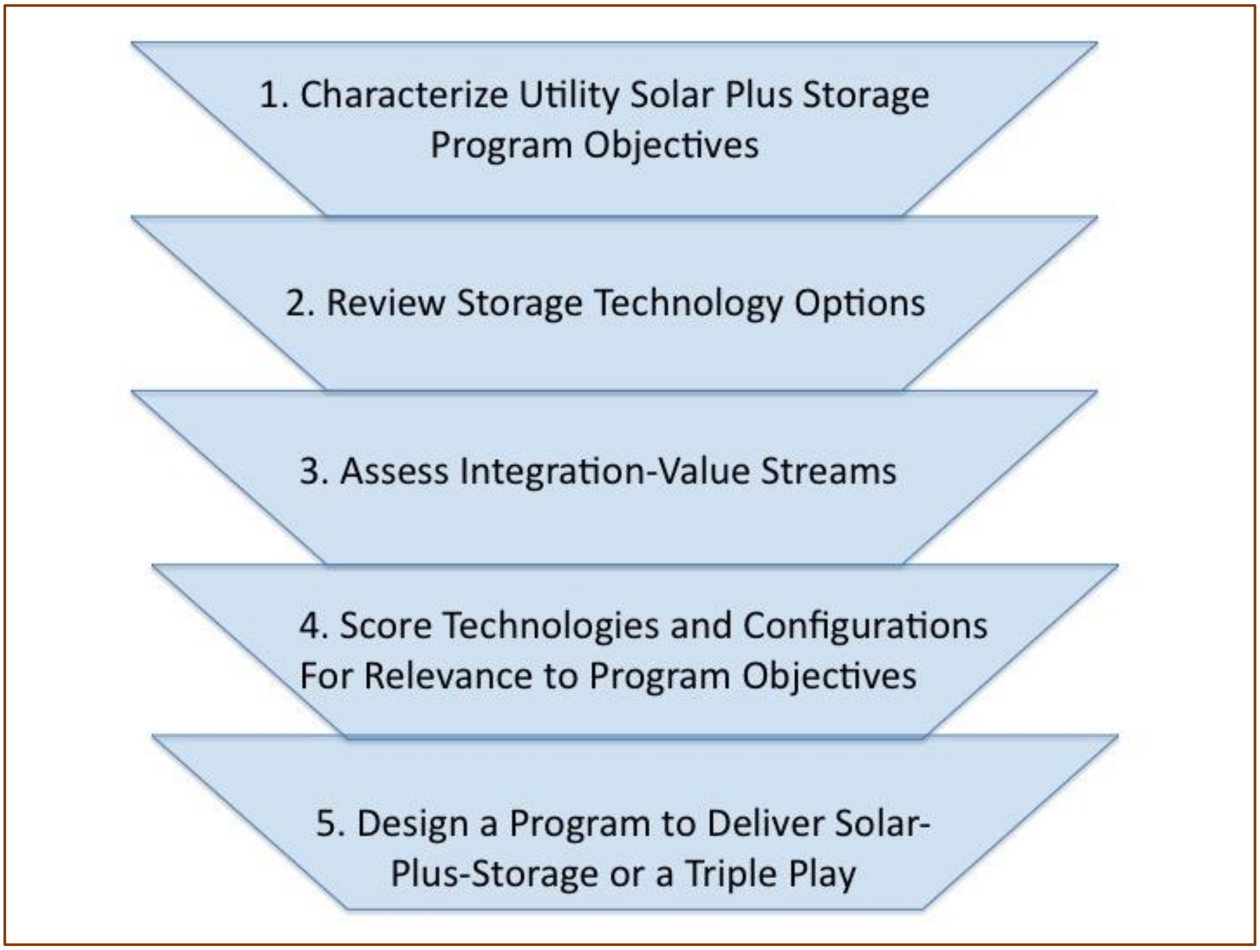

Figure 2. Utility Planning Steps for a Solar Plus Storage Program or Triple Play

Here, we briefly introduce each step in this process. Later, will return to the process in Section 8, where the information presented on different storage technologies, value streams, targeted configurations and program elements will come into focus for the utility's final consideration of program design and delivery.

1. Characterize Utility Solar Plus Storage Program Objectives. The list of possible program objectives is long, and it is divided by perspective, whether from the utility view or from the customer view. Within the utility category, these include needs to address system wide renewable energy penetration; to address renewables penetration on a particular circuit; to address local power quality problems; to respond to customer interest; to test storage configurations for technical and market-based applicability; to manage market risks from so-called grid defection, and to respond to emerging policies and regional markets (e.g., an ISO that will monetize some integration values). On the customer side, there may be specific reliability or power quality needs. More often, the need to deploy integration technologies arises from a desire to cut electricity bills, to take advantage of special incentives, to promote emergency service resilience, or to decarbonize energy used. Such needs may be important to the customer and to the utility, too, in light customer-satisfaction goals. Using CSVP program design process as a reference, check both utility-side and market-side perspectives. The utility planner should be able to answer the all-important question: *Why* pursue solar-plus at this utility today? With the answer in hand, the planner is more likely to gain all-important top-level support.

2. Review Storage Technology Options. Section 4 of this guide describes currently useful storage technologies, which are deployed on either side of the meter. Familiarity with the range of technical options and applications (e.g., the types of batteries and their merits; types of thermal storage and their merits) will give the planner a better understanding of which technologies belong in this utility's solar plus plan.

3. Assess Integration Value Streams. Section 5 of this guide describes integration value streams that drive interest in solar plus storage. These are divided between integration values that the utility can realize directly and those that are primarily realized by the customer. Examples include ancillary/grid services, delivered by the strategic use of storage technologies. Planners can assess which technologies tap which value streams, and under what market conditions. In this way, they can prioritize technologies for further consideration. Then, Section 6 is geared to help planners envision suitable deployment configurations. The five generic configurations discussed are differentiated by the location of solar and storage on the utility-side or customer-side of the meter and whether these technologies are operated independently or as one.

4. Score Technologies and Configurations for Relevance to Program Objectives. This step helps define which technologies would be most desirable for a given utility program. It offers two matrices for scoring value: one from the utility's perspective and one from the customer's perspective. If the utility plans to promote customer-side storage, then both utility and customer value streams are relevant. A supporting discussion focuses on understanding how utility assumptions might change outcomes. CSVP offers a sample assessment, using defined assumptions, but it also invites planners to make their own, customized assumptions, for their own program scoring.

5. Design the Program to Deliver Solar Plus Storage or a Triple Play. At this step, the planner may refer to the overall program-design process, which takes input from both the utility side and marketing side. Here, generic configurations become program *companion measures*. This section poses program-design questions that are especially important or unique to working with solar plus storage and/or DR. (CVSP refers to the latter, three-part combination as the *Triple Play*.) This guide does not provide detailed program design advice, but it will help planners to set the stage for program design success.

4 Storage Technologies for Community Solar Program Design

If deploying or evaluating storage as a remedy for renewables-related integration challenges is among top program objectives, then it is important to begin with an understanding of current utility system design and operations. Planners can achieve this best by working cross-departmentally and developing a collaborative understanding of solar plus storage project objectives. While cautious, distribution system engineers are interested in finding the most reliable and cost-effective ways to maintain and upgrade service, as local and regional energy markets continue to change.

This guide is written primarily for the non-engineer, but it can provide a common foundation of knowledge for cross-departmental and decision-level discussions related to solar plus storage planning. The focus is on readily accessible storage technology options, including options on either side of the meter:

- Utility-side energy storage options
    - Pumped hydro-power
    - Compressed air
    - Thermal storage
    - Flywheels
    - Stationary batteries

- Customer-side energy storage options: batteries
    - Stationary batteries
    - Smart electric vehicle charging

- Customer-side energy storage options: thermal storage
    - Electric water heaters, with storage and controls
    - Storage in thermal mass for space heating
    - Building pre-cooling
    - Ice storage for air conditioning
    - Cold water storage for commercial air conditioning
    - Ice storage for grocery refrigeration

Most utility-side storage and battery storage options convert electricity into various forms of potential energy (e.g., chemical energy in batteries) and convert it back to electricity at a later time. Thermal storage options store energy in either warm or cold mass, but generally cannot convert that stored energy back into electricity. (An exception might be high-temperature molten salts, being tested for centralized solar generation.) In addition, advanced chemical storage processes, including hydrogen storage, may become important in coming years, but these are not detailed in this guide. Each storage option discussed here includes a definition, brief review of technology variations, advantages or limitations and applications.

4.1 Storage in the Context of Strategic Solar

Some solar-design measures are aimed at achieving the same renewables-integration objectives as are achieved by stand-alone storage technologies, and projects can take advantage of solar-plus synergies by looking at options together. Note that some PV system-design options are suited for particular solar-resource conditions. In many cases, strategic solar orientation or the use of single-axis tracking systems can improve on-peak system performance. And most importantly, solar forecasting and smart inverters or advanced inverter design can add integration value—expanding the capabilities of a solar-plus configuration more cost-effectively than relying on batteries or other storage options alone.

Smart inverters have reactive power and real power functions. Their ability to address reactive power needs, in terms of VARs and power-factor correction, is among their most valuable attributes. Solar projects that use advanced inverters can provide very fast autonomous real power (e.g. virtual inertial response) or reactive power (e.g. voltage regulation) services, as fast as 50 to 100 milliseconds. These inverters, which are commonplace for new PV systems, have been under-utilized to address voltage and frequency issues and grid synchronization needs. This problem is more common for customer-side solar projects than for utility-side projects. In order to optimize inverter potential, customers would need to participate in a control strategy and be compensated for operations beyond simple kWh production. By contrast, the utility has easy access to inverter controls and a big-picture view of solar economics.

Smart/advanced inverter control in combination with advanced solar forecasting can change the economics for storage. Program planners are advised to work closely with utility engineering staff and qualified solar engineers in order to make sure that each technology in a solar-plus configuration is utilized to its best, most economic, advantage (Chakraborty, 2017).

4.2 Utility-side Storage Options

A sampling of technologies for utility-side storage are defined here, in order to familiarize planners with available options and for a local project or program. The majority of utility-side storage projects today tap battery options, for their widespread applicability and availability. However, it is important to recognize that many storage technologies are market-proven or in various stages of research and development today, as the field of energy storage gains global importance. Refer to *CSVP Resource Links for Solar Plus Storage* (Cliburn et al., 2017) for detailed research, after pre-screening storage options.

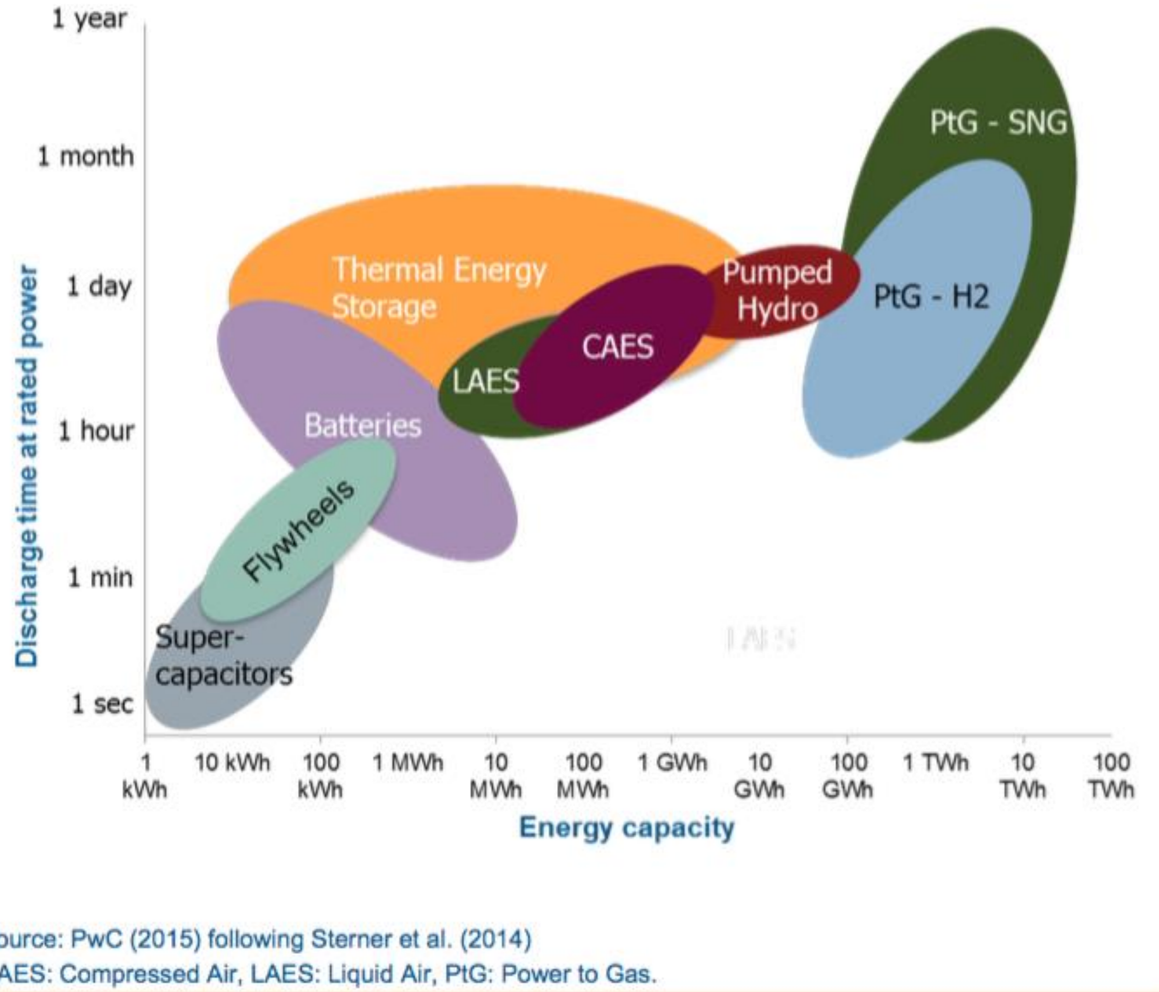

Figure 3. Utility-side Storage Options (World Energy Council, 2016)

Pumped Hydro-power

Pumped hydro-power (pumped hydro) stores energy by moving water uphill to a higher elevation. Pumped hydro installations include an upper and lower storage reservoir, a water turbine and piping and a control system. To charge the system, water is pumped from the lower to the upper reservoir, using the on-site turbine generators. To discharge the system and generate electricity, water is run downhill through the turbines, which are then run to generate electricity. The typical round-trip efficiency is 75 percent, although theoretical efficiency can be as high as 85 percent.

Pumped hydro has been popular because of its relative simplicity, low cost and use of well-established technologies. However, its potential for future development is limited. It relies on the presence of two large reservoirs, separated by suitable height. There are potential environmental issues with disrupting natural ecosystems to construct new pumped hydro installations. In some cases, modifications to existing reservoirs would be relatively simple.

Pumped hydro is currently the largest source of utility energy storage. In 2013 pumped hydro accounted for 97 percent of utility-scale energy storage in the US, totaling 21.6 GW of installed capacity (U.S. DOE, 2015). Examples of distribution-system pumped hydro projects are rare, but some exist in California, led by irrigation districts that have both water and energy needs (California Municipal Utilities Association, 2017). The concept of distributed solar plus pumped hydro was tested by the South San Joaquin Irrigation District nearly a decade ago. Traditionally, pumped hydro plants have been utilized to take advantage of seasonal or daily electricity price differentials, e.g., pumping to store energy at night and releasing water during peak hours to generate electricity.

Compressed Air

Compressed air storage involves using electricity to run air through a compressor and store it either underground or in pipes or storage tanks. Underground storage systems that use abandoned mines or caves are cheaper, but are dependent on suitable geology. To generate electricity, the air is expanded and heated and run through a turbine. The heat source is typically natural gas, although the waste heat from the compression process may be used. A significant weakness of compressed air storage is low efficiency, with current systems operating at 42-54%. German companies are demonstrating a high-efficiency, wind-powered compressed air storage system (Luo, Wang, Dooner, & Clarke, 2015), but commercial applications are not yet available in the U.S.

Flywheels

Flywheel systems store kinetic energy by using a spinning rotor of high mass, attached to a motor/generator. They draw power from the grid to increase rotational speed. Then the system is run in reverse to generate electricity, which slows down the rotor. Flywheels have fast response times and high power density. They also have long cycle life and good performance through the full charge cycle. They are attractive for short-term frequency regulation, and they are already in use by some industrial energy customers. However, they can lose up to 20 percent of stored energy in an hour and are not well suited for longer-duration energy storage, backup power, or residential applications (Luo et al., 2015).

Battery Storage

An electrochemical battery storage system typically includes the battery cells, a control system, and a power conversion system. The conversion system is needed to convert AC power from the electrical grid to DC power for storage in the batteries and back again. Solar-plus-battery applications can use direct DC to DC energy storage, but most are designed for the added flexibility of advanced inverters, which allow both grid-tied and islanded (off-grid) operations.

Several battery chemistries are used for grid storage. Table 1 provides a summary of these, plus their relative advantages and disadvantages for grid storage applications. Additional details on these battery options are provided below.

Table 1. Comparison of Battery Storage Options

Technology	Advantages	Disadvantages
Lead Acid	• Low cost • Mature technology	• Short cycle life(1) • Low energy density(2) • Poor operation at low temperatures
Lithium Ion (Li-Ion)	• High energy density • Long cycle life • Dominates utility-scale and behind-the-meter markets	• Require advanced control • High, though rapidly declining cost
Sodium Sulfur (NaS)	• High energy density	• Relatively high operating costs • Not easily moveable
Flow Battery	• High efficiency • Long usable life	• Relatively high cost • High complexity

1. Cycle life is a measure of the number of complete charge/discharge cycles the battery can handle before its capacity falls below 80% of its original capacity.

2. Energy density is a measure of the amount of energy a battery can store for a given volume, usually measured in kWh/L.

(Source: Hirtenstein, 2015)

Lead Acid batteries, commonly recognized as standard car batteries, are a very mature technology, advantageous for grid-scale storage due to their low cost. However, they have short cycle life and can have poor performance at low temperatures.

Lithium Ion (Li-Ion) batteries have gained favor in recent years due to their presence in consumer electronics and electric vehicles (EVs). They have demonstrated rapidly declining costs. They have high energy density and high efficiency compared to other battery technologies, but they need computer control systems to ensure safe operation. The high energy density of Li-Ion batteries make them ideal for mobile storage applications, to defer transmission and distribution system upgrades.

Sodium Sulfur (NaS) batteries use molten sodium and sulfur as electrodes. As a result, they have a high operating cost and are not easily moveable. NaS batteries have relatively high energy densities, making them attractive for space-constrained large-scale operations. NaS were an early battery-market leader, though their growth rate is significantly lower compared to Li-Ion (International Renewable Energy Agency [IRENA], 2015).

Flow Batteries are made of two electrolyte liquid tanks and operate based on reduction-oxidation reactions between the tanks. Unlike traditional batteries, these require no tradeoffs between energy density and power density; they are relatively easy to size optimally. Like electrochemical batteries, flow batteries can provide voltage support and peak shaving, and they can help with renewables integration. However, they are relatively high-cost and complicated, especially for smaller-scale, distributed energy storage purposes. The most common and mature flow battery is the vanadium redox battery (VRB). Luo et al. (2015) offers examples of their use for utility-scale renewables integration.

Emerging Technologies include high-temperature molten salt storage, which holds at more than 1000 degrees F. This technology is currently associated with very high-temperature concentrating solar collectors. Power to Gas (PtG or P2G) uses electricity—including solar generation where it is available—to create hydrogen by electrolysis. Stored energy in hydrogen has been the focus of a fuel-cell development push in recent decades.

Other emerging storage methods are similar to pumped hydro storage, as they use gravity to run electric generating turbines. Examples, ranging from electric storage trains that are run up a mountain when energy is cheap and released when it is needed, to elaborate lifts for rocks or other objects, have site-specific uses. Yet these remain out of reach for most distribution utilities that are interested in solar-plus strategies.

One very important consideration for planners who are working with storage options is that both technology assessments and market-based data are subject to change. This is especially true in the battery industry, where Li-Ion battery costs have fallen by more than 60 percent in 2012-16 and improved systems are constantly emerging.

In 2015, CSVP published a white paper intended to shake old notions that storage would remain technically and economically out of reach; two years later, that paper is out of date. GTM Research (Lacey, 2017) recently began to track this problem, which dramatically came into focus after the California Energy Commission (CEC) used data that were several years old for a current market assessment. Based on the past trajectory, it predicted *future* battery costs that are already available today. The future for batteries cannot be predicted based only on a straight-line projection of any one factor, such as increasing manufacturing output, but only on a detailed understanding of industry forces. This does not mean that investing in a battery-storage program or pilot today is a bad bet. Utility experience in solar and other rapidly developing markets suggests that early experience can be invaluable, providing a much-needed edge when the market suddenly takes off.

This same thinking applies to non-battery storage technologies. It is unrealistic and unnecessary to expect all future storage needs to be met with batteries. The cost and environmental risk to any utility of a batteries-only storage strategy would be very high. A combination of utility-side and customer side options, including battery storage plus thermal storage and other options, plus DR appears most promising for a renewable-energy future.

It is worth noting that, with the exception of pumped hydro, the majority of U.S. energy storage projects by capacity today are on the utility side of the meter, and the majority of those are battery storage projects. SEPA (2017b) reports that total energy storage capacity in 2016 was about 620 MW—about 500 of which were located on the utility side of the meter. Batteries accounted for more than 95 percent of utility-side storage projects at that time.

States that have been most active in promoting utility-side storage include California, Massachusetts, Nevada, and Oregon. Indiana, Ohio, Hawaii, and other states and territories also have provided recent, utility-led initiatives.

One project that has gained attention for its relationship to community solar is Austin Energy's distributed-solar plus storage pilot. For one aspect of the project, the utility received $1 million from the Texas Commission on Environmental Quality to help fund a 1.5-MW (3.0 MWh) Tesla battery system, co-located with a 2 MW community solar project. While community solar program participants do not directly support the storage project, the co-location of solar plus storage offers the utility a prime opportunity to explore solar-plus synergies. The project is aimed at achieving a full-system levelized cost of $0.14/kWh for distributed solar and storage.

In addition, Austin Energy received U.S. DOE SunShot funding to integrate a grid-scale battery with rooftop commercial and residential solar in a mixed-use development. The project is in early stage development (Spector, 2017a).

4.3 Customer-sited Storage Options: Thermal

Customer-sited storage options include primarily thermal storage and battery storage. Thermal storage itself is a broad category. These technologies typically transform electricity into heat energy (or, in turn, heat-to-cold) and store it at relatively moderate temperatures, which are ideal for customer-sited storage configurations. They typically involve hot water storage, storage of heat in rocks, bricks, and other thermal mass or some kind of chilled water or ice storage.

While this section is aimed at reviewing thermal storage technologies by themselves, these technologies require program infrastructure for delivery. Therefore, this section also previews program-delivery options.

Hot Water and Thermal Storage Units

Hot water energy storage is typically straightforward, using highly insulated electric resistance water heaters or boilers. A 105-gallon water heater can store the energy equivalent of 13 kWh of electricity at a fraction of the cost of any battery currently offered in the residential or commercial market (Little, 2016). With electric units holding an estimated 40 percent of the U.S. water heater market, the potential for hot water energy storage is vast. There are obvious limitations in transforming from electricity to thermal energy, but an aggregation of grid-interactive water heaters can provide services to energy, capacity, and ancillary/grid services markets. These units may tap different value streams; they are most often used for peak load shifting and easing a steep load-ramp, or for fine-tuned load shifting (arbitrage), frequency regulation or grid stabilization.

Some water heater units are manufactured expressly for storage functions. In addition to bi-directional controls, these systems feature mixing valves to ensure that the water temperature remains consistent at the point of use. Market leaders include Steffes Corporation, which has worked extensively in the electric cooperative market, and Vaughn Thermal Corporation.

This segment of the water heater industry touts *community storage* as a natural corollary to community solar. Some providers have innovated finer, faster DR controls, which capture grid-integration value beyond simple load-shifting. The technology may be applied to new GIWH units and to existing units, as a retrofit with bi-directional control technology. Most use secure internet protocol (IP) communications, some replacing a previous generation of radio-controlled units. For example, Mosaic Power has been controlling water heaters in homes and low-income housing to participate in PJM's frequency regulation market. Other manufacturers in the field include Carina, Power Over Time, and Sequentric (Podorson, 2016).

Case studies to review include the PowerShift Atlantic project in eastern Canada, recent deployments by Hawaiian Electric in West Oahu and the various initiatives the Bonneville Power Administration and Great River Energy, a cooperative G&T. For example, Great River Energy aggregates 65,000 water heater storage units to store a gigawatt-hour of energy, on average, every night (Grant, Keegan, & Wheeless, 2016). While the majority of the energy stored is generated by wind, at least two GRE distribution co-ops have launched programs that incorporate community solar plus water heater storage.

One challenge to this strategy is simply that electric resistance water heating has been more expensive to operate than fossil-fueled alternatives. If natural gas is available, net costs must be compared. Environmental impacts depend on the source of the electricity generation that is being stored. In a growing number of cases, night-time wind generation is stored and environmental results are favorable (Hart, Miller, & Robbins, 2016). Controlled electric water heating is considered a promising clean electrification option as renewable energy penetration continues to rise.

Notably, in regions where radiant floor heating or ground-source heat pumps are popular, boilers and heat-exchange systems may be adapted for whole-house heat-storage applications. In addition to using water, other types of thermal mass may be used. Electric Thermal Storage (ETS) units have a footprint similar to large space heaters and have been marketed for decades as an off-peak heat storage option. Electric cooperatives have been at the forefront in promoting these systems for load management; new grid-interactive control systems may spur a resurgence in these markets.

Pre-cooling and HVAC Control in Buildings

A simple example of thermal storage is using air conditioners to pre-cool buildings. Buildings can be programmed to turn on air conditioners before the peak hours of the day, so that air conditioners do not have to run as much later, during steep ramping or peak hours. A number of utilities, including CoServ, a Texas-based cooperative G&T,

have paired smart-thermostat controls with the concept of solar load management. CoServe simply encourages rooftop solar customers to use off-the-shelf thermostats, controlled with the help of their DR services provider, Enernoc. The strategy is aimed at easing the steep ramp in afternoon load, when the solar resource begins to subside (Cliburn, 2017).

More refined pre-cooling strategies are integrated with high-efficiency building architecture. For example, the addition of thermal mass in walls, floors, etc., supports thermal storage while easing temperature swings. Depending on building characteristics, pre-cooling may reduce total energy consumption, because it reduces the air conditioner run time at higher temperatures and lower efficiency. New systems, including both building elements and equipment innovations, are still in development to achieve both maximum peak load shaving and energy conservation (German, Hoeshele, & Springer, 2014). Because HVAC-related energy storage has typically been addressed as a DR strategy, CSVP refers readers to its guide to *Demand Response Measures for High-Value Community Solar Programs* (Huffaker & Powers, 2016) for more details.

Cold Water or Ice Storage

Similar to heat storage, water- or ice-based storage systems work by using electricity to chill or freeze water during off-peak hours. Like GIWH, these units may tap different value streams, including peak load shifting and easing steep ramping, fine-tuned load shifting (through a fleet strategy), and frequency regulation. Cold water and ice technologies are limited by their capacity to store "coolth." Once the water reaches a freezing point, there are significant energy storage benefits in phase change, but to increase storage capacity beyond that, the logical option is to store yet more ice. Residential units in particular are limited by size. The impacts of frequent control operations on system compressors present some limitations, too, but at least one manufacturer addresses this issue by delivering aggregated fleet services, instead of controlling each unit separately.

New ice storage technologies, including residential-scale systems designed to work with low-profile heat pumps, are coming on the market today. After many years of slow growth and incremental technology improvements, markets for residential and commercial ice storage and chilled water storage systems in commercial buildings are expanding. Market leaders include CALMAC and Ice Energy (Trabish, 2015). For example, in early 2017, Ice Energy announced a program with Southern California Public Power Authority (SCPPA) to provide ice storage at 100 homes, with the same impact as a 1-MW battery storage unit (Hutchins, 2017).

Ice storage for grocery refrigeration is a particularly promising application, forming the basis for potential commercial-sector solar plus programs. Refrigeration can account for up to 60 percent of the total electricity usage of a supermarket (Wesoff, 2017). A relatively new company, Axiom Exergy, has developed an ice storage system that can provide more than 1,000 kWh of storage. Each installation can shift six hours of refrigeration load from one period of the day to another. When scaled to a major grocery chain in a large service territory, this can add up quickly. This approach holds promise for load-shifting, including relatively long-term storage and hourly shifting, though it has not been marketed as a source of ancillary grid services.

4.4 Customer-sited Storage Options: Batteries

Behind-the-meter battery storage was almost non-existent a decade ago, but is fast emerging for residential, commercial, and industrial customers today. Vendors, including STEM, Tesla, Sonnen and dozens of others now offer systems to capture value streams including renewables integration, demand-charge management, DR and resiliency. Most of these systems are geared to commercial customers that pay high demand charges and can access other incentives. Commercial solar markets are especially poised to benefit. Affordable battery storage systems (possibly in combination with DR) attack the barriers presented by commercial rate structures, which feature relatively lower energy rates and high demand charges.

While the promise of batteries has long been discussed, the market was largely transformed in 2015, with the introduction of the Tesla Powerwall—a 6.4-kWh lithium-ion battery system that was within reach of many residential and small business users. The Powerwall Model 2 was released in 2017, with twice the capacity. In 2016, Tesla introduced a similar product, called the Powerpack, for C&I customer markets.

The majority of customer-side battery systems rely upon lithium-ion technologies. There are differences among brands, including the convenience of mounting and controls and use of organic versus inorganic cells that affect the level of battery toxicity. Of other battery technologies, lead-acid products are losing market share, while flow batteries are on the rise. The vanadium redox flow battery (VRFB) is often cited as the most promising of these. As its costs decline, its operational advantages, including cycling flexibility, will be better demonstrated in the market.

According to SEPA's 2017 Utility Energy Storage Market Snapshot, eight percent of utilities currently have some kind of behind-the-meter battery storage program for residential customers, and slightly more have programs for non-residential customers (SEPA, 2017b).

While this section is primarily focused on reviewing viable storage technologies, it is helpful to preview how each technology, and especially battery technologies, performs in a program context. Relevant integration value streams are discussed in Section 5 of this report, but it is worth noting that batteries are often considered the standard by which other storage devices are measured for their load-shifting and ancillary/grid services value.

For example, Green Mountain Power (GMP) in Vermont led the customer-side battery market, when it first offered Tesla Powerwalls to its customers through a one-time purchase option or a low-cost financing plan. In 2017, that program was updated, with price cuts derived from improved battery capacity and energy output, along with the use of control software developed by SolarCity to help provide grid benefits. The cost is now $15 per month per unit. GMP allows customer control for backup energy in case of an outage, but controls the units at other times and aggregates their integration value. Grid services include dynamic capacity, meaning energy reserves that can be dispatched when they are needed most, plus arbitrage sales into the New England electricity market (Walton, 2017).

A solar-plus battery storage project is under development in Prescott, Arizona, using Sonnen battery technology. Homes in this near-zero energy (NZE) community are super-efficient and fitted with appropriately sized solar arrays. Batteries allow homeowners to take advantage of a new pilot rate from Arizona Public Service designed to incentivize peak demand reductions and to promote DER integration. The rate includes a per-day service charge, plus a high demand charge, matched with very low per-kWh pricing. Customers that have solar plus storage and EVs are well-positioned to benefit. In addition, control systems draw this subdivision into what Sonnen calls a virtual power plant model. However, the solar-plus developer and the utility have not yet come to agreement on how to monetize available, aggregated grid services (Spector, 2017b).

Other storage companies offer similar services in the international DER arena, including Sunverge, a U.S.-based company that recently struck a deal to provide large-scale customer-side battery deployment in Australia. Sunverge has a commercial battery system of its own, but also has begun to provide control services across battery platforms.

California has been the site of several customer-side storage programs, administered in whole or part by the state's leading utilities. For example PG&E's Supply Side Pilot (SSP) has tested integration and participation in the market for load reduction and shifting. In particular, stationary and EV battery storage have been tested with customers who are on solar net energy metering (NEM) rates. A related Excess Supply Pilot (XSP) is predicated on the notion that when excess generation from solar and wind drives prices lower, storage devices can capture value by charging during low and even negative price periods. This pilot uses actual price signals, but the resources are not bid into the CAISO market, inasmuch as market mechanisms are still being developed (Anderson & Burrows, 2017).

The California Self-Generation Incentive Program (SGIP) was established in 2001 primarily to incentivize commercial-scale, non-utility renewable energy projects, but in recent years the focus has shifted to energy storage. In 2017, several rounds of SGIP funding, totaling almost $600 million, were approved through 2019, with 80 percent allocated to funding energy storage. The focus is on commercial-scale storage greater than 10 kW, but 13 percent of total funding is allocated for residential-scale projects of less than 10 kW (Center for Sustainable Energy, 2017). Applying the investment tax credit and the SGIP rebate can cover nearly the full cost for a typical residential system.

Because the battery storage program is being implemented in tandem with new time-of-use rates—a strategy out of the DR playbook—these new California programs may be considered the first market-scale implementation of a storage plus DR strategy. In the presence of customer-side solar, it represents what CSVP has called solar-plus triple play.

The CSVP's primary utility partner, the Sacramento Municipal Utility District, has committed to a new community solar development plan, which pairs TOU rates with community-solar participation. That utility also has plans to encourage use of battery-powered EVs for at least one targeted community solar program option.

Hawaii is also pairing TOU rates with community solar through its Community Based Renewable Energy (CBRE) plan (Trabish, 2017a). Hawaiian Electric is also promoting customer-side energy storage options, through its customer self-supply program. That program incentivizes customers that do not export electricity to the grid. Other states that have developed incentive programs for customer-side storage (not necessarily paired with renewables) include Massachusetts, Nevada, and New Jersey. Readers are advised to check the current status of these state-funded programs.

While lithium-ion batteries receive most of the attention, developers of other chemistries and technologies are also developing innovative solutions. Utility planners may familiarize themselves with different battery technologies and how they address different capacity and cycling needs.

Electric Vehicle Battery Storage

In October, 2017, General Motors (GM) announced an accelerated transition to an all-electric fleet. It will begin with at least 18 new all-electric models, introduced by 2023. This puts the U.S. auto industry leader on track with car-makers in other countries, like France and the U.K. (and more recently, China), in aiming to get gasoline and diesel engines off the road by mid-century. The trend may have political undertones, but the overtone is purely business. According to *Forbes*, "Sales of EVs in China are forecasted to grow 30% to 680,000 units in 2017, with a 46% increase projected for 2019" (Perkowski, 2017). Driven by the need for standardization in the global market, the auto industry worldwide is expected to turn out 14 million EVs annually by 2025. When it comes to electric vehicles, China's market power is turning the globe.

The development of EVs could be a huge problem for U.S. utilities, or—if managed well—could be a game-changing benefit. For example, SMUD recently commissioned a grid study that assumed little control over its burgeoning EV fleet. It estimated that the impact of unmanaged EV charging, just in terms of the need to upgrade distribution transformers, could cost the utility some $90 million. However, SMUD and other utilities nationwide are pursuing research and planning, so they will not be caught off-guard by the EV boom. A 2017 SEPA survey indicated that about 70 percent of utilities already engaged in some type of planning or preparations to manage EVs (SEPA, 2017b).

The national energy labs also have provided in-depth collaborative research and strategic innovations. The National Renewable Energy Laboratory (NREL) has developed a portal for utilities seeking cutting-edge information on vehicle-to-grid technology solutions (https://www.nrel.gov/transportation/project-ev-grid-integration.html).

Currently, most EVs do not allow for discharging their batteries back to the grid. But over the long term, properly integrated EVs can provide substantial grid benefits. For example, a recent U.S. DOE inter-lab collaboration, called INTEGRATE, illustrated the potential for V2G performance, modeled on a utility that generates half its electricity from renewables (NREL, 2017a) One modeled scenario, calling on three million EVs, with 50 percent optimized charging, indicated the following potential benefits:

- Over $300 million in grid savings
- Reduced electricity costs by as much as 3%
- Reduced peak demand by 1.5%
- Reduced grid-related CO_2 emissions by 1–4%
- Reduced renewables curtailment by 25%

Efforts to capture integration value from EVs on this massive scale are in the earliest stages. In the meantime, many utilities have found that it is not too soon to learn how to manage EV batteries. They are promoting smart-charging, using TOU rates and deeply discounted real-time pricing and testing convenience measures, such as midday park-and-charge discounts at solar-shaded locations, in order to engage with customers on the challenge of creating an electric vehicle win-win.

5 Integration Value Streams

The previous section referred to the grid-value of various storage technologies; here we define some of the specific value streams that utility- or customer-driven solar plus storage projects can tap. A *value stream*, if monetized internally or through a grid-integration market, is a benefit that can drive technology investments and use. In some markets, such as California, the idea that the availability of a value stream can help build a case for technology use has spawned yet another term, *use cases* (Fortune, Williams, & Edgette, 2014). Terminology choices aside, integration value streams are typically derived from load shifting, distribution upgrade deferral, ancillary/grid services, customer demand-charge management, back-up power, and so on.

A subsequent section of this guide discusses how these value streams are realized in various solar plus *configurations*. A configuration includes a technical layout and also a depiction of the flow of benefits, including utility and/or customer benefits.

As the discussion is geared primarily for program planners, it takes an introductory tone. The CSVP anticipates that this guide will facilitate better cross-departmental discussions, as local utilities strive to solve renewables-integration problems near the source, on their own distribution grids. Planners also may gain a baseline understanding for working with market-level (e.g., ISO) engineers, storage product providers, and third-party grid-service aggregators. The documents and websites recommended in *CSVP Resource Links for Solar Plus Storage* (Cliburn et al., 2017), as well as the sources referenced here, will be useful to those requiring more detail about integration challenges and solutions.

Storage projects today generally fall into two categories: those driven primarily by utility value, and those driven primarily by customer value. There is overlap—especially for customer-side storage that is utility-controlled. For the sake of discussion, we treat the utility-side and the customer-side perspectives separately.

5.1 Value Streams from the Utility Perspective

This section reviews value streams that support grid integration. Engaging these value streams typically lowers the cost to operate the grid and to provide consistent service, even as market penetration of variable renewable resources increases. Figure 4 offers one perspective on the defining characteristics of common grid-integration strategies. In general, ancillary service responses are quicker and more frequent; load shifting to address daily or seasonal peaks, ramping and emerging duck curve issues are fairly long-duration events. They may be somewhat frequent (e.g., daily load shifting) or infrequent (e.g., shifting to correct a forecast error). In each case, deploying grid-integration strategies taps a corresponding value-stream.

While storage is a promising grid-integration tool, utility system engineers are developing multiple possible solutions for some grid-integration issues. In coming years, these may reduce the need to use storage for some ancillary/grid services. Yet, other storage applications are likely to increase in value, as utilities integrate more and more variable renewable resources to the grid.

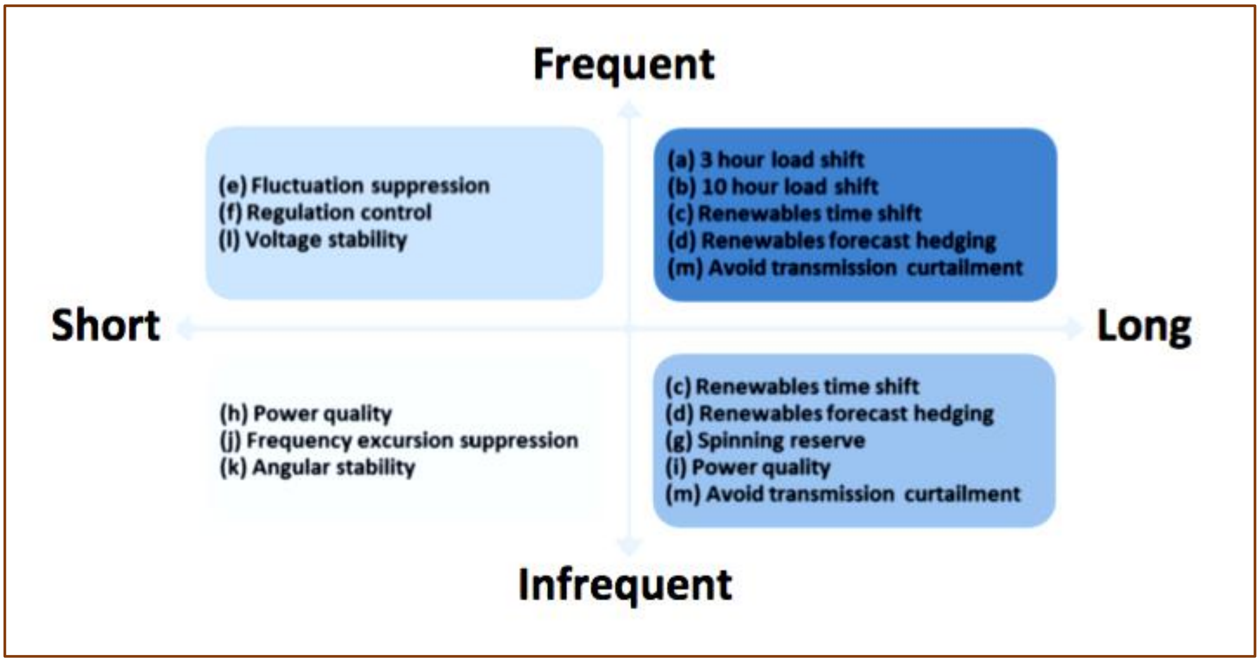

Figure 4. Examples of Utility Storage Capabilities, Considering Response Time and Frequency (Source: Carnegie, Gotham, Nderitu, & Preckel, 2013)

Load Shifting and Arbitrage

As the penetration of distributed solar increases, utilities anticipate challenges in actively balancing supply and demand. A utility can use solar-plus technologies to store energy produced during periods of low demand, and then use that energy during periods of high demand. Generally, prices track demand, so the technical benefits of smoothing the load curve are accompanied by economic benefits. When utilities or third-party aggregators gear the use of different generation and DR or storage strategies primarily to market price signals, the practice is called *arbitrage*—the simultaneous purchase and sale of an asset to profit from a difference in the price.

When storage has been used in the past, it has typically been to charge a battery or other storage device at night, when the predominant generation (nuclear and coal) would have low marginal cost, and then to release that energy in the afternoon, when prices peak. This approach is used in regions with high wind penetrations, where wind generation is usually greatest—and cheapest—at night. The approach could be adapted to store energy at any time when it is abundant and relatively cheap, so it could be discharged when supplies are short and prices are high.

It is important to note that load shifting has valuable indirect benefits to the utility, too. By balancing the system, storage technologies can help reduce the utility's allocated obligations for spinning, supplemental, and replacement reserves. According to one report by R.W. Beck, "Such reductions may permit the utility to avoid or defer the installation of reserve capacity to be provided by future generating resources, or may permit the utility to sell its surplus reserve capacity, or reduce its transmission service reservation and associated reserves if it is purchasing these reserves through a transmission tariff" (Beck, 2011). In general, a utility with well-managed, relatively level loads on a daily and seasonal basis would experience fewer and less costly operational challenges. This includes conventional load shifting during rare, but critical events, when utility system reliability is at stake.

Yet, increasing renewable-energy generation complicates grid operations. Rising solar penetration has already begun to impact California, Hawaii, pockets of the Southwest, and other regions in the U.S. and Europe. In these regions, solar production in the middle of the day can exceed demand. The result is depressed midday wholesale energy prices and increased the need for flexibility. This problem can be severe in so-called shoulder months, such as March and April, when solar generation is strong, but air conditioning loads are small. Indeed, the California Independent System Operator (CAISO) reported wind and solar curtailment of over 80 GWH per month in March and April, 2017 (CAISO, 2017). Storage may be used to absorb excess solar production midday and release it in the early evening, as loads increase and prices rise.

Ancillary Services or Grid Services

The Federal Energy Regulatory Commission (FERC) defines ancillary services as *services necessary to support the transmission of electric power from seller to purchaser, given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system*. The term *grid services* is a bit broader, referring collectively to services that a regional grid operator or a local utility operator can provide, as it orchestrates the use of generators and DERs and flexible loads (including DR) to keep the power grid stable, reliable and economically efficient.

Ancillary/grid services have traditionally been provided by fast-acting generation resources, such as hydroelectric plants or gas turbines. While all utilities must provide these services, a few regional markets, led by PJM in the Northeast and the CAISO in the West, allow DERs and DR to monetize ancillary services. A Grid Modernization

Consortium, led by the U.S. DOE and the national energy labs, is currently establishing methods and metrics for valuing grid-service DERs and flexible load strategies. The task is challenging because of differences in scale, operation, and especially synergistic impacts when working with solar-plus configurations. Yet market experience has been instructive, too. Utilities that never set a precise value on frequency or voltage regulation or other grid services have been quick to recognize that there is value in balancing their systems, even before they look to a regional market for solutions.

Advanced Inverters and Engineering Solutions Also in Play

A study of resilient and self-healing grid design and operation is beyond the scope of this guide, but storage planners must work with their engineering departments to be sure that predicted grid issues are being addressed in the most cost-effective and strategic manner possible. For example, the use of solar forecasting and smart inverters can address some solar integration issues and ease the way to more cost-effective solar fleet management. Solar program managers can insure that engineering staff are aware of these options. Conversely, solar and storage planners will sometimes find that a standard grid solution is best. In one case, the CSVP worked with PNM, in New Mexico, in modeling the use of solar plus customer-side storage, as it would address a circuit-level voltage issue. Staff engineers knew that relatively low-cost capacitors were the immediate solution, but modeling also indicated that a solar plus strategy could resolve the issue (Hawkins & Sena, 2017). Cross-departmental planning might weigh the merits of looking for a similar opportunity to engage customers in a solar plus solution, where the wires solution could still be held for later use. Today, grid planning and operations is exceedingly dynamic, and utilities need to be prepared for all kinds of supply- and demand-side shifts, over numerous time horizons.

Ancillary services that storage generally addresses include

- **Voltage Regulation.** Storage can be used by utilities to provide extra power to the grid to reduce voltage sags and spikes. Voltage management includes fast response (typically less than 1 second) with reactive and real power, as well as preparing grid systems to minimize voltage problems and respond.
- **Frequency Regulation/Response.** Storage can provide automated power output to help maintain grid frequency, until dispatchable loads that perform this service routinely can come online. Many generators are set to automatically control for real-time balancing of supply and demand. However, this reduces system efficiency and increases equipment wear and tear. Further, generators alone may not respond fast enough to the signal. Regulation response typically must be fast, in a matter of seconds. Several types of storage can provide fast response as needed. While this market is not yet mature, there is potential for the regulation/response market to grow, to compensate for increasingly variable generation.
- **Spinning and Non-spinning Reserves.** Storage can supplement or replace spinning reserves that are operating at partial load, ready for a fast ramp-up as needed. Further, non-spinning reserves typically turn on and respond within 10

minutes. This reduces the wear-and tear on thermal generators, and it can reduce the need for little-used and often inefficient generators to be kept as reserves.

- **Black Start Support.** Storage—and especially utility-side batteries—can provide the initial power needed to get generators online, in the case of an outage that cuts off all power.

Strategic utilization of storage includes planning for which value streams to address, given that each technology and each configuration has limitations. Yet solar plus DER strategies tend to be flexible, so they may be designed on the basis of one application or value stream, and then be repurposed if a different one is more compelling.

Distribution Upgrade Deferral

This value stream derives from the ability to eliminate or delay upgrades of the utility's transmission or distribution (T&D) infrastructure. Currently, there is increasing strain on T&D systems due to aging infrastructure, pockets of increasing demand, increasing distributed generation, increasing needs for reliability, and other factors.

In addition, in areas of high distributed solar penetration, the distribution grid must accommodate large power flows from distributed solar during the afternoons and then reverse that flow as evening approaches, when solar output drops and demand increases. Supporting large bidirectional power flows could require costly infrastructure upgrades. Localized storage can reduce grid congestion and correct related power quality problems *near the source*, meaning nearer to the customer load. Even delaying the need for an expensive upgrade by one year can be sufficient economic justification for integrated DER solutions—especially solar plus storage.

Utilities are still gaining experience with distribution upgrade deferral, leading some utilities to take a conservative view of deferral value. As one solution, members of the CSVP team have suggested a discounted deferral strategy, assuming that for any set of proposed solar plus deferral projects, some percentage will be successful (Bourg, Cliburn, & Powers, 2017). As utilities gain experience with solar plus storage and DR strategies, they will get better at selecting and implementing deferral projects, so the percentage of successful projects will increase, along with accepted deferral value.

An emerging value, which may be considerable, is related to portability. Some battery storage systems are mobile, meaning they can be relocated to strained parts of the distribution system to provide the greatest value in upgrade deferral. Some distributed-solar products and installation methods have been tested for portability value as well, with limited success to date.

5.2 Value Streams From the Customer Perspective

Here, we address value streams for energy storage that primarily benefit the customer. These value streams typically lower customer electricity bills, provide backup power or additional revenue streams for better project return on investment. Some apply well to solar plus storage configurations. Some address needs of residential customers, while others address commercial and industrial customers.

Demand Charge Management

Most large commercial and industrial utility rates include a demand charge, usually based on the greatest load requirement the customer imposes during any one 15-minute interval per month. Behind-the-meter storage systems can be used to reduce these demand charges. For example, batteries may be controlled to store energy at low-cost times and to discharge them during peak hours. Today, most residential customers do not pay demand charges, but TOU rates and load management incentives are common. Some utilities also foresee introducing residential demand charges as rate structures evolve. Note that demand charge management also benefits the utility. Achieving a more predictable load curve, where large customers contribute less to system peaks can ease wholesale capacity requirements and reduce utility system operating costs.

Managing Costs under TOU Rates

For customers on a TOU rate schedule, storage can be used behind-the-meter to manage costs. This practice of customer-driven arbitrage has been available for decades; Consistent benefits for utilities and customers have been documented across more than 30 TOU pilot projects in the U.S. and abroad (Faruqui, Serguci, & Schultz, 2013). With appropriate automation, solar plus storage or solar plus DR can capture this value stream. Notably, community solar pairs well with TOU rate arbitrage, as illustrated by new programs in Hawaii and California.

Power Quality

Customer-side storage may be used by commercial and industrial customers to improve power quality, through power factor correction and by eliminating voltage sag. This can be important in avoiding power factor charges and maintaining operation of critical equipment, which requires performance in a tight range of voltage to operate smoothly. The utility may provide incentives for additional customer-side power quality measures, in order to increase its value streams for ancillary services, distribution upgrade deferral, etc.

Back-up Power and Resilience

Local storage can provide backup power during grid outages. This could be at the individual customer level, if each has its own storage system, or at a community level using a shared storage system. When back-up batteries or solar plus battery systems are used, they often provide power only to critical loads (e.g., refrigeration, communications, emergency lighting), in order to maintain cost-effectiveness. A solar plus project might be designed primarily for resilience, but also to allow the project to regularly tap grid-integration value streams—or vice versa (Simpkins, Anderson, Cutler, & Olis, 2016). The utility may incentivize participation with a larger aggregation of customers, in order to tap ancillary/grid services markets, as well as reliability-related value streams.

Micro-grid Service

When solar is paired with storage in a local or stand-alone micro-grid configuration, it can serve some or all facility loads without regular utility service. Alternatively, a micro-grid could be grid-tied, in order to provide services to the grid or to rely upon the grid, using special pricing that reflects its burden or benefit. A solar micro-grid could charge storage batteries or other devices during the day and discharge at night. Grid islanding could be achieved for critical loads, or household-, facility- or community-level service.

Zero Net Energy (ZNE)

Houses or communities with solar could achieve zero net energy (ZNE) status or certification if the total amount of energy they consume is less than that which is produced by integrated solar PV. In some cases, ZNE guidelines allow the customer to use net metering on the grid as a virtual storage strategy. In most cases, customer-side battery or thermal storage are the preferred options, with storage located on site at the household or community level. ZNE certification is strictly voluntary in most states. However, California has a goal for full compliance with ZNE in residential new developments by 2020. All commercial development and half of existing commercial buildings in California must achieve ZNE by 2030.

Ancillary- or Grid-Service Markets

In some regions, customers with storage systems or solar plus storage configurations can tap markets for grid services, usually with the support of a utility or third-party aggregator. This is true for customers in certain wholesale markets, if the DER assets are properly monitored and controlled. For example, in the PJM region, customer-side storage with fast-response control technology can participate in the ancillary/grid services market for regulation.

Storage may also be compensated in some wholesale markets for its capacity contribution towards meeting peak demand, as well for meeting expected flexible resource adequacy. The latter use case is currently in play in California, with other regions assessing CAISO market outcomes. Utilities that are interested in learning more about these opportunities may wish to review the services provided by third-party aggregators, as these utility partners currently hold the most market experience.

6 Solar Plus Storage and Triple Play Configurations

A planning step closely related to the choice of storage technologies is the choice of a configuration that puts solar plus storage in play. A configuration typically includes a technical layout and also a depiction of the flow of benefits, including utility and/or customer benefits. For example, in a configuration that features customer-side thermal storage, the customer might enjoy special rates or incentive payments. There may be utility benefits as well. Those might include customer satisfaction, customer retention and (depending on the market structure) lower wholesale costs, greater reliability, grid integration benefits, and so on. When a value stream is monetized by the wholesale energy market (e.g., the CAISO), benefits are accrued by the customer, and also by the third-party aggregator and, in most cases, the utility.

Utility-side storage configurations include those where the storage is provided by the utility and directly integrated into the grid. Only one utility-side configuration is described here, because it is most applicable to a community solar plus strategy. Subsequently, we review configurations where one or more technical components are located on the customer side of the meter.

6.1 Utility-Side Solar Plus Storage

Here, both the solar array and energy storage (typically batteries) are directly integrated into the grid, as shown in *Figure* 5. If this were a community solar project, participants could hold a share of the output from the solar plus project, or the project could track benefits of the solar and storage aspects separately. The configuration in Figure 5 shows the option for customer-side electric vehicle charging, but that is not a core element for this model.

In another variation on this configuration, similar to a community solar plus model currently piloted in Austin, Texas, the utility offers customer participation only in the community solar portion of the project. It owns and operates the storage portion of the project separately, to benefit all customers.

This configuration is typically developed so the utility can capture value streams, such as intra-day load shifting for daily peak reduction or shoulder-season management of the duck curve. If located on a stressed circuit and properly sized, this configuration can help to provide voltage support and, if properly controlled, could provide other integration services to the utility.

From the customer perspective, this configuration is well suited to a ZNE community. CSVP has worked with SMUD to develop this a version of this model for possible implementation as an alternative for ZNE community development, where siting individual homes for solar access could be a problem. Note that customers may also benefit from utility incentives to increase the utility-side benefits—for example, responding to TOU rates or DR load controls.

One variation on this model could offer rooftop leasing for utility-owned solar plus storage. The CPS Energy program in San Antonio has demonstrated rooftop leasing, and the model could be expanded to include grid-connected, utility controlled storage as well. This alternative model would promote direct, widespread customer engagement in helping to manifest the 21st Century grid.

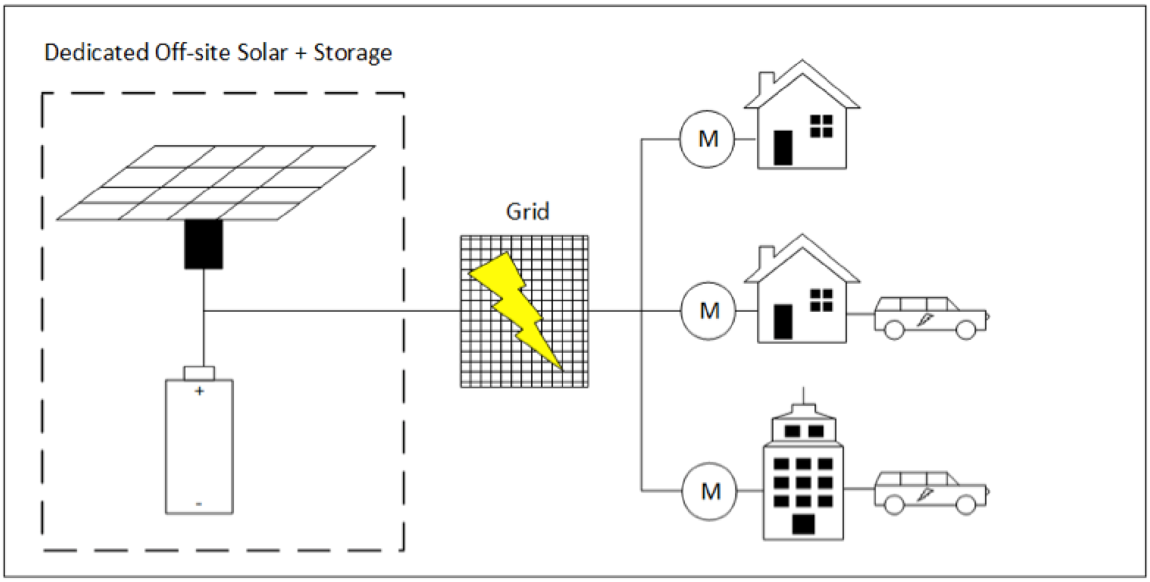

Figure 5. Utility-side Solar Plus Storage Configuration

6.2 Customer-side Storage Configurations

Here, the storage is provided on the customer side of the meter. These configurations include solar and storage that are integrated with each customer premise, or where a community solar array and storage system are integrated. There are many possible behind-the-meter storage configurations; here we consider a few of the most promising. Note that the opportunity to monetize different value streams does not mean that the project would be economical. In most cases today, solar plus battery storage still requires subsidy, either from a government program or from a business partner that sees value in being early to market. Further, there is always a customer segment of early adopters for batteries and EVs, but utilities are cautioned to perform market research before moving ahead. As noted earlier in this guide, thermal storage and DR options are relatively more mature and far more cost effective; they may be good choices for a first-generation solar plus storage or triple play project.

Utility-side Solar Plus With Customer-side Storage

In this configuration, shown in Figure 6, there is still a dedicated off-site community solar array, but each customer participating in the community solar program has a grid-tied, customer-side storage system. This could be in the form of batteries, such as a Tesla Powerwall, or thermal storage technologies, such as grid-interactive electric water heating, pre-cooling or ice cooling. The utility might serve as the aggregator of customer-side value streams, or it could work with a third-party aggregator. This configuration might also include controlled charging for electric vehicles or even a pilot bi-directional V2G system. It is a versatile configuration—the likely choice for many community solar plus programs.

The utility may select which value streams to tap, depending on its own interests and access to grid-services markets. Since the storage is on the customer side of the meter, the customer incentive to participate must be successful in order for grid-services value streams to flow.

From the customer perspective, there may be ready opportunities for demand-charge management, TOU rate arbitrage, power-quality enhancement, and back-up emergency power. Depending on the exact location of the solar array, this configuration is also well suited to ZNE community development.

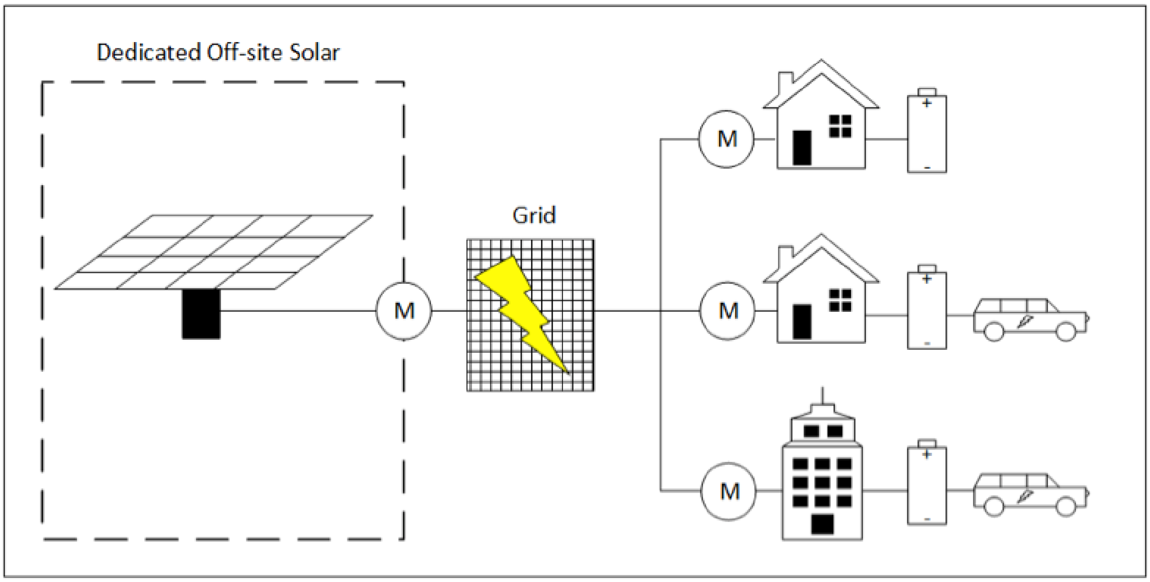

Figure 6. Utility-side Solar Plus Customer-side Storage

Customer-side Integrated Solar Plus Storage

This model is not suited for a conventional community solar project, but it may support rooftop leasing options or group-buy solar programs. In this configuration, shown in Figure 7, both a solar array and storage system are integrated separately with each household or commercial customer. With this configuration, there is an added capability that each household could potentially island itself and operate completely off grid.

Utility benefits depend on strategic choices of which value streams to tap. With storage and solar on the customer side of the meter, the utility may be challenged to capture added value. However, utilities like Hawaiian Electric, which have severe grid constraints, may find that this configuration suits their needs. Depending on regulatory rules, the utility may aggregate customer grid services (from storage or DR), or it might work with a third party.

Typical customer-side value streams for this configuration include demand charge management, TOU rate arbitrage, power quality, and back-up emergency power. Individual customers may opt to island during emergencies or over a longer term.

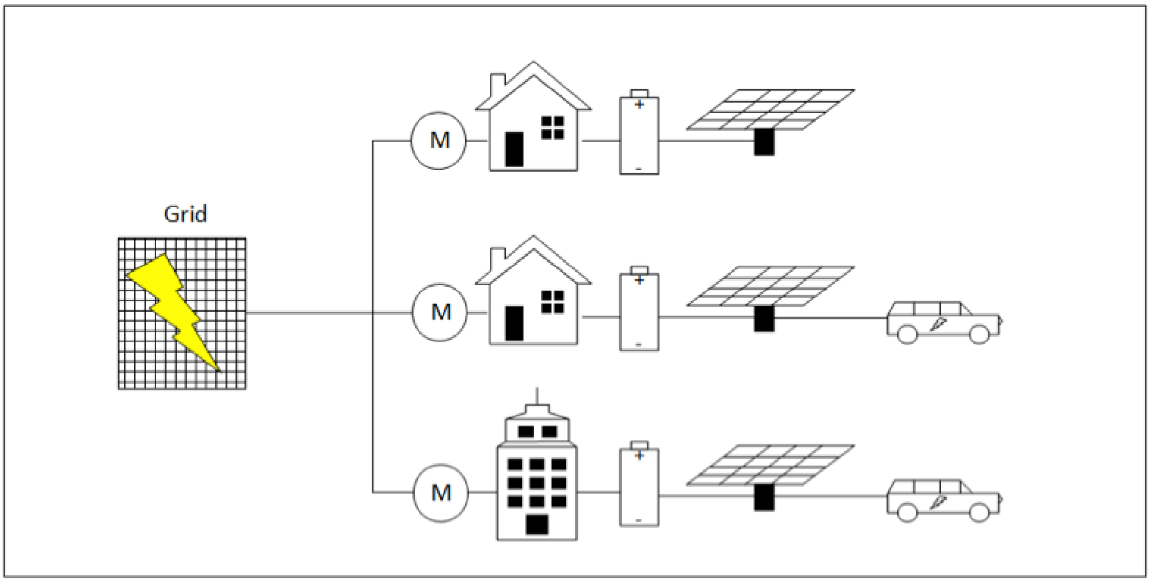

Figure 7. Customer-Side Solar Plus Storage

Customer-side Integrated Solar Plus Storage as a Micro-grid

This configuration, shown in Figure 8, is very similar to the customer-side solar plus storage configuration, except that the entire community is metered in aggregate as a micro grid. It is assumed that battery storage is the primary storage technology choice, though other storage and DR technologies could be used. This configuration allows buildings within the community to share solar and storage resources, and therefore to provide islanding or backup power at a community level. This also could simplify aggregation for ancillary/grid services, increasing value to customers.

The local utility could benefit from ancillary services, but the extent depends in part on rules around working with the regional grid operator and third-party service aggregators. This configuration brings to the fore the question of why to solve integration problems locally. What is the benefit to the local utility of promoting a micro-grid project? It may provide distribution upgrade deferral and improve power quality and reliability on a particular circuit. More likely, the utility would support this configuration in order to serve customers that play a key role in a community resilience plan. Especially in the case of a regional emergency, the ability to serve critical loads in the community could be highly valuable.

On a regular basis, customers could realize any of the full range of customer-side value streams: demand charge management, TOU rate arbitrage, power quality, backup power by household or community, micro-grid by household or community, ZNE household or community, or working with a third party aggregator, if available to monetize grid service value.

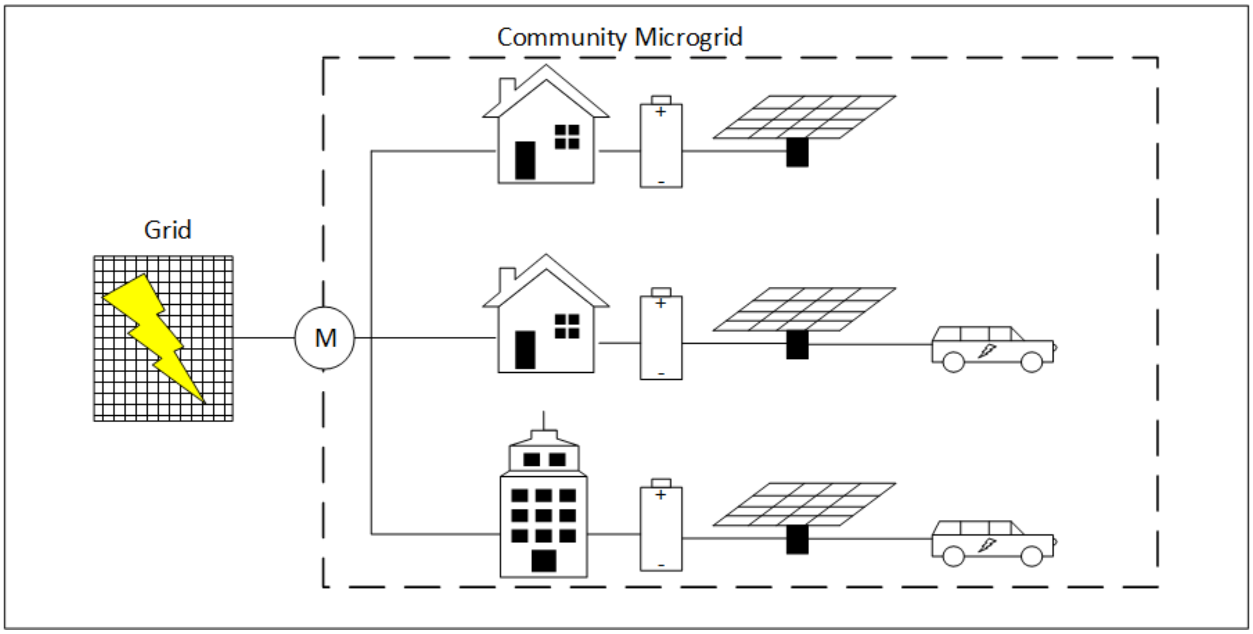

Figure 8. Multi-Customer Integrated Solar Plus Storage, Operated as a Micro-grid

Community Micro-grid with Shared Solar Plus Storage

This configuration, shown in Figure 9, is very similar to the integrated solar plus storage configuration, above, except that the entire community is metered in aggregate as a micro-grid. It is assumed that battery storage is the primary storage technology choice, though other storage and DR technologies may be used. For example, this model could be adapted to a large-scale ground-source heat pump system with storage. The storage is operated for the advantage of all participants within the defined community.

This micro-grid configuration is similar to configuration with individual customer micro-grids, but having shared solar plus storage configured as a community micro-grid lowers costs and add community resilience benefits. At the same time, this means losing the potential for individual customer back-up power, islanding, or ZNE at the individual customer level.

Again, utility considerations would be similar to those for any micro-grid project. The shared solar configuration offers certain advantages in terms of solar siting, economy of scale, and O&M monitoring. If the utility is involved directly, it might prefer to work with this larger-scale solar option.

Customer benefits are also similar to those for the configurations above. These include demand charge management, TOU rate arbitrage, power quality, backup power by community, islanding by community, ZNE community, and marketing of grid services, if available.

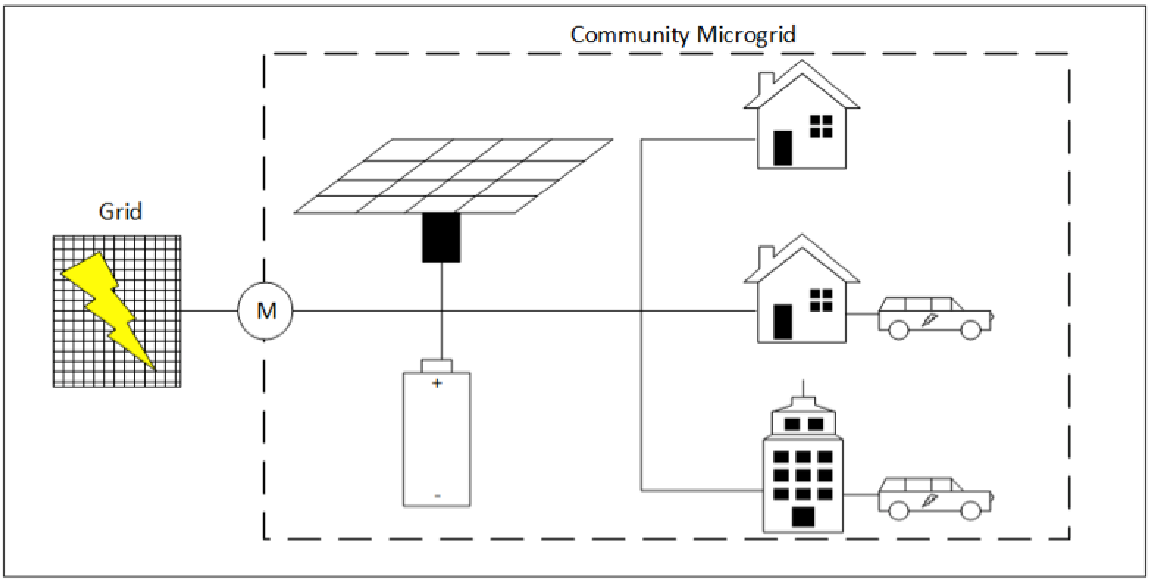

Figure 9. Community Micro-grid with Shared Solar Plus Storage Configuration

6.3 Summary: Matching Solar Plus Storage Configurations to Relevant Value Streams

The summary of solar plus storage configurations, matched against typically relevant value streams—shown in Table 2 below—indicates relatively few configurations where it would be impossible to tap any given value stream. One take-away is that these configurations are quite flexible, and that strategic program design is as important as the technical plan.

Section 7 will suggest how different technology choices—and different assumptions about how those technologies are used—would impact the full value available from a given solar plus configuration. In practice, some value streams are mutually limiting: For example, if a storage technology were used primarily for load shifting it might not be able to get a full charge in time to simultaneously participated in frequency regulation.

After fitting specific storage technologies into a given configuration, the choices that are most practical, customer-focused, and economical become clearer. For example, community solar plus customer-side batteries would not yield customer-side grid-service benefits *unless* the utility could incentivize customer participation and aggregate the desired grid services, directly or through a third-party that could monetize that value.

Utilities and third-party market players are still gaining early experience with solar plus configurations, so it is safe to assume that they will be looking for program designs that can scale up as they are tested and perfected. The benefit of using community solar plus storage as a market-based laboratory is that it is ideal for gaining real market experience on a limited, but scalable basis. Beyond load shifting, integration benefits could be estimated during the planning and approval stage, and then evaluated based on actual program performance. Whether or not the relevant regional balancing authority has a functioning market for grid services, the utility could gain experience with voluntary, community solar plus participants and assess the value of solving integration problems close to the source, on the distribution grid. Evolving programs could begin with a general, early-adopter market or they might target preparing for community emergencies, where resilient solar plus systems would have local value far beyond what markets typically would pay.

Of course, utilities and customers can access integration markets in some regions today. There, the appropriate test case might be for the utility to participate in the market on a limited scale, while planning for full, market-scale replication.

Table 2. Summary of Solar Plus Configurations and Value Streams.

Solar-Plus Configuration	Utility-side Solar Plus Storage	Utility-Side Solar Plus Integrated Storage	Customer-side Integrated or Shared Solar Plus Storage	Micro-grid with Integrated Solar Plus Storage	Micro-grid with Shared Solar Plus Storage
Utility-side Value Streams					
Load shifting for eased ramp/peak, or arbitrage	√	√	√	√	√
Transmission or distribution upgrade deferral	√	√	√	√	√
Ancillary/grid services (Market dependent; may require aggregation)	√	√	√	√	√
Demand charge management	N/A	√	√	√	√
Customer-side Value Streams					
TOU rate arbitrage	N/A	√	√	√	√
Power quality	N/A	√	√	√	√
Backup power	N/A	√	√	√	√
Micro-grid (Islanding)	N/A	N/A	√	√	√
ZNE	√	√	√	√	√
Grid-service aggregation	√	√	√	√	√

(See Section 7, below for assumption that would apply to a generic utility- or customer-focused storage application. Different assumptions would impact how well a given solar-plus configuration would address different applications and value streams.)

7 Scoring Technology Options

Given that several storage technologies could work within most of the configurations discussed above, Tables 3 and 5 are matrices, designed to help utility planners to focus on which options best match their specific integration needs. Table 3 matches storage options to utility-focused value streams and Table 5 matches storage options to customer-focused value streams. For each, scoring is based on assumptions that are described in Tables 4 and 6, respectively.

Looking first at Table 3, the value streams are ordered along the top horizontal axis, based on the approximate speed of response needed to realize the integration-value goal. On the vertical axis, technologies are listed in order, based on their ability to provide reliable capacity. For example, flywheels lose capacity quickly; EVs may, in aggregate, have considerable capacity, but bi-directional strategies are still emerging. Further, there are variations among the listed technologies. These include a range of stationary battery technologies and controlled thermal storage. Alternative assumptions about the technologies listed could change their integration-response characteristics. For example, the response times for thermal storage may be slower or faster, depending on the control technologies used.

As long as these storage options are grid-connected, the utility (and possibly the ISO) will reap benefits, but in working with highly distributed storage technologies, the customer will reap benefits, too. Table 5 takes the customer's viewpoint. Again, the value streams are ordered along the top horizontal axis, based on the approximate speed of response needed to achieve the integration goal. On the vertical axis, technologies are listed in order, based on their estimated ability to provide reliable capacity. Note that for a number of these technologies, individual systems must be aggregated in order to monetize their value. Grid-interactive storage water heaters, for example, may not bid resources into a regional market on a per-unit basis; they must be aggregated. Customer-side storage technologies represent a first line of cost-effective measures today, not only for the customer, but also for the utility/aggregator. Incentives provided by the utility to achieve utility-centric goals become an additional value stream for the customer.

After studying these sample matrices, we recommend customizing them, using utility-specific assumptions and prioritizing attainable value streams. This is important because (1) there are more variations in storage technologies than any one summary table can show, and (2) even if a given technology could tap several value streams in theory, in practice it would probably be directed to achieve at most a few integration goals. For example, if a battery is discharged to meet late afternoon peaks, it would not be available to provide ancillary/grid services during the same time frame.

This scoring process can give planners who do not customarily work on integration issues an introductory understanding. That would be useful for working with system engineers, who in turn may be fairly new to DER strategies. Many utility planners find that a scoring process like this helps them to build a case for promoting relatively low-cost customer-side storage, in cases where it might be just as effective as battery systems. The CSVP's utility-based engineering advisors have embraced the benefits of using thermal storage and DR, in order to assure that batteries could be available for challenges that specifically require electricity storage and dispatch.

However, not all utilities and not all customers can monetize all storage-technology value streams. First, the chosen technologies must fit into a viable solar plus configuration, as discussed above. Even then, planners must complete the program design, bringing targeted customers, technologies, configurations, and stakeholders together to actually develop and implement high-value strategies. Additional guidance on program design is included in Section 8.

Table 3. Sample Scoring for Storage Options Focused on Utility Value Streams

Fast Acting ⟵⟶ Slow Acting

		Frequency Regulation and Response	Voltage Support	Spinning and Non-spinning Reserves	Intra-Day Load Shifting	Black-start Support	Seasonal Load Shifting	Transmission and Distribution Upgrade Deferral
High Capacity	Pumped Hydro	◔	◑	●	●	●	◑	◔
	Compressed Air	◔	◑	●	◕	○	○	◔
	Thermal Storage	◑	◑	◕	◕	○	○	◑
	Batteries	●	●	◕	◑	◔	◔	◕
	Electric Vehicles	◔	◔	◑	◕	○	○	◔
Low Capacity	Flywheels	◕	◕	◕	◔	◔	○	○

Table 4. Definitions and Assumptions for Sample Scoring in Table 3, Storage Options Focused on Utility Value Streams

Storage Technology	**Definition and Assumptions Used in Table 7-1, Sample Scoring for Storage Options Focused on Utility Value Streams**
Pumped Hydro	Most pumped hydro facilities are considered too large to be matched with community solar programs. Here, we assume a pumped hydro facility that would be shared between community solar and other uses.
Compressed Air	Compressed air technologies include industrial-scale devices using indoor tank storage and relatively rare, utility-scale facilities using underground caverns with appropriate geology. Similar scoring would apply to either approach.
Thermal Storage	Utilities can utilize large-scale thermal storage, such as molten salt; however, most utilities would opt for widely available and economic customer-side storage systems. Utilities can reap a range of benefits from these systems, depending on their market penetration. Scoring here is conservative due to the challenges of reaching full market penetration; however on a per-unit basis, value streams, especially including load shifting, are great.
Batteries	Utilities can reap integration benefits, whether deploying batteries on the utility side of the meter or on the customer side of the meter. On the utility side, we assume lithium ion battery systems with at least 500-kW capacity, located strategically on the distribution grid. On the customer-side of the meter, lithium ion battery systems comparable to the Tesla Powerwall are aggregated and controlled by the utility. Customers also would reap value from customer-sited systems, as indicated in the Table below. We urge program planner to investigate multiple vendors and technologies, as the market is changing rapidly.
Electric Vehicles	Smart charging of electric vehicles enables the utility to time charging to match grid conditions, including periods of high solar generation. Various controls and incentives may be used, with customers benefitting as well. Current EV technology provides an opportunity for most utilities; similarly, uncontrolled charging would be a significant risk. As this market is still evolving, we assume a relatively small, aggregated fleet, deployed in a market-based test. Bi-directional EVs, which can supply power to the grid, are not considered in this sample case, as market-based testing programs are still rare.
Flywheels	We assume behind-the-meter flywheels in industrial facilities, controlled by the utility to reap integration benefits. Participating customers can tap value streams from demand management and other incentives.

Table 5. Sample Scoring for Storage Options Focused on Customer Value Streams

Short Duration ⟵⟶ Long Duration

		Power Quality	Grid Services	Demand Charge Managem	TOU Rate Arbitrage	Backup Power	Micro-grid	Zero Net Energy
High Capacity	Thermal Storage—Refrigeration Ice Storage	○	◔	◑	●	○	◔	◑
	Thermal Storage—Ice for Cool/AC Storage	◑	◑	◕	●	○	◔	◑
	Thermal Storage—Water Heating	◑	◕	◑	●	○	◔	◑
	Thermal Storage—Chilled Water	◔	◔	◕	●	○	◔	◑
	Batteries	◕	●	●	◕	◕	◕	◑
	Electric Vehicles	○	◑	◑	◕	◔	◔	◔
	Building Pre-Cooling/AC Control	○	○	◕	◑	○	◔	◔
Low Capacity	Flywheels	◕	●	◔	◔	◑	◑	◔

Table 6. Definitions and Assumptions for Sample Scoring in Table 5, Storage Options Focused on Customer Value Streams

Storage Technology	**Definitions and Assumptions Used in Table 7-3, Sample Scoring for Storage Options Focused on Customer Value Streams**
Electric Water Heater – Grid Interactive (GIWH)	Assume use of new residential GIWHs of 55 gallons or more, or smaller, older units that are retrofitted. Most early-market evaluations support use of broadband/wi-fi, bi-directional control signals. For demand charge management, other load profiles also must be considered. In addition to load-shifting, frequency regulation and grid stabilization are achieved.
Thermal Storage – Refrigeration Ice Storage	We assume use of ice storage units large enough to meet all commercial refrigeration needs of a supermarket for at least six hours on a summer day. Axiom is a market leader. Grocery store loads are relatively stable, but capabilities for demand-charge management should be evaluated. While ice systems can provide ancillary/grid services, that use could limit the systems primary, load-shifting capabilities.
Thermal Storage – Ice Storage for Air Conditioning	This sample case assumes commercial-building cool storage, using readily available package units; ice is typically made in off-peak times, and it is melted to meet cooling load when power is costly. Residential ice storage is also available. Assumes AC is a likely driver of demand charges; load profiles of other loads also must be considered. The technology has frequency regulation capability, and fleet-wide control may allow aggregated load following. However, use for ancillary/grid services could limit load-shifting capabilities, which are likely to be most valuable. Ice Energy is a market leader.
Thermal Storage – Cold Water Storage for Air Conditioning	The most common form of cool storage in commercial buildings with central chillers stores extra mass of cold water in large tanks. Water is chilled when power is inexpensive, and used to meet cooling load when power is expensive. Assumes AC is a likely driver of demand charges; load profiles of other loads also must be considered. When storage space is scarce, these systems can be complemented with ice making equipment. CALMAC is a market leader.
Batteries	Stationary batteries are often considered the standard against which other technologies' integration value is measured. There are multiple chemistries, configurations, and sizing options for customer-side batteries. We assume lithium ion batteries similar to those used by market leading vendors. Planners should explore multiple vendors, as the market is changing rapidly.
Electric Vehicles	Assume smart charging of electric vehicles enables the customer to time vehicle charging in response to TOU rates or other incentives. Opportunities to provide additional grid services with bi-directional controls are considered to be just emerging. Scores are likely to improve as the market develops.
Pre-cooling of buildings/AC control	Assume buildings with good insulation and significant thermal mass; poorly insulated buildings are unsuitable for pre-cooling. Note an overlap with advanced AC demand response controls.
Flywheels	Assume behind-the-meter flywheels in industrial facilities (the most common use case). New market entrant Amber Kinetics has introduced more general purpose flywheel applications.

8 Program Design Considerations

Recalling the planning steps introduced in Section 3, number of non-technical, strategic considerations come in—both at the beginning and the end of the process (Figure 15, below). At the front end, the utility must have answered the questions, why storage, and why now? The answers should help the planner envision a program that begins on a relatively limited scale, such as a community solar program that builds out a fleet and takes on more solar plus customers over time. Given the way storage and DER markets are fast-evolving, it is wise to consider a program design that will grow in stages. It is also wise to consider a program design that is not shackled to a pilot, but rather grows seamlessly into market-scale deployment. One thing that is known about the fast-evolving storage market is that it is here—in some form—to stay.

Program design comes to the forefront after the technologies are selected and configurations are prioritized. In fact, program-related market research should be part of the earlier process, as well. What is the anticipated customer-acceptance for a given technology or configuration? Does the utility have a tentative site for the solar project? Will the utility be installing one or more large-scale utility-side storage projects, or is the utility planning to offer customer-side storage measures? What is the likely customer response to different alternatives? What terms and pricing are most likely to support program success? CSVP has proposed a complete program-design process, which can encompass the steps for solar-plus technology selection and project configuration. This process is illustrated in Figure 15.

If the utility is drawn to the utility-side solar-plus-storage configuration, then program design for the community solar program will need a solar-plus narrative that passes along "virtual storage benefits," rather than hands-on customer-side storage experience. This is entirely plausible. Austin Energy currently has co-located a community solar project with battery storage, though storage benefits are not explicitly part of its community solar offer. Arguably, the utility could extend the community solar offer and attract participants in return for a share of solar *and* storage benefits. This seems most workable around the concept of solar plus storage for community resilience; such projects are under discussion in several states.

However, the thrust of this guide is planning for solar plus storage programs that include some element of customer-side storage, whether that is a solar plus grid-integrated water heater program or a solar plus electric vehicles program, or a program that incorporates customer-side batteries, under at least partial utility control. These options are readily characterized as "companion measures," which has been the focus of the CSVP.

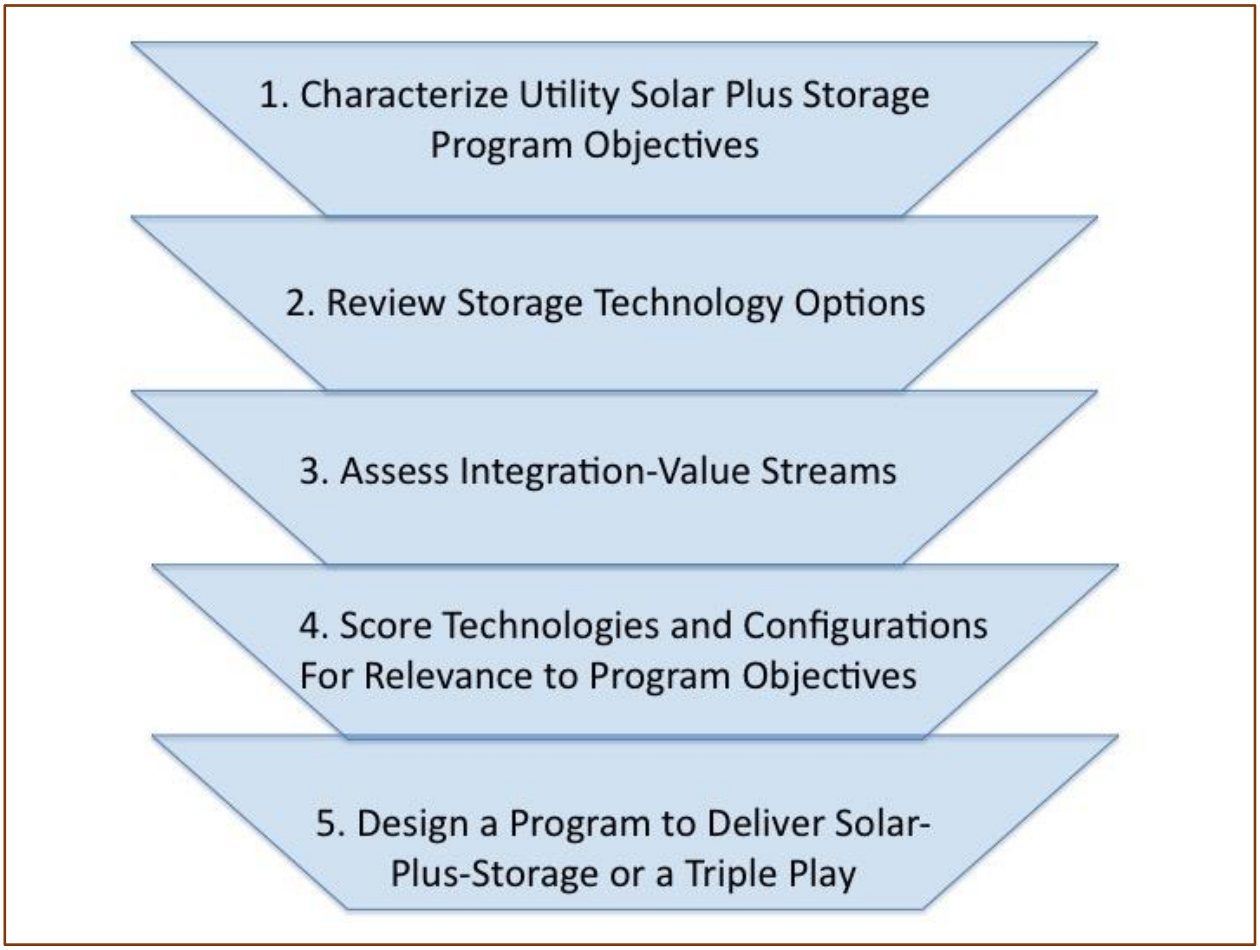

Figure 15. CSVP Steps in the Solar-Plus Storage Planning Process

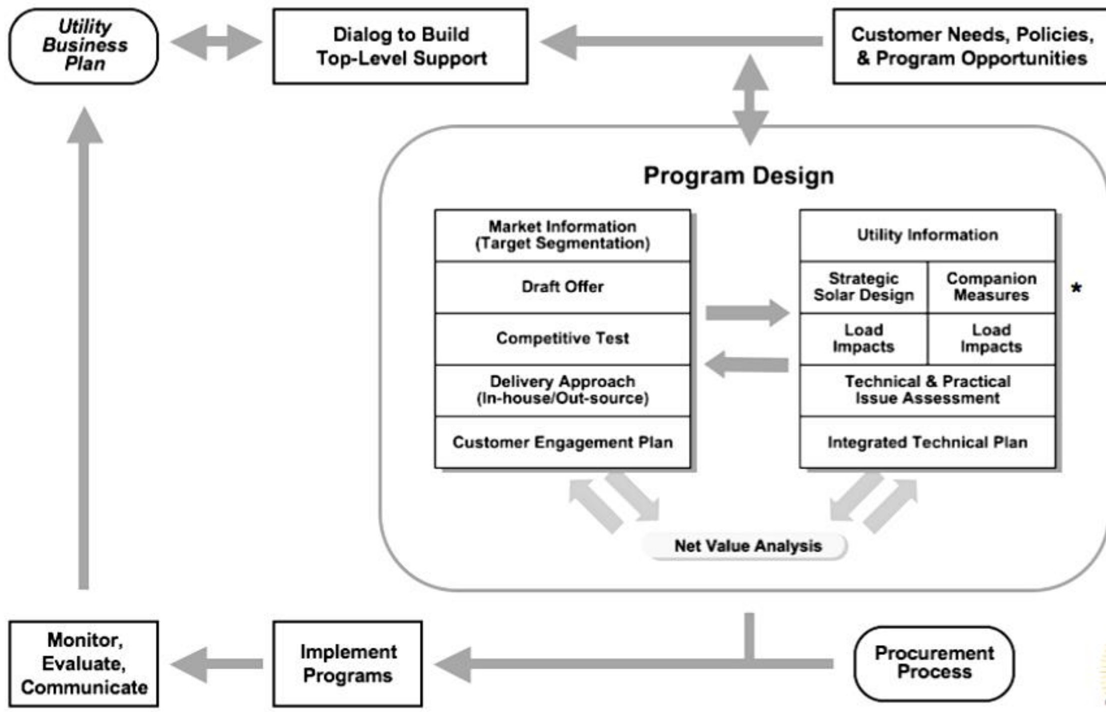

Figure 16. CSVP Planning Process for Community Solar Plus Storage Companion Measures

In Figure 16, the balance between customer-side program-design elements and utility-side considerations is clearly illustrated. As a process focused on community solar, the program design steps related to companion measures could be ignored, but this guide is focused *on just those steps*, diving deeper into the technical storage options, assessment of load impacts, technical and practical issue assessment and development of a solar-plus net value analysis. The result is what CSVP has called *high-value community solar*, with the inclusion of companion measures.

While this guide does not focus on the program-design process itself, a few observations should be evident:

1. Development of a technical plan that includes DERs will only be successful when customer-side issues and opportunities are also considered.

2. The program-design process is iterative and collaborative: The program designer must work cross-departmentally and respect the importance of each utility stakeholder perspective.

3. The steps in strategic program design are consistent and proven. A review of all program-design resources on the CSVP website is recommended.

4. Here, the utility-side options might include a customer-engaged community solar program. Or that choice could be simplified by focusing on storage and DR measures that are used to balance the utility's *community-scale solar*, not necessarily offered

for direct customer participation as a community-solar offer. In other words, utility planners must decide, early on, where their priorities lie. Community solar plus efforts, such as demonstrated by the Steele Waseca Electric Cooperative in Minnesota, show that model as fully market-ready and attractive. Still, utilities have options in how they design their specific program.

8.1 Program-Design Considerations Specific to Storage

Some program-design questions are specific to programs with storage measures. These questions vary regionally and can be regulatory- or market-related. Below, we summarize some of these questions, with comments on how they might be addressed.

The Case for Integrated Solar Plus Storage

Implied in the short list of observations above is a question: How integrated will the solar and storage measures be? If, for example, the utility decides it will market test storage measures separately from a community solar program offer, then that decision has strong implications for target market segmentation, incentive development and delivery, economics, and monitoring and evaluation. The case for packaging community solar together with storage and/or DR measures is worth considering. For one thing, market research data from the Smart Grid Consumer Collaborative (SGCC) and other sources suggests that several of the same customer target groups are interested in both smart-grid technologies and PV (SGCC, 2015). Considering that the cost of customer-acquisition is one of the biggest soft costs for either community solar or storage program implementation, it makes sense to potentially double the value of each customer contact and capitalize on the excitement and accessibility that is already associated with community solar.

Still, this observation comes with the caveat that some micro-market segments are more interested in personal control or savings, and other micro-market segments are more interested in the environmental and community-oriented aspects of an offer. This is true whether the offer is for community solar alone, storage alone, or solar-plus storage. Market research is key to any program's success.

Using an Iterative Program-Design Process

As indicated above, the CSVP program-design process requires cross-departmental collaboration, in which participants with customer-focused expertise and utility-operations expertise regularly meet and come to agreement on strategies that work for both sides. It is helpful to review the CSVP Program Design summary guide (a presentation-format report, available from CSVP), which provides touch-points for that process.

Planning for Existing and Emerging Markets

Another key question pertains to the ability to monetize integration value streams in existing and emerging markets. Upon a full review of value streams that are available to utilities and customers today, CSVP has concluded that the most widely available and readily monetized applications have to do with load shifting, TOU rate arbitrage, demand-charge management, and other energy-related functions. This is especially true for using relatively low-cost measures, such as GIWH and ice storage and DR strategies. Such strategies represent a first-line actions to manage loads cost-effectively and to ensure that battery storage and other costlier or more environmentally concerning approaches are put the their best use. Further, by balancing system loads—lowering peaks and easing ramp rates—storage technologies can help reduce the utility's exposure to grid-service issues. These eliminate the need to go to markets for some grid services and, in effect, "solve problems closer to the source." The results include reducing the technical and economic risks inherent in relying on regional markets.

Market readiness is still an important consideration. Early in the planning process, utilities must consider their regional and state regulatory regimes, including relationships that may exist between consumer-owned utilities and their power suppliers and any changes they might anticipate. Many of the grid services derived from storage require automated control from the local utility, power supplier, regional ISO, or a DR aggregator. In many cases, state law and regulation dictate which options are available. Even if choices are available, participating in one control strategy may limit the program from using another control strategy. For example, a storage resource being used for a utility-run DR program likely will not be able to bid other services into the wholesale market.

This does not mean that strategies aimed at market values are ill-advised. One take-away from the discussion of technology choices and alternative solar plus configurations is that most of these are flexible. By incorporating solar plus storage measures into a DER plan, a utility has options to capture values both today and in the future, even if this means running a different control strategy as customer use patterns and markets change.

Some issues related to monetizing solar-plus storage or DR value have to do with the siloing of utility programs by regulators or by the utility itself. For example, if a utility is required to meet targets for DR and can rate base certain DR costs, then the accounting for such programs is likely going to be kept separate. The challenges of running an integrated DER program, including how to identify and categorize synergistic effects, can be resolved. But they will challenge utility planners and other stakeholders for years to come.

CSVP underscores the viability of a market-laboratory approach—e.g., focusing on an almost universal value stream, like load shifting, while evaluating how the storage configuration also could yield grid service value. Chances are that markets will be developing everywhere in coming years, whether they will monetize values locally or regionally, or both. The utility that knows how to approach customers with a storage option will be ahead of the game and ready to grow its program to an impactful (and economic) scale.

Economics of Different Storage Options

Storage project economics depend greatly upon the configurations applied and value streams available. Thus, the tools for assessing storage projects are still evolving. CSVP points readers to some of these tools in *CSVP Resource Links for Solar Plus Storage* (Cliburn et al., 2017). In particular, one tool, the ReOpt model from NREL, is roughly compatible with the popular System Advisor Model (SAM) for solar, and it is emerging as a leading tool for solar plus storage assessment. (National Renewable Energy Laboratory, 2017b) The Clean Energy States Alliance (http://www.cesa.org), which is a center for the Energy Storage Technology Advancement Partnership, also offers up to date information for planners who need to assess storage system economics.

In particular, stationery battery storage projects to date have been supported with research and development funding assistance. In 2009, the U.S. DOE put $185 million from the American Recovery and Reinvestment Act (ARRA) into funding for energy storage projects. This triggered some 500 MW in various technical pilots, including utility-side battery demonstrations.

Besides applying the investment tax credit (ITC) on qualifying projects, most sponsors for battery projects today look to state funding incentives to help close a steadily narrowing, yet persistent cost-effectiveness gap. This includes a $10 million round, recently announced for the Massachusetts Energy Storage Initiative or latest round of California's massive Self-Generation Incentive Program (SGIP). That program will put nearly $400 million into storage incentives for commercial and residential customers through 2019. Utilities that are interested in battery storage programs on any scale would be wise to look into whatever incentives and special financing are available.

By comparison, customer-side thermal storage projects remain at the forefront for cost-effectiveness for both the utility and its customer participants. Many economic analysts anticipate increasing cost-competition among battery and non-battery options, but there should be reasons to justify either in suitable settings for decades to come.

To get a feel for the relationship between value streams and net storage benefits, we refer to an overview of results from the 2016 LCOE study of specific storage use cases from Lazard, shown in Figures 12 and 13 below (Lazard, 2016).

While other studies have estimated the cost of each storage technology at a given point in time, few have provided specific assumptions that produce reasonably comparable LCOE results (See Appendix A for Lazard assumptions; data used by permission). The authors of the Lazard study use somewhat unique terminology for each storage application, but the presentation is compatible with that presented in this guide. Note that storage costs have been changing rapidly; utility planners are cautioned to check current prices before estimating actual project economics.

8.2 Conclusion

There are inevitable challenges to high-penetration renewables integration, which utilities can only address through experience in an actual market setting, working with customers and collaborative partners under real-world supply and demand conditions. Yet markets for integration value *per se* are still forming today. The situation is anything but hopeless; the fact is that high-value solutions to relatively straightforward problems—such as the need to smooth the "duck curve"—are ready today. Because of their inherent flexibility, many of these solutions could be applied to more advanced integration problems as markets evolve and change.

A primary objective for solar plus storage programs should be to learn to solve more integration problems close to home. This would minimize the local utility's exposure to regional reliability risks and risks related inevitable price and supply swings in regional ISO markets. For some utilities, there are also benefits in strengthening relationships with customers. As utility planners get started, they will see ways to unlock untapped value streams, improving storage economics for the utility and its customers.

Lessons about assessing storage technologies and configurations, and about fitting these into a successful utility program design, will be useful to utility planners whether or not they choose to match community solar directly with storage and/or DR companion measures. Yet the case for deploying *local community solar* together with storage and/or DR measures is worth considering.

Utilities realize that no single resource or technology can meet the multifaceted needs of tomorrow's utility customers. Centralized energy resources are increasingly likely to be complemented by a local, DER approach. This would include integrated generation and storage options, with advanced controls and price signals for DR, plus energy efficiency and infrastructure improvements. Introducing community solar with companion measures can engage customers directly with this emerging 21st Century utility model. The community solar plus storage model can be a scalable, market-based laboratory for utilities working in partnership with customers and third-party innovators as they all learn to succeed in a fast-changing market.

This guide is an introduction for utility planners to lead one aspect of a far-reaching and profound transformation in the way we generate, distribute, and use electricity. The authors fully anticipate that planners will take exception to some of the best practices cultivated from industry progress on solar-plus strategies so far, in order to implement new solutions. Over the course of our work with a dozen members in the CSVP Utility Forum and our broader experience working in this industry, we have learned to expect unexpected innovations from all corners of the field. We welcome reader comments and suggestions for future updates of this guide.

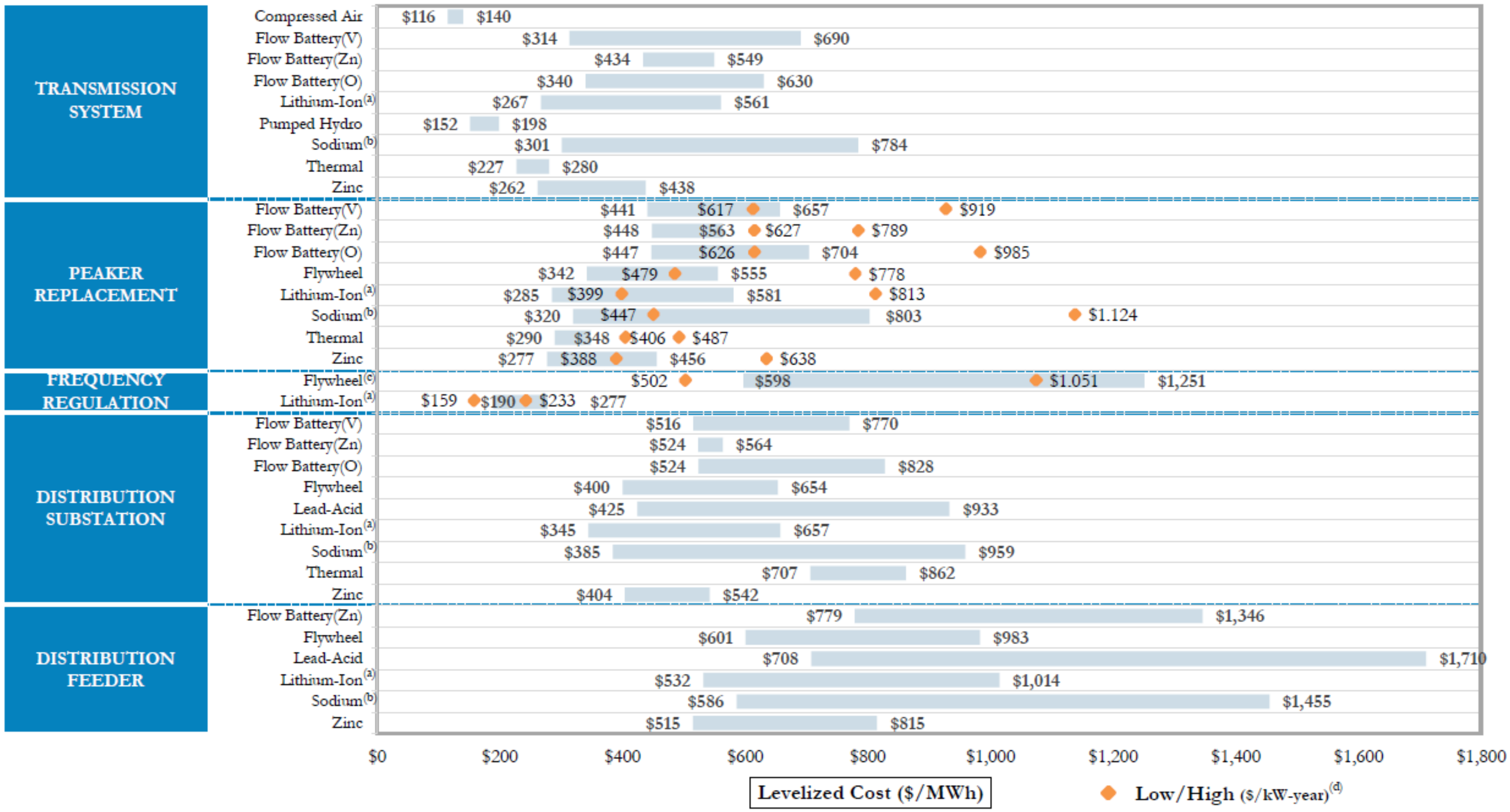

Figure 12. LCOE of Storage Technologies in Different Siting Regimes on the Utility Side of the Meter (Source: Lazard, 2016, by permission)

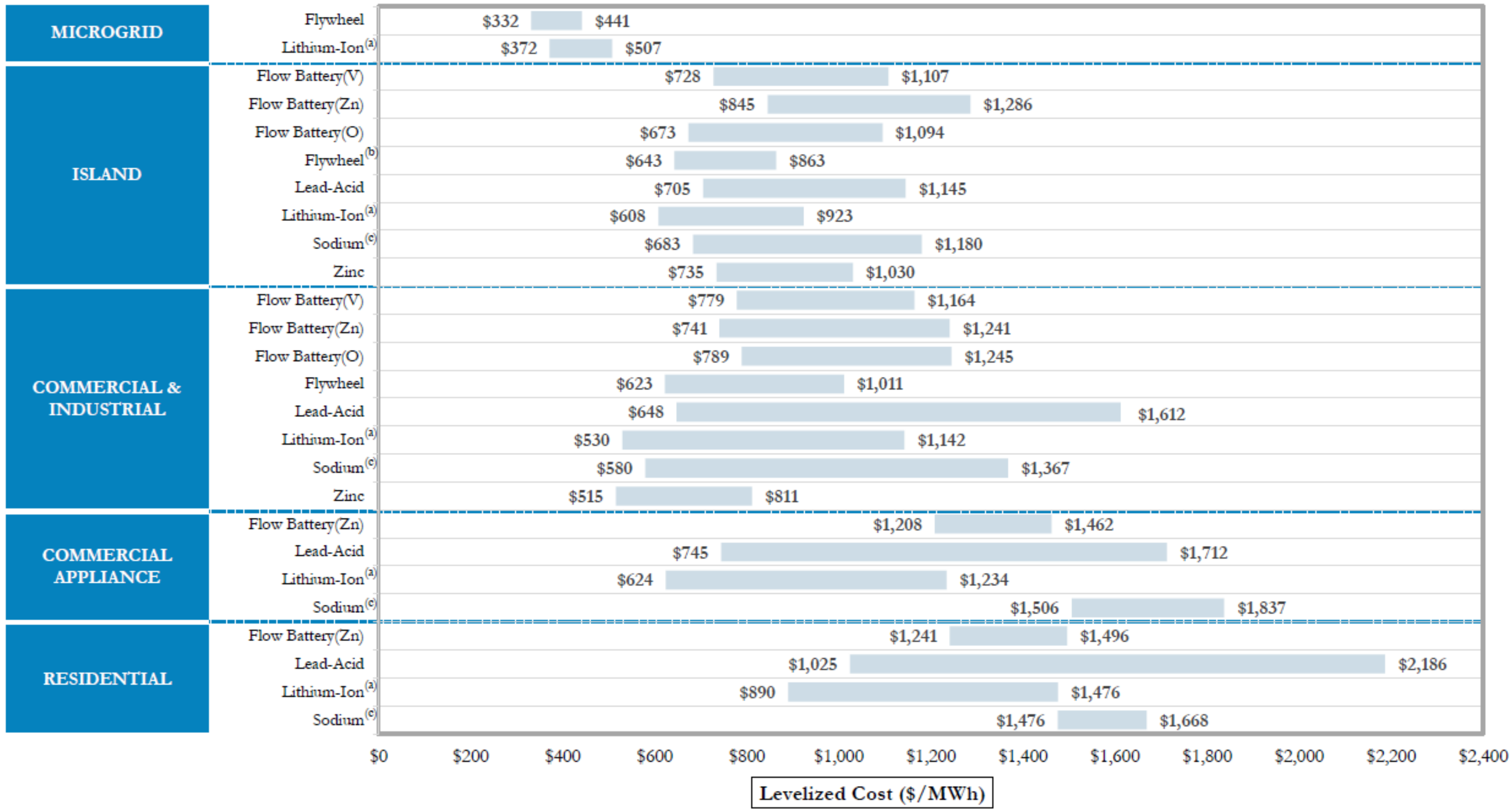

Figure 13. LCOE of Storage Technologies in Different Siting Regimes on the Customer-side of the Meter (Source: Lazard, 2016, by permission)

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Appendix A

	PROJECT LIFE (YEARS)	MW[a]	MWh OF CAPACITY[b]	100% DOD CYCLES/ DAY[c]	DAYS / YEAR[d]	ANNUAL MWh	PROJECT MWh
TRANSMISSION SYSTEM	20	100	800	1	350	280,000	5,600,000
PEAKER REPLACEMENT	20	100	400	1	350	140,000	2,800,000
FREQUENCY REGULATION	10	10	5	4.8	350	8,400	84,000
DISTRIBUTION SUBSTATION	20	4	16	1	300	4,800	96,000
DISTRIBUTION FEEDER	20	0.5	1.5	1	200	300	6,000
MICROGRID	20	2	2	2	350	1,400	28,000
ISLAND GRID	20	1	8	1	350	2,800	56,000
COMMERCIAL & INDUSTRIAL	10	0.5	2	1	250	500	5,000
COMMERCIAL APPLIANCE	10	0.1	0.2	1	250	50	500
RESIDENTIAL	10	0.005	0.01	1	250	2.5	25

[dashed box] = "Usable Energy"[e]

(a) Indicates power rating of system (i.e., system size).
(b) Indicates total battery energy content on a single, 100% charge, or "usable energy." Usable energy divided by power rating (in MW) reflects hourly duration of system.
(c) "DOD" denotes depth of battery discharge (i.e., the percent of the battery's energy content that is discharged). Depth of discharge of 100% indicates that a fully charged battery discharges all of its energy. For example, a battery that cycles 48 times per day with a 10% depth of discharge would be rated at 4.8 100% DOD Cycles per Day.
(d) Indicates number of days of system operation per calendar year.
(e) Usable energy indicates energy stored and able to be dispatched from system.

Figure 14. Assumptions. (Source: Lazard, 2016)

Figure 14 shows the most important assumptions employed in the study (Lazard, 2016) discussed in Section 8. Without such information, it is impossible to interpret the headline numbers often used in common references to the cost of storage technologies. A cost for batteries at $x/kWh, should always be viewed skeptically until assumptions are checked, regarding how a specific battery technology would be operated.

Community Solar
Program-Development Landscape

A Brief for Utility Program Designers

Community Solar Value Project
December 2016

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Navigant Consulting

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Community Solar Value Project

Powered by SunShot
U.S. Department of Energy

Summary

Community Solar Program-Development Landscape is part of the *Community Solar Value Project (CSVP) Solutions Toolkit*. This brief provides an overview of community solar program drivers, choices, and trends, as they impact utility-led community solar programs. This includes a quick review of state policies, of business standards and innovations, and of the players who are active in the market today. It also provides a context to help utilities respond to specific local needs and opportunities to increase the net value of their offerings. For many utilities, an early decision point focuses on whether and how to develop program components in-house or by engaging third-parties. This brief aims to support an informed decision process.

In several states, the regulated utilities' role in community solar is defined largely by legislation or regulatory policy. Here, utilities may be limited to involvement in interconnections and as billing agents for third-party program providers. In other states, or in consumer-owned utility markets where policy does not strictly define community solar, utilities have more leeway. This brief is geared primarily for those utilities.

Program-design choices maybe be characterized in term of a value chain, a set of successive activities that players operating in a specific industry perform, in order to deliver a product or service. The "links" in the community solar value chain span from planning support services through procurement of the solar resource, through all aspects of customer acquisition, administration and billing, and ongoing program implementation. In business theory, one key to improving cost-efficiency is to balance the number of profit-seeking players in the value chain against the need to involve the most capable and efficient players at each link of the chain. In seeking that balance, the utility may find answers to its questions about whether or how to outsource different program components.

Within the decision to outsource, there are yet more choices, among different kinds of solar developers and service providers. These range from established national providers (turnkey and *a la carte* developers), emerging national providers, local companies, and specialized service providers, primarily consultants. This brief looks at what each player can bring to support utility program development. Taking this broad view can facilitate more efficient and productive procurements. Finally, the brief offers a few insights about how successful utilities have led and continue to improve upon best-practices and increase the value of community solar for all stakeholders.

This work was funded in part by the Solar Market Pathways Program, powered by SunShot, in the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, an agency of the United States Government, under Award Number DE-EE0006905.

Key words: community solar, utility, procurement, program design, outsource.

About the Community Solar Value Project

The Community Solar Value Project (http://www.communitysolarvalueproject.com) is aimed at developing best practices for new community-solar programs at electric utilities, including guidelines on how to achieve greater reach and net value in four areas: strategic solar project siting and design, project financing and procurement, target marketing for customer acquisition, and integration with solar-plus companion measures, such as demand-response and storage. In 2016, the Project also supported adoption of "win-win" program-pricing.

The project is led by Extensible Energy, LLC, with support from Cliburn and Associates, Olivine, Inc., and Navigant Consulting. Utility participants include the Sacramento (California) Municipal Utility District (SMUD), Public Service of New Mexico, and other utilities nationwide. The project is powered by SunShot, under the Solar Market Pathways program of the U.S. Department of Energy.

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Disclaimer

Table of Contents

1. A Varied National Landscape for Community Solar

Since community solar emerged among a handful of consumer-owned utilities more than a decade ago, it has spawned a variety of business models, appealing to a range of utility- and non-utility stakeholders. Most utilities view community solar as an opportunity to offer more customer choice, especially for customers who cannot access conventional rooftop solar. Some utilities also see community solar as way to retain customers, to test alternatives to typical net energy metering (NEM) rates, or to capture technical benefits, such as strategic siting and grid integration strategies. Nascent utility interests in community solar include interest in using it as a springboard for promoting companion measures, such as demand response and storage. According to SEPA (Trabish, 2016), more than 75 utilities are offering or planning new community solar programs this year, and the majority of them are not primarily compliance-driven.

At the same time, state policies have trended toward non-utility leadership in this market, or toward mandated partnerships between utilities and third-party community solar developers. As of September 2016, 16 states and Washington D.C. have enacted community solar legislation—much of it emphasizing the non-utility role.

Whether influenced by utility leadership or by policy, community solar developments have emerged in at least 25 states. According to the Solar Energy Industries Association (SEIA), completed community solar project capacity totaled just over 100 MW in 2015, with another 100 MW expected in 2016. However, there is uncertainty about community-solar market projections, largely due to shifting policies from state to state. These conditions are typical of a young market, which benefits from experimentation, but which also struggles for degrees of certainty and standardization.

In its Q3 2016 *Solar Market Insight Report*, SEIA noted that it would hold to its 100-MW year-end projection for new community solar, even though only 10 MW had been built in the second quarter (SEIA, 2016). Many industry analysts imply that this young market will find its trajectory, if not this year, then very soon. Estimates of the market potential by 2020 range from a 2014 forecast of 1.8 gigawatts (GW) by GTM Research, to a peak range of 5.5 to 11 GW, offered by the National Renewable Energy Laboratory (NREL). Navigant forecasts that community solar will have a compound annual growth rate (CAGR) of 75 percent between 2016 and 2020, with the projected cumulative community solar market reaching roughly 1.5 GW by 2020 (Labastida et al, 2016).

The cost-competitiveness and overall value of utility-led community solar programs—especially relative to other solar choices—will likely influence how policymakers see the utilities' role in this market, moving forward. Smart utility decisions about how to design customer offers and whether or exactly how to work with third-parties can increase benefits for utilities, customers, and a range of stakeholders for years to come.

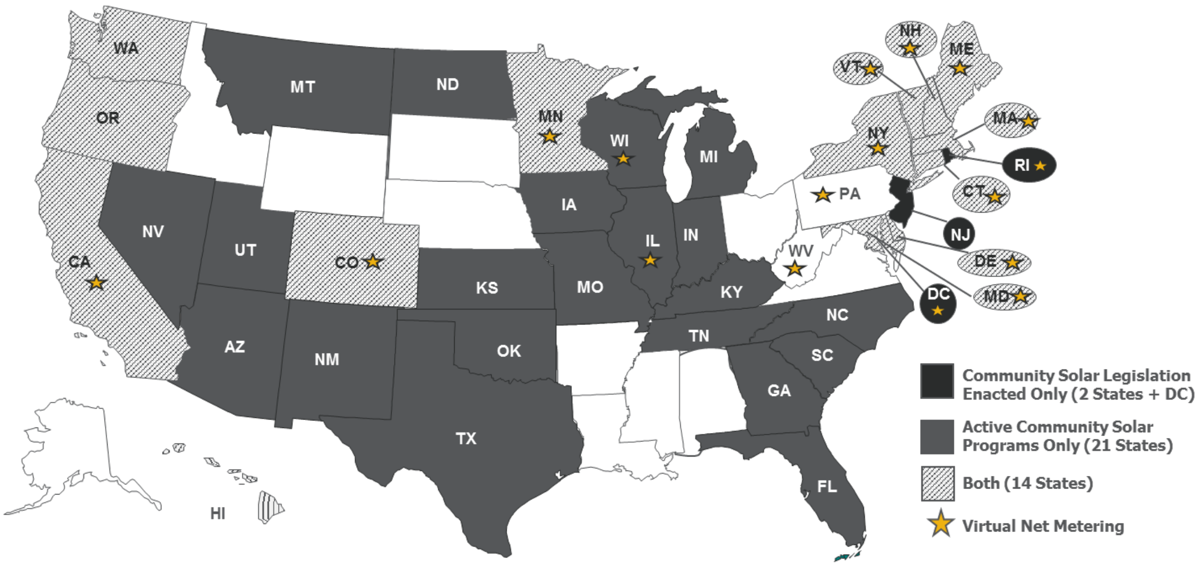

Figure 1: United States Community Solar Policy Landscape, 2016. *Source: Navigant. This map designates the states with enacted legislation and active community solar programs. California, Colorado, Massachusetts and Minnesota have the leading community solar policies and are expected to install the majority of the community solar capacity over the next two years.*

1.1 A Value-Chain for Solar Program Development

The CSVP has introduced a model program development process for utility-led community solar, which acknowledges its cross-departmental nature and facilitates the necessary give and take between market and technical concerns (Cliburn, 2016). This process, illustrated in Figure 2 below, is familiar in many ways to other utility program development processes. Yet community solar requires a relatively greater degree of cross-departmental participation, as well as alignment of sometimes-competing interests, in order to get from the idea stage to cost-competitive, strategic, and enduring program results.

It may be useful for the lead program designer to distill out of this process a simplified progression of program-development activities, from market research to program planning, to marketing, solar procurement, financing, billing, IT, ongoing project O&M, and overall program management. Bearing in mind that utility program development is truly a complex process, it is certainly practical to focus on each component activity as a progressive decision point, where the right choices can add value or cut costs. In effect, each decision point may be envisioned as one link in a solar program development value chain.

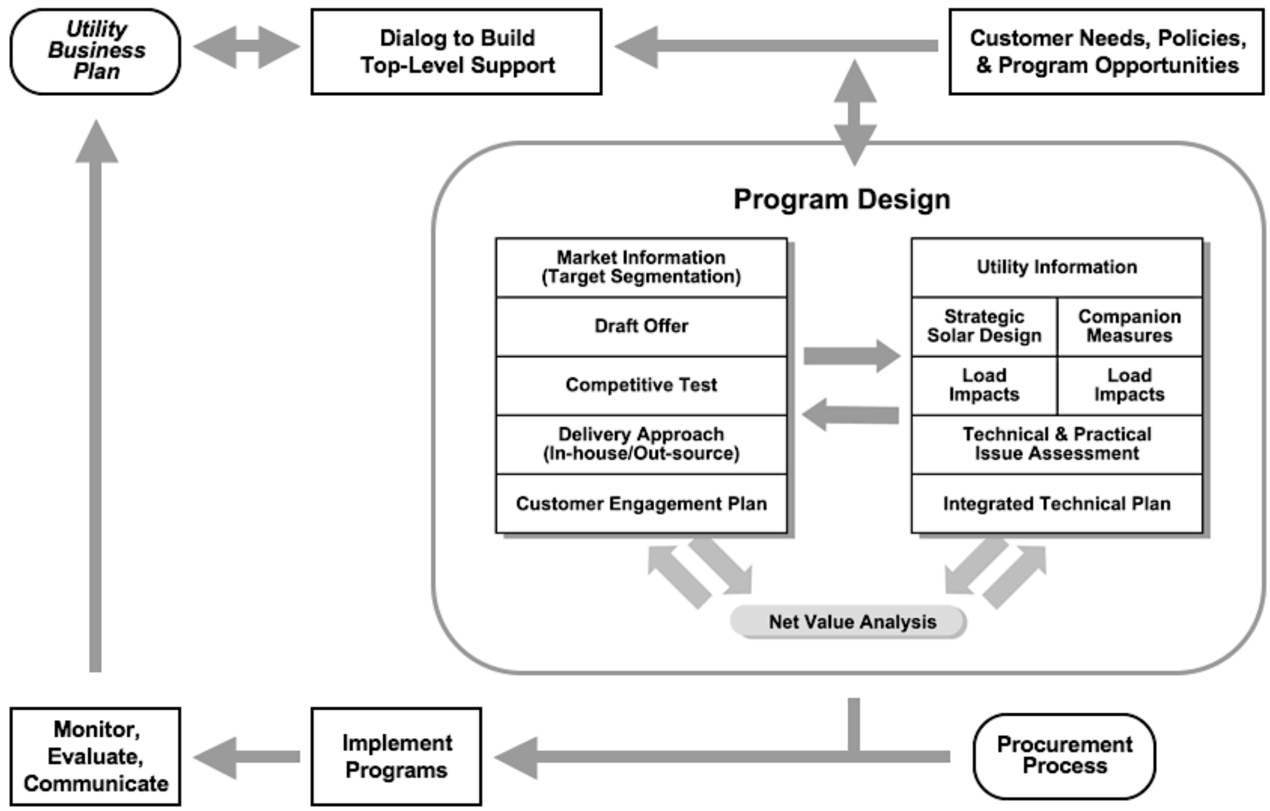

Figure 2: CSVP Community-Solar Program Development Process. Source: Community Solar Value Project. *This diagram illustrates the process whereby cross-departmental utility planning participants create their plan to manage each program component. This is, by nature, an iterative and complex process. Yet it is possible to distill out of this process a simplified progression of activities (See Figure 3), represented as a value chain.*

By definition, a value chain is a set of activities that players operating in a specific industry perform in order to deliver a valuable product or service for the market. In the solar industry, the full value chain is long, beginning with the manufacture of solar cells and panels and continuing through many component/links in solar product delivery. Here, we focus on the downstream links that are especially relevant to a successful community solar program.

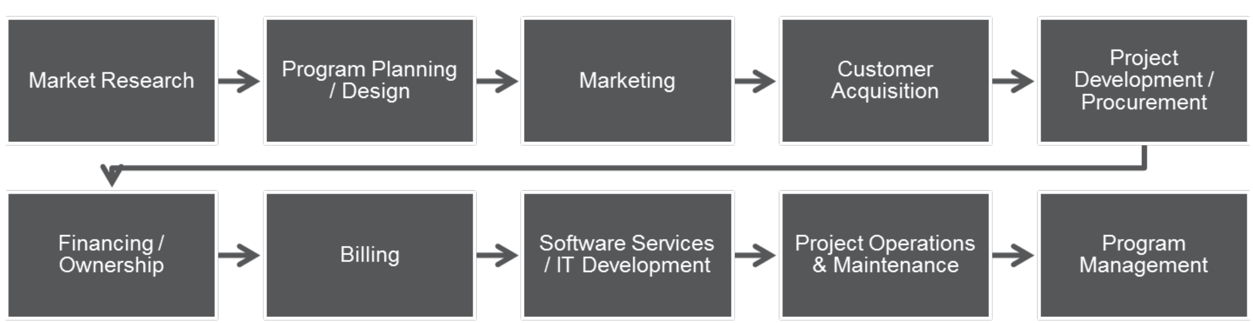

Figure 3: Simple Community-Solar Program Value Chain. Source: Navigant. *This simplified diagram highlights the products and services that a utility must access, either using in-house or out-sourced resources, in order to implement a successful community solar program.*

In business theory, one key to improving cost-efficiency is to balance the number of profit-seeking players in the value chain against the need to involve the most capable and efficient players for delivering value at each link. The right balance is going to be different for each utility: When is it better to rely primarily on in-house expertise and resources, and when is it better to outsource, in order to acquire necessary program products or services?

The community solar market was initially driven by smaller utilities, many of which lacked in-house solar expertise. Many of these utilities found that working with third parties was a practical solution. Clean Energy Collective (CEC) and SunShare were two early industry leaders spearheading a popular "one-stop-shop" community solar approach. Today, these companies and others also offer *a la carte* products and services to utilities, adapting to many policy structures. In addition, some third-party providers today work on only one or two links of the value chain, providing highly specialized products and services.

On the other end of the spectrum, a few utilities, such as Tucson Electric Power (TEP), have proposed to meet most their program needs internally. For example, TEP has an in-house solar developer, who leads utility identification and acquisition of solar sites, organizes financing, takes a hand in project design, and selects and oversees the EPC contractor. By compressing the value chain, TEP has driven significant costs out of solar procurement and has proposed a highly competitive program offer.

According to the *2015 Utility Solar Snapshot* (Edge et al., 2016), utilities planning community solar programs preferred utility-managed programs over third-party managed programs. Yet nearly one-third of all utilities surveyed said they would consider both approaches. More examples of why and how utilities assess their program-development choices, and how this impacts overall costs and benefits, are discussed in sections below.

2. Community Solar Business Models

Although many different business models are potentially useful for community solar, there are essentially two broadly defined generic models that represent starting points for utility program development. One model is generally associated with utility-led programs, and the other with third-party led programs.

To some extent, policy dictates which community-solar business model prevails in any given jurisdiction, and how it might be customized or improved upon. For example, states with vertically integrated monopoly utilities generally have the most leeway on utility project ownership and operations. In restructured states, utilities may be restricted from owning solar assets, but often may arrange third-party PPAs. In states like Massachusetts, only third parties can own and operate community solar. Consumer-owned utilities are generally unconstrained by state regulations on community solar, but they have tax considerations in determining whether to finance their own solar resources. Resources, such as the U.S. Department of Energy Solar Market Pathways Community Solar Toolkit (http://solarmarketpathways.org/toolkit/community-solar) can help utilities to get their policy bearings. In addition, CSVP offers additional guidance on financing for community solar on its website.

The following are generic descriptions of the two predominant utility business models. Note that there are many variations on each, especially in regard to which component products or services in the value chain the utility opts to provide directly, and which it opts to acquire from one or more third parties. Federal securities regulations and laws governing specific jurisdictions can affect the details of a viable business model, adding yet more variation to the market landscape.

2.1 Utility Outsourced Model

The outsourced model allows the utility to roll out a program relatively quickly and to shift many program risks, including project development and customer acquisition risks, to a third-party developer. In this model, the participating customer pays the third-party an upfront or monthly fee in exchange for a bill credit from the utility. The most typical utility-outsourced model is a full turnkey program.

This model has proven to be very popular with smaller utilities, but less so with larger and investor-owned utilities (IOUs). Typically, the utility does not own the solar asset. However, it is not uncommon for a PPA structures to allow the utility to have step-in rights, i.e. the right of first refusal to buy out a project or the right to take ownership at the end of the term of the contract when the solar asset is fully depreciated. In this way, the out-sourced model can deliver long-term utility value.

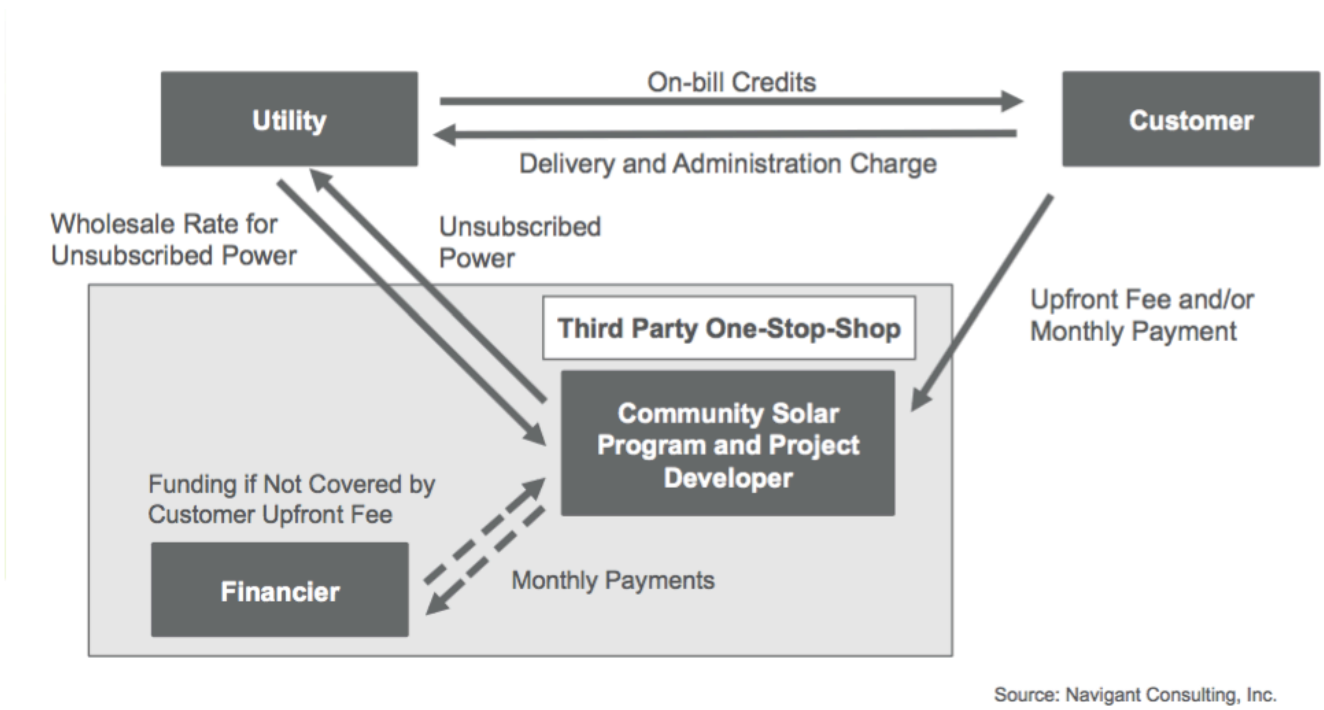

Figure 4: Generic Business Model for Outsourced Community Solar. Source: Navigant.

2.2 Utility-Led Model

The utility-led model offers the utility the greatest leeway for strategic customization and clear utility branding, which may benefit customer acquisition and retention. In the generic utility-led model, the participating customer pays the utility a monthly fee or rate for community solar in exchange for a bill credit. The utility develops the customer offer and implementation details, and it procures the community-solar resource. Procurement may involve development and direct ownership of the project. Alternatively, it may involve a PPA with a third-party developer, with or without an eventual utility "flip" or buyout. Often, the question of "ownership versus PPA" is dictated by state policies, including normalization rules, or by the tax status of the utility.

In the utility-led model, utility leadership may extend to some or all components of the value chain. Some utilities have found significant added value through their RFP specifications, for example, identifying sites that incur relatively low system-integration costs, calling for smart inverters or other preferred technologies, or by simply requiring a high level of transparency in how bidders explain their cost structures. A nascent trend involves utilities calling for community solar to be compatible with companion measures, e.g., offering energy efficiency, storage, or load management opportunities to enhance the community solar offer.

As more IOUs begin to launch community solar programs and as programs grow in size, the market is expected to tilt toward a utility-led model. Due to the market shift toward this generic model, developers have responded with more customized service offerings, in addition to the original "one-stop-shop" option.

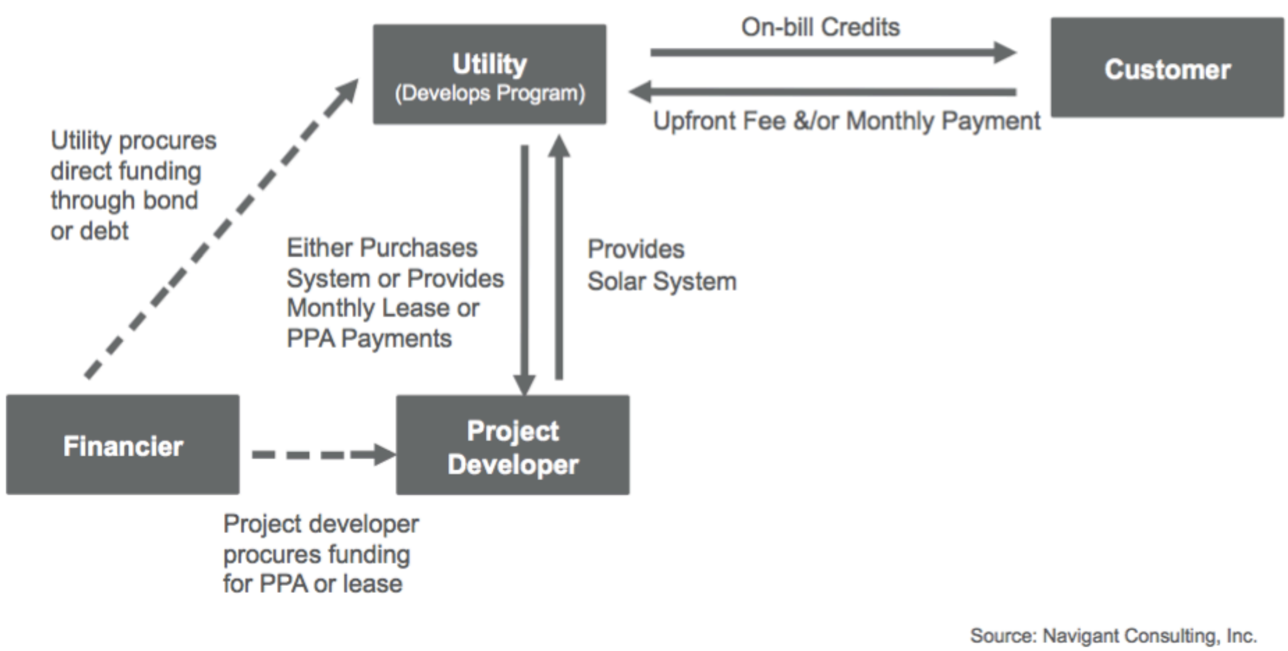

Figure 5: Generic Business Model for Utility-Led Community Solar. Source: Navigant.

2.3 Pricing Strategies and the Relationship to Scale

Interviews with utilities for this brief revealed that being able to offer customers a competitively priced program, relative to current electricity rates, is one of the most important program design objectives. Some utilities design the offer, including pricing, in-house; others rely on turnkey program developers or on consultants to design pricing. The long-term outcome is better if the utility brings an understanding of community solar offers and pricing options, as well as its concerns about pricing, to the discussion with third-party providers. If the utility is satisfied with the program cost and pricing structure, it is more likely to promote program success and expansion.

Over the last five years, two generic pricing models have emerged:

Panel Purchase or Lease. The customer pays an upfront one-time payment to purchase one or more panels in the solar project. On a monthly basis over the term of the agreement (between five and 20+ years), customers are credited on their bills for the electricity produced by their panel(s). The rate each customer is credited for share generation ($/kWh) depends on the program, usually determined by the utility, following an internal or state-mandated methodology. Some community solar programs offer customers the ability to participate through incremental monthly lease payments, or they finance the purchase through monthly payments. The purchase and lease variations look similar, but raise different tax and risk-management issues.

Subscription Rate. The customer enters an agreement with the utility or third-party program developer to pay a community solar rate ($/kWh) for a share of project output. This rate may be higher than the current standard rate, but many programs lock the rate in for a set term, so long as customers remain in the program. In this way, as standard utility rates rise, customers may save over the term of the their participation in the program. Customers are usually exempt from fuel-adjustment charges, clean energy riders, etc., but they pay a customer service charge. Variations to the subscription approach may include a periodic "true-up" based on actual project generation or different ways to define the share, i.e., keying to kWh blocks or to a percentage of the customer's energy use.

As larger utilities and state programs become more prominent in the community solar landscape, the market has shifted away from the panel purchase or lease model and toward the subscription model. Most customers do not want to make a large up-front investment, and program designers (especially for large utility-led programs) see managing many separate long-term agreements with participants as burdensome. The panel-purchase model is especially troubling for utilities that are concerned about the long-term disposition of the community solar assets.

In terms of price point, community solar was initially accepted as a premium-priced offer. However, with across-the-board solar cost reductions and the long-term cost stability of solar generation, many community solar customers have come to expect long-term cost-savings. Survey research conducted by Shelton Group and SEPA found that on the whole, customer interest in solar is driven by potential financial benefits (65%), followed by environmental impact (38%) and energy control (34%). (SEPA & Shelton, 2016) Many customers are willing to pay a small premium (ideally in the range of one to two cents) in the short run, assuming the program price is locked in as retail rates rise, and that the program is otherwise structured to customer needs.

Market research for community solar is a fairly new field, as community solar itself is unfamiliar to most utility customers. CSVP offers information resources (Mitchell-Jackson et al., 2016) on best-practices for community solar market research, including ways to segment the market to match pricing and other aspects of the program offer to market-segment needs. Like other links in the community solar value chain, market research may be out-sourced or completed mostly in-house.

Whether a customer saves money immediately or has to pay a premium to subscribe depends on current utility electricity rates, solar procurement costs, the accepted net value ($/kWh) of the solar resource, and state policy on NEM.

Many community solar programs struggle to compete with the rooftop solar market, as generation from community solar is seldom credited at full retail NEM rates, which rooftop systems currently receive in major markets. Despite evidence that customers are looking for a better deal, many utility-led community solar programs have charged a $0.01/kWh to $0.04/kWh premium, and many programs have simple paybacks approaching ten years or more.

With the ongoing debate across the country about value of solar (VOS) and NEM policy reform, uncertainty exists regarding how states will compensate all forms of distributed solar in the future. Many states are now exploring changing their NEM policies away from full retail NEM compensation. Such changes would impact the competitiveness of many community solar programs. Currently, community solar must receive full retail NEM compensation only in Massachusetts, while Colorado and Minnesota offer a VOS rate; California values community solar at the avoided cost of energy, and other community solar programs vary. According to Navigant Research (Navigant, 2016), NEM rate reform may actually cause a market shift from rooftop solar to larger community solar projects, which offer relative economies of scale.

The quest for community solar cost-competitiveness, absent full NEM compensation, has led to another debate, over the proper location and project scale for community solar. Some states specify that community solar should be located on the distribution grid or meet “community scale” size restrictions. For example, Minnesota law limits community solar projects to one MW each, in maximum groupings of five co-located projects. California’s community solar law states that projects should be “in reasonable proximity to enrolled participants” (Stanton & Klein, 2016). Such guidelines are rooted in the idea that community solar is a proxy for local customer systems. But some utilities and third parties argue for projects on the high end of distribution scale (up to 20 MW) or for solar power purchased out of remote utility-scale systems in order to maximize economies of scale and customer savings.

The CSVP and others, including the Rocky Mountain Institute (Brehm et al., 2016) argue for keeping community solar local, building portfolios of mid-sized projects (primarily less than 5 MW) that unleash other distributed energy benefits, beyond what CSVP has called the solar “sticker price” (Cliburn et al., 2016). RMI has asserted that “community-scale solar is at a sweet spot between utility-scale and behind-the-meter solar.” RMI cites its work with relatively small set of utilities that have dramatically reduced community-scale solar costs. Cliburn, Bourg, and Powers have modeled how just a few, carefully selected and conservatively assessed values can close the gap between utility-scale and distribution-scale projects, at least to within range of an inconsequential initial premium.

The latest PV pricing benchmarks from NREL (Fu et al., 2016) calculate national weighted-average installed costs per Watt DC for projects of different sizes in Q1 2016. A 500-kW commercial rooftop project was benchmarked at $2.06; a 1-MW project was benchmarked at $2.03. On the utility scale, a 5-MW fixed-tilt ground-mount project was benchmarked at $1.92; a 10-MW project at $1.83, and a centralized 100-MW project at $1.49. Actual installed costs vary considerably by region and by individual project. Further, design improvements, such as single-axis tracking, which raises 5- and 10-MW project costs by about a dime each, may significantly improve net economics. Nevertheless these benchmarks are a useful starting place for closing the cost gap. Figure 6 shows typical cost components of small- to large utility-scale systems. It is important to ask, 1) can improved procurement strategies reduce the installed costs of project fleets, and 2) what are the net total benefits an improved local strategy, and how does that improve the net levelized cost of energy from the procurement decision? CSVP will release a brief in 2017 on lowering community solar procurement costs. A few examples of utility lessons learned are summarized in Section 4.

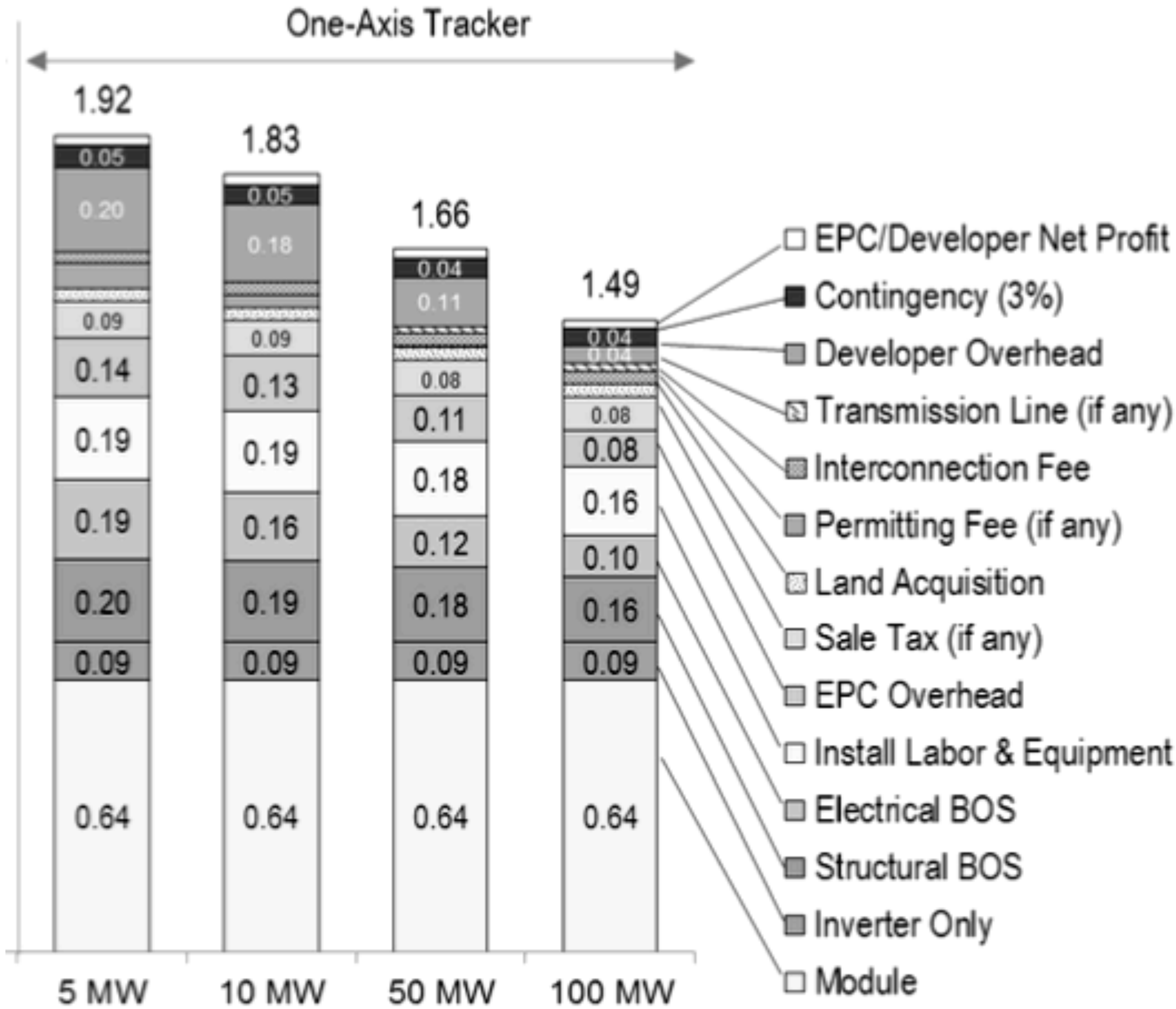

Figure 6: Benchmark Installed Solar Costs ($/W DC) for a Utility-Scale Single-Axis Tracking Projects. Source: NREL, Q 1 2016. *The breakout of component costs suggests areas where costs may be reduced for distribution-scale project procurements, relative to the 50- and 100-MW centralized project options. In addition, a full economic analysis of community-solar options would include strategic values associated with local vs. centralized installations.*

In some jurisdictions, policy-makers have agreed to test the value of community-scale solar as an integrated distributed energy resource (iDER) strategy. The result could be a higher accepted net value of the solar resource ($/kWh); a partial wires-charge reduction for these projects; or some other form of compensation to program participants for associated grid benefits. Some utilities, like Sacramento Municipal Utility District, are launching shared solar programs that use large-scale solar resources along with some distributed solar projects, too. They hope to capture ready economies of scale, while further testing the local-solar value proposition. The New York Public Service Commission has been one leader of local solar iDER strategies, which encompass community solar (Stanton & Kline, 2016).

Navigant cites interviews completed for this brief, with major solar developers and utilities that are moving to larger utility-scale projects, as evidence of a significant trend. No doubt, scaling up will be one way—but perhaps only one among many—that utilities and third-parties use to lower costs and program pricing.

3. Third-Party Providers and the Utility Request for Proposals

A number of companies provide products and services all along the community solar value chain. These industry players can be divided into four categories:

- *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 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).

National Providers	Emerging National Providers*	Local 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 • 3Degrees • Tendril • Project Economics • Ampion • Navigant • Smart Electric Power Alliance

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

Figure 7: Community Solar Third-Party Players. Source: Community Solar Value Project. *This reflects a market assessment as of late-summer 2016. Listings of companies are representative, and not all-inclusive.*

The field of providers that focus on community solar has grown slowly, and two providers, Clean Energy Collective and SunShare, have held the lead for more than five years. Other providers (exemplified in Figure 7) have strong business models, including some that focus on solar development and others that offer services in program design and delivery.

3.1 Third-Party Perspectives on Barriers to Market Growth

In interviews for this brief, community solar developers and service providers were asked to identify industry barriers, i.e., asking, What changes in procurement requests would trigger greater interest on your part? Their suggestions to spur the market included

- *Procurements that capture greater economies of scale.* This might include procuring projects in the 2- to 10-MW range, instead of projects under 0.5 MW; procuring multiple projects in the 500-kW to 1-MW range simultaneously through one request for proposals (RFP); building a larger project of greater than 5 MW and carving out a portion of the capacity for community solar.
- *Joint or shared procurements.* These include consumer-owned utilities that wish to procure a smaller project, working with neighboring utilities or through associations on a joint RFP.
- *Pre-identification of sites.* If the utility can identify a few sites prior to the RFP, this shortens the project development timeline and manages risks associated with the uncertainty and risk of finding and obtaining land. Giving developers two or three sites to choose from allows them to determine their most appropriate site and to bid more aggressively. In some states, such as New York and California, utilities are also asked to identify best sites in terms of grid capacity.
- *Improved third-party developer compensation.* Development contracts vary from utility to utility, making it difficult for developers to replicate their business models. If the developer is involved in acquiring customers and managing ongoing participation, too, then associated utility agreements and rates structures must be mutually agreeable.

- *RFPs that welcome creative project solutions*. Developers interviewed consistently said that they prefer flexibility to strict specifications on requests for proposals, and they benefit from meetings (e.g., bidders' calls) to discuss the job.
- *Policy support*. While this is not an immediate remedy, developers look for support at the state and national level to increase standardization of programs and processes.

As large regional markets for community solar develop, including California's 600-MW market potential, project procurement concerns will undoubtedly shift. Yet for now, the community solar market nationwide is largely comprised of electric cooperative and municipal utilities, together representing almost 90 percent of community solar programs (Deloitte, 2016). Their average project size is well within the range suitable for siting on the distribution grid. And, in fact, a number of third party providers, both local and national, are working to serve them.

Especially if the utility program is going to focus on distribution-scale solar, then developers who are successful and committed to working at the specified scale may be best prepared for the job. For them, challenges often center on risk management: Is the site identified and pre-screened? Assuming a PPA agreement, will the utility be the contractual off-taker for unsubscribed shares? Is construction contingent upon reaching a project subscription goal? These and other concerns affect project finance and the development timeline.

3.2 Utility-Identified Benefits of Working with Third Parties

For the utility, the decision to outsource some or all components of the program development value chain requires an internal review of many trade-offs. Moreover, the utility program manager must complete this review within the broader context of an interdepartmental program planning process. But in summary, the potential benefits of a well-considered outsourcing plan include:

- *Improved Program Roll-out*. Third-parties can offer quick, efficient program roll-out.
- *Potential for Improved Cost Effectiveness*. Particularly for smaller community solar programs, bringing in third-party expertise instead of reinventing the wheel can be beneficial and cost effective.
- *Access to Experience*. Third parties can bring previous experience designing and marketing community solar programs and acquiring program participants.
- *Bill Integration*. Some third parties offer billing and software integration platforms.
- *Federal Incentive Monetization*. Third-party developers can help consumer-owned utilities or IOUs subject to normalization to take better advantage of tax incentives.

4. Utility Leadership in Lowering Costs and Adding Value to Community Solar Programs

The CSVP holds a premise that utility leadership can add value to community solar, whether program components are developed in-house or whether they are significantly outsourced to third parties. Under most state policy regimes, there are opportunities for utilities to lower costs and add value all along the community solar value chain. These opportunities are present, whether through direct utility involvement in project development or through their leadership working with third-parties.

A half-dozen utility community solar program managers were interviewed for this brief, supplementing information already available in the literature. Reflecting upon their decisions about working with third parties, utilities commonly cited the following areas of concern:

- *Preparedness for Program Design and Procurement*. Several utilities cited the importance of self-education, involving program managers and others across utility departments, in order to assess capabilities and needs, and in order to spot ways to improve program cost-effectiveness.
- *Pricing Transparency*. Utilities would appreciate more transparency in pricing from community solar providers, as the utilities decide whether to handle aspects of the project scope internally or not, and how to maximize savings that they could pass along to customers. Some utilities recognized that third parties are becoming more open about their cost structures, as the community solar market grows.
- *Consistency and Quality of RFP Responses*. Some utilities mentioned that RFP respondents used different assumptions in their analyses, making it difficult to compare bottom line economics of different solar development proposals. The solution to this problem rests partly with the utilities' care in writing the RFP and partly with the developers' care in responding. A CSVP *Resource Guide for Local Procurement* (Romano & Auker, 2016) is an early response to this concern, referring to best-practice processes and linking to an archive of sample utility community solar RFPs.
- *Contract Negotiation*. A number of utilities that have contracted with third-parties commented on the length and difficulty of contract negotiations, requesting an easier process to avoid project delay.
- *Partial Value Chain Support*. The increasing willingness of third-parties to provide flexible offerings has been helpful. For cooperatives and municipal utilities, working with third parties to leverage tax benefits can add value, but not all of these utilities want turnkey services. Many prefer to draw on in-house capabilities, as well as on other sources of expertise. Generally, smaller and consumer-owned utilities are open to using third-party expertise for program design, marketing and customer acquisition, and billing/IT. Yet, larger investor-owned utilities view such activities as core to their business model, and they tend to develop such capabilities in-house. A few utilities interviewed are moving to create community-solar development processes that parallel their existing processes for developing other customer programs and engineering project procurements. These utilities may prefer to use third parties only for solar EPC services on pre-identified sites.
- *Operation and Maintenance Funds*. Utilities that are considering outsourcing project development expressed the importance of setting aside operation and maintenance (O&M) funding for the duration project.
- *Utility as Primary Customer Contact*. Several utilities commented that they prefer the utility to remain the primary customer contact.

Examples of replicable, high-value utility innovations cover all areas of CSVP's interests. As noted, these will be further documented and assessed in upcoming CSVP publications. A few examples, drawn from utility interviews, focus on project siting and design; customizing to meet target-market needs; incorporating solar-plus companion measures; and attention to the procurement process.

Examples of Utility-Led Community Solar Innovation

1) Strategic Solar Siting and Design

- One utility estimated that finding the project site typically represents 5 to 7% of developer's cost. This utility and others have reduced costs by identifying or providing the site. Utilities may leverage decades-long relationships with local governments and other utilities (e.g., water utilities), to obtain good sites that would elude third parties. Strategic siting is an emerging interest; most often, utilities can tell developers where adding solar would be problem, but they are exploring new ways to tell where solar could add grid benefits.
- Utilities concurred that careful site review is important, in order to minimize permitting and compliance costs, and to address NIMBY issues before they arise. Whether the developer or the utility chooses the site, it may present costs and delays that are not readily apparent.
- Several utilities asserted that they are more likely than a developer to include system design improvements that might add costs upfront, in return for benefits that accrue over the long term. This includes strategic use of single-axis trackers or selecting and operating new interconnection technologies for added project value. The utility may wish to include strategic design objectives in RFP specifications.

2) Customizing to Meet Target Market Needs

- A major innovation in this area involves utilities partnering with third-party developers and non-profits that focus on low- to moderate-income needs. For example, one utility worked with a third party to mobilize volunteer labor for a "solar barn-raising" construction event, which lowered project costs and also attracted media coverage, to help meet subscription goals.

3) Incorporating Solar-Plus Companion Measures

- Some utilities see community solar as (to use a CSVP phrase) creating a market-based laboratory, to test innovations that boost grid-integration value. For example, Austin Energy will co-locate a utility-side storage battery with its new community solar project. There is not an immediate pay-off, as the storage project will be run separately and requires an upstream subsidy at this time. However, the utility is looking to gain experience with storage, and it is giving customers the chance to be part of the utility's unfolding 21st Century iDER strategy.

continued on next page

- Other utilities are using storage water heaters as a currently economical companion measure for community solar. The controlled water heaters reliably provide hot water, at the same time as they serve as thermal batteries. Utilities aggregate this demand-response resource across participants, and share the benefits back, by buying down the cost of the community solar resource or providing other incentives. Utilities have been the leaders for this innovation, but third parties in both demand-response and solar have expressed interest in supporting it.

4) Attention to the Procurement Process

- Several utilities interviewed are taking a fleet-development approach to accessing economies of scale. For example, utilities can deploy similar community-scale projects under one procurement. If projects are to be built out over time, the final cost paid to the developer for succeeding units can be adjusted to update the pricing. Early subscribers could benefit from this arrangement, too, if their subscription costs are adjusted to factor in declining fleet average costs in future years. Distribution engineers prefer the geographic diversity of these projects, compared to one large-scale project.
- Smaller utilities may have trouble building expertise in-house, but for electric co-ops and public power utilities, their generating and transmission (G&T) cooperatives, joint-action agencies, or financing partners (e.g., CFC), may step in. This innovation mirrors the developers' desire for larger, shared procurements.
- Some utilities work with "buy-side consultants" to oversee project procurement and to help negotiate more confidently. RMI has cited a Lawrence Berkeley National Lab study that shows a 60 percent spread in installed costs for larger commercial and industrial solar projects; this range suggests that some contracts are not being effectively negotiated (Brehm et al., 2016). Several utilities interviewed said they issued a Request for Information before the procurement, as a way to self-educate before they issued the RFP.

5. Conclusion

Community solar is a concept that is evolving, affected by broader solar economics, policies, other competing customer choices, and by utility and non-utility players who together comprise the community solar program-development landscape. Most utilities view community solar as an opportunity to offer more customer choice, especially for customers who cannot access conventional rooftop solar or who find other aspects of the program offer appealing. Some utilities also see community solar as way to retain customers, to test alternatives to typical NEM rates, or to capture technical benefits, such as strategic siting for solar projects and grid integration strategies or operational flexibility. Utility leadership in community solar has spawned innovations in program design and development, as well as rising demand for even more attractive and carefully targeted programs. In these ways, utilities are better able to serve customer interests in financial gain; positive environmental impact; control and choice in their energy use, and more.

The pressures utilities feel to compete on price with net-metered rooftop solar and to some degree with programs styled after green tariffs, has created some uncertainty about how community solar will develop in the future. Further, state policies have trended toward non-utility leadership in this market. This includes a strong role for third parties in the emerging California market, which could reach 600 MW and affect market trends nationwide. Questions of whether or how NEM policies may change nationwide also could have far-reaching impacts. An easing of net metering rules could make community solar—which tends not to include a full net metering benefit—relatively more attractive.

In this environment, many third-party community-solar developers, as well as some utilities, see promoting economies of scale as the surest way to lower program costs, and improve competitiveness.

Other utilities—and particularly those that have regulatory leeway—are still focused on community solar as an opportunity to unlock numerous economic benefits of distributed solar and iDERs. They have innovated ways to mimic economies of scale by procuring multiple, similar community-scale projects, or by arranging a group buy. These are led by several electric cooperatives, but the fleet-development approach is widely applicable, and the group-buy concept may be adapted in different ways, such as working with a carport-solar site host who could monetize the value of the shade, while helping to make local community solar happen. Other utilities have promoted opportunities in strategic solar siting and strategic design, or target marketing, or in adding demand-response and storage companion measures, and in new pricing plans that offer a good deal for both the utility and the customer. Some of these utilities are working with third-party developers and service providers, driving selective and careful procurement strategies, to determine which are the best choices for getting each of the program-development components they need. The CSVP team has demonstrated that in many cases, the economics of local, community-scale solar can compare favorably with large-scale, centralized solar options, and CSVP's work to document cost-reductions and value enhancements is ongoing.

This brief specifically highlights the challenges and the benefits to utilities in working with third-party providers. As the community solar market is evolving, there is increasing diversity among third-party providers, from those specializing in one component of the solar value chain to those offering both full-service program development and *a la carte* options. In this market, there is also a key role for utility leadership, to set a high bar for their internal cross-departmental teams and for their third-party partners, so community solar can reach its game-changing potential.

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Twelve Community-Solar Pricing Strategies From Utilities in the U.S.

A Summary Table

Community Solar Value Project

September 2017

Summary

Twelve Community-Solar Pricing Strategies for U.S. Utilities is an illustrative round-up of strategies from utilities in Arizona, California, Colorado, Massachusetts, Iowa, Minnesota and Texas. In each case, the summaries are written from the utility perspective, even though in several cases, state policies have dictated a relatively narrow role for the utility. CSVP embarked on this effort in order to show the range of program and pricing options currently in the marketplace. While each of the utilities featured have incorporated some best-practice elements into their plans, we do not attempt to rank or evaluate them. Community solar program design must be suited to each utility, in consideration for state policy, utility energy-supply relationships, internal utility-team strengths and limitations and customer preferences. Yet a careful study of the strategies described here can suggest directions for utilities to travel—or to avoid.

The challenges in creating a document of this type are considerable. Programs are constantly changing, as are their points of contact. Further, the summaries assume certain background knowledge about community solar and utility pricing and tariff conventions. We refer readers to additional program-design information and resources on the program website, www.communitysolarvalueproject.com.

Key words: community solar, utility solar, solar rate, solar tariff, solar program design, case study

This work was funded in part by the Solar Market Pathways Program, powered by SunShot, in the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, an agency of the United States Government, under Award Number DE-EE0006905.

About the Community Solar Value Project

The Community Solar Value Project (http://www.communitysolarvalueproject.com) is aimed at developing best practices for community-solar programs at electric utilities, including guidelines on how to achieve greater reach and net value in four areas: strategic solar project siting and design, project financing and procurement, target marketing, and integration with solar-plus companion measures, such as demand-response and storage.

The project is led by Extensible Energy, with support from Cliburn and Associates, LLC, Olivine, Inc., and Navigant Consulting. Utility participants include the Sacramento (California) Municipal Utility District (SMUD), and other utilities nationwide. The project is powered by SunShot, under the Solar Market Pathways program of the U.S. Department of Energy.

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Disclaimers

Community Solar Program Pricing Models: 12 Utility Examples

Utility Program Name	Pricing Model	Rate or Billing Structure	Competitive Impact: Customer Monthly Bill	Comments/Lessons Learned	Project Contact and Website
AZ **Salt River Project, EarthWise Community Solar Project** **(program closed to new subscribers)**	Block charge: $/kWh based on the generation per 1-kW capacity blocks Customers could subscribe for 1-kW block for each 5,000 kWh of annual energy usage, up to 50% of their total annual usage. Subscribers' past 12 months of usage determines the number of blocks allowed.	Term: 5 years. The agreement could be transferred to new location within SRP territory. Subscribers could cancel anytime but could not re-enroll for 12 months after cancelling. They could add or drop kW blocks once every 12 months. Residential customers pay $0.099/kWh and commercial and school customers pay $0.089/kWh for solar electricity generated from their share. RECs: SRP owns the RECs.	Program has offered savings for customers on Basic and EZ3 price plans. Time-of-Use price plan customers paid a slight premium. The average SRP customer uses 15,000 kWh annually, so is eligible for a 3 1-kW blocks. Sample customer savings/loss per rate: Basic: $5.03/yr. savings EZ3: $30.10/yr. savings TOU: $42.15/yr. premium	Since March 2015, the program has been closed to new enrollment. A new program is being deployed (see below). Reportedly, customer uptake was slow due to the minimal savings on the Basic rate and the premium that resulted for customers on the TOU rate. The determination was that a simpler program, albeit with a premium charge, would be more popular.	Melissa Burger Melissa.Burger@srpnet.com http://www.srpnet.com/environment/SolarforNonprofits/projects.aspx
AZ **SRP EarthWise Energy #2**	Rate: $.01/kWh premium, similar to Green Tariff Customers choose to green 50% or 100% of their electricity use, with RECs that the utility procures from renewable energy wind, solar, biomass and/or geothermal.	Term: Begins with the next available billing cycle and may be canceled anytime. SRP EarthWise Energy works with all residential rate plans except M-Power and most business plans. RECs: Retired for subscribers, who receive an annual statement for RECs acquired on their behalf.	Competitive Offer: If a subscriber uses 1,000 kWh in a given month, they would pay an additional $10.00 to green up 100% of their energy use; $5.00 based on 50% of their usage that month. If SRP acquires RECs for less than $0.01/kWh, all remaining revenue will help fund SRP's renewable energy and energy-efficiency programs. This benefits all customers by helping to advance these sustainable options.	Sustainable resources now provide 14.5% of SRP customers' energy needs, ahead of schedule to meet the utility's target of 20% by 2020. The utility plan puts emphasis on a diversity of utility-scale renewable energy resources.	Melissa Burger Melissa.Burger@srpnet.com https://myaccount.srpnet.com/myaccount/earthwiseenergy

AZ **Tucson Electric Power,** **Bright Tucson Community Solar Program**	Block charge: $3/Month for 150 kWh	Term: 20-years from opting into the program. Customers may cancel their participation at any time, but would lose potential benefits. Structure includes locking in the base energy charge for the share, and exempting fuel- and renewable energy surcharges. RECs: TEP owns RECs.	Program premium of $0.02 per kWh allows customers to engage with solar with no-hassle and opportunities for long-term benefits. Solar fields located on the distribution grid. Revenue from the premium is put back into utility's RPS program.	The current retail rates is about $0.12/kWh, so asking customers to pay an extra 15% or $0.14kWh was considered a reasonable premium for this market. Participation remains strong, with about 30 MW dedicated; however the hybrid program (below) was proposed as an improved option.	Ted Burhans tburhans@tep.com https://www.tep.com/news/community-solar/
AZ **Tucson Electric Power,** **Hybrid Residential Community Solar Program**	Flat Rate: based on $/Month for energy production of each 1-kW capacity block; multiple blocks may cover 100% of customer usage	Term: 10 years, for an agreement that will effectively green 100% of the bill. $17.50/Month per kW block; applied to customer's total energy usage. Structure: Based on fixing the energy charge and exempting fuel- and renewable energy surcharges. Contract required; customers pay a penalty if they leave early. RECs: TEP owns RECs	A flat-bill, remains the same if use is 15% above or below contracted rate. Competitive based on budget-certainty, long-term set cost, no-hassle solar option. Community-scale systems would be located on distribution grid, and at a location easy to view.	Although the utility may not recover all costs, it aims for greater customer retention. Program is still be considered as part of general rate case. Final plan anticipated in late 2017.	Ted Burhans tburhans@tep.com https://www.tep.com/residential-solar/
CA **Pacific Gas & Electric,** **Green Tariff Shared Renewables Program (GTSR)**	Rate: $/kWh applied to a % of the total bill (GT) The new Green Tariff (GT) for the Solar Choice program and Enhanced Community Renewables (ECR) Regional Renewable Choice program rate schedules are available in Public Utilities Commission Advice	Term: Customers can disenroll and change participation levels at any time. However, they cannot re-enroll or make other participation level changes for 12 months after disenrolling. PG&E's GT is called Solar Choice (available now): Subscribe 50% or 100% of usage from a pool of small	Competitive Profile: GT rate is based on portfolio of projects, and has a 2-3 cent per kWh premium at the current time. ECR rate is based on the customer's agreement with the developer. Advantage: Opportunity for those who cannot support solar through other means to green their energy use. No hassle approach.	As PG&E's overall generation costs increase and solar costs decline, it is possible that the premium will diminish.	Molly Hoyt M2HX@pge.com https://www.pge.com/en_US/residential/solar-and-vehicles/options/solar/solar-choice/which-program-is-best-for-you.page https://www.pge.com/en_US/for-our-business-

	Letter 4639-E-A	and mid-sized solar projects created for this program in PG&E's service territory. PG&E's ECR is called Regional Renewable Choice (opening late 2018): Requires a separate agreement with a solar developer to buy subscription rights for a selected portion of a local solar project's output. RECs: PG&E retires RECs on the customer's behalf.	Program is in response to California legislation, SB 43. Utility must recover all costs from customers participating in the GT program. Projects from which solar is generated may not be specifically known to customers; considered a green-power premium program by most observers.		partners/floating-pages/community-solar-choice/community-solar-choice.page
CA **Sacramento Municipal Utility District, Residential Solar Shares Program**	Block charge: $/500-kWh block Actual rate is pending a utility-wide revision of the rate structure, to incorporate time-of-use (TOU). Rate based on pass-through cost of the community solar resource portfolio (PPAs). Total Price = Energy Cost Component + Delivery Service Cost Component	Term: Annual basis An existing SolarShare program is continuing, with generation from a 1-MW PV project; it is closed to new subscribers. RECs: SMUD retires them on customer's behalf.	If the SolarShare allocation exceeds the customer's usage for a specific TOU period, the excess will appear on the bill as a credit based on the calculation of the energy-only portion of the customer's standard rate during that period. If this credit exceeds the customer's energy charges for the month the credit occurs, the remaining unused portion will be carried over to the succeeding month's energy charges until the credit is fully utilized. If the SolarShares allocation over a 12-month period exceeds the customer's usage, SMUD will buy the unused portion back at the price the customer paid for the energy-only portion of the SolarShares and will adjust customer's allowed share for the next 12-month period.	To be determined once the $/kWh rate is set. Utility calculates the capacity of solar needed based on seasonal generation patterns of PV systems in the service territory The Delivery Service Cost Component is based on delivery costs normally included in the customer's standard rates. These include: Generation Capacity, Ancillary Services, Delivery Services (T&D), Public Goods, Fixed Distribution Facilities Recovered in Energy, Power Factor Adjustments, and Program Administration. The Energy Cost Component is equal to the average cost of energy from all SolarShares installations. The Energy Cost Component could decrease over	Patrick McCoy Patrick.McCoy@smud.org https://www.smud.org/en/residential/environment/solarshares.htm See also case study on http://www.communitysolarvalueproject.com

				time as more solar projects are added to the program. TBD: Whether early adopters will receive this adjustment.	
CO **Xcel Energy** **Solar Rewards Community (third-party implementation)** **also *Renewable Connect (in-state solar green tariff run directly by Xcel)***	Solar Rewards Rate: Depends on the third-party offer. Some projects require capacity purchases ($/kW or $/panel upfront), while other projects are energy-based ($/kWh). *Renewable Connect Rate: Xcel solar green power tariff, to be finalized for 2018 program.* *In addition, the utility offers Windsource, a wind-based green power tariff, for a $0.015/kWh premium.*	Solar Rewards Term: 25 years. Ability to exit/transfer the program depends on the third-party provider. Each "Garden Operator" can make changes in its offer, and file that information. Retail net metering is in effect for solar energy generation for Solar Rewards. RECs: Xcel purchases RECs from the third-party developer/project owner.	Competitive offer: Community solar was introduced in Colorado through legislation, and the offer in each state relies upon NEM benefits (credits) paid back to subscribers for the solar kWh produced. Under a 2017 settlement agreement, projects 100 kW to 2 MW are accepted into the program on competitive bid; Xcel will buy up to 105 MW 2017-19, plus 4 MW/yr from projects on this scale serving low-income customers. For projects under 100 kW, the standard offer (by which Xcel buys the generation) is $20/MWH. Projects <100 kW serving low-income customers get a $10/MWH adder ($30/MWH total) standard offer; 500 kW total/yr. The utility participates in billing for third-party providers. Customer economics for SolarRewards are not known to the utility, as they vary by third-party provider and by project.	In CO, projects must have at least 10 subscribers and no subscriber can own more than 40% of the project. Each customer's share cannot produce more than 120% of a customer's historical usage (true-up will be provided). *Renewable Connect is anticipated to offer a subscription for solar power from large, in-state solar projects, using a simple tariff. The utility plans to offer a program that would not directly compete with the Solar Rewards third-party offer. Total capacity is anticipated at 225 MW through 2019.*	Jonathan Bach jonathan.r.bach@xcelenergy.com https://www.xcelenergy.com/company/media_room/news_releases/parties_reach_settlement_on_key_colorado_energy_issues Colorado Bill Credits are available on the Xcel Energy website: https://www.xcelenergy.com
MA **Community Solar for National Grid customers –CEC example**	Non-Utility Model Rate: $/kWh Subscription, for energy from provider-financed solar projects Shares based on % of	Term: Savings agreement for 20 years. For this program, CEC offers 15% savings on the energy that is provided by solar under a CEC	Competitive offer is based on the availability of net-metering and the SREC-market credits; also CEC has a $0 –down sign-up offer. Different MA utility service areas have different arrangements with third-party	State-mandated utility participation in Community Solar; the program, including solar development, is run by third parties, such as CEC. Other MA utilities have different arrangements, e.g., Eversource pays	Dan Mcilroy Dan.Mcilroy@Easycleanenergy.com http://www.easycleanenergy.com/

	customer's energy needs; e.g., 100% of usage CEC is one of several third-party providers, each having a branded program offer.	subscriber agreement. RECs: CEC owns RECs and sells them on the market as Class A SRECs so receive 100% of the SREC value.	providers. For National Grid customers, the utility provides all solar bill credits to the customer. Customers pay CEC for their subscription, and net a 15% savings monthly.	the credits (10 to 15% savings) to CEC, and CEC sends subscribers a payment for their share of credits. This model depends on mandated NEM. It is only replicable in states with a similar regulatory framework and assurance for the term (e.g., 20 years) of the typical offer.	See also: http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/community-shared-solar.html
IA **Cedar Falls Utilities** **Simple Solar**	Capacity purchase: Unit/share purchase, with $/kWh credits paid for solar generation Solar project completed by third party, but other aspects of procurement, sales, administration and billing provided by Cedar Falls Utilities. Rough average retail rate for standard customer is $0.08 per kWh.	Term: 20 years. Share cost: $270 for 170W panel; utility provides on-bill financing. Monthly credits for the kWh generated per share is calculated based on the value of solar (avoided wholesale energy, generation capacity, and transmission capacity costs). Calculated on the total production of the system, not on individual panel production. EXAMPLE: Participant is billed for the amount of power they consume each month ($0.08 - $0.10 per kWh current average rate). Then participant receives a credit for each kWh produced by the Simple Solar share. Credit is currently $0.057/ kWh	Competitive offer: Currently bill credits range between $1-$3 per unit/share per month, based on the amount of solar power generated each month. Net savings are likely to be realized over time. Credit will be updated annually, based on wholesale power cost and calculated value. This rate is roughly competitive with the offer for customers that have rooftop solar, and there is an on-bill financing option for community solar. A popular, live dashboard shows community solar project production Customer response was relatively fast and strong. At 1.5 MW, the solar array is currently the largest community solar project in Iowa.	This program is 1.5 MW with about 1,250 participants. Open to all customer classes, including retail, wholesale, residential, and non-residential. Cedar Falls Utilities acts as an aggregator and agent for customers. Program is revenue neutral. This credit amount will change over time, because CFU annually changes the rate at which customers are paid. This program generates less than 1% of the utility's load but delivers power at peak load times.	Erin Buchanan erin.buchanan@cfunet.net https://www.cfu.net/save-energy/simple-solar-/

MN **Steele Waseca Electric Co-op, Sunna Project**	Capacity purchase with companion-measure benefits: Cost: $170/ 410W panel; utility pays credits for solar generation. SWCE's 16-Hour Water Heater Program provides willing members with a 105-gallon electric water heater at no additional cost. Water heater is used for load shifting by the utility. Additional panels are $1,225	Term: 20 years. Subscription moves with customers within the SWCE territory; if customer moves out of territory, they can transfer it to another member or sell it back to SWCE. Maximum of 20 panels/household, capped so generation matches average annual energy usage. Monthly electric bill kWh credit for kWh produced by panels. If credit exceeds monthly kWh usage, the unused credit rolls over to the next month. RECs: Owned by utility.	Competitive benefits: With solar-plus participation, the cost of solar energy is $0.12 or less for the 20-year term. The $170 panel has an installed-solar cost equivalent to $0.41/Watt; the full-priced panel has an installed cost of $2.99/Watt Annual water-heater control benefits are the same as those for the utility's system-wide water heater program; the technology assures little or no customer inconvenience, and it allows the utility to more fully utilize wind power resources.	No cross-subsidization; an attractive alternative to NEM-based solar programs. The solar-plus approach is widely supported by sustainability groups in MN Great River Energy, the G&T power supplier is also working on EV charging strategies for future solar-plus programs	Syd Briggs sbriggs@swce.coop http://swce.coop/swce-field-services/renewables/
TX **Austin Energy Community Solar Program**	Rate: $.01/kWh premium; green tariff relies on local solar resources. Subscribers pay a Community Solar Adjustment (CSA) instead of a Power Supply Adjustment (PSA) on their bill.	Term: Fixed rate for 15 years. Subscribers may disenroll at any time but must wait 12-months to re-enroll. Austin Energy's PSA is replaced by The CSA, which is currently $0.015higher; thus the program currently has a $0.015/kWh premium. Savings possible if the PSA increases, over 15-year term. The CSA is fixed year-round; customers who pay the PSA now pay $0.02829/kWh in summer and $0.02727/kWh in winter.	Competitive offer: Subscribers pay for the cost of the solar minus a credit for the positive attributes of local solar, which benefit all utility customers. Subscribers with an average electric usage of 660 kWh per month in the Winter and 1350 kWh per month in the Summer may expect a bill increase of about $10-$19 per month. Provides access to solar energy for customers unable to install solar panels on their own homes. Program was introduced with discounts for early-enrollment and low-income residents who lived near one of the solar plants.	Program is administered internally; administration costs are negligible. This program supports Austin's Climate Protection Plan, and the local solar goal of 200 MW by 2025. It is based on a pass-through of costs and is considered unsubsidized. The Kingsbury Community Solar Project (2-MW), one of the projects that supplies this program, is also the site of a utility-side energy storage (solar-plus) project. Currently fully subscribed, pending	Karen Poff karen.poff@austinenergy.com City of Austin Electric Tariff: https://austinenergy.com/wps/portal/ae/rates/approved-rates-schedules/approved-rates-schedules-for-city-of-austin http://www.austinenergy.com/wps/portal/ae/green-power/solar-solutions/

				commissioning of a new solar plant.	
TX **CPS San Antonio Roofless Solar Program**	Capacity purchase: Customers buy panels 107-W panels from third-party (CEC); utility pays credits $/kWh for solar generated. Participants receive a utility bill credit for kWh generated by their panel/s Each array has its own escrow account, to assure that long-term costs are covered (under CEC agreement).	Term: 25 years Participants receive $0.141 credit from CPS for 85% of production from their share. The credit for the other 15% of generation goes into the escrow account, which assures that O&M and long-term costs will be covered (managed by CEC). Additional costs incurred are covered by a slight increase in the Fuel Adjustment Charge for all CPS customers. Reportedly negligible, due to scale.	Competitive offer: Customers anticipated to break even after 10 years, with savings continuing for the term. Participants are exempt from the standard Fuel Adjustment Charge. CEC provided upfront financing for the overall project; with CPS entering into a backstop PPA. Also competitive with standard rooftop solar option, which gets net metering. Under that program, the utility would buy back the power at the retail rate, but that would be subject to change. Roofless (community solar) is fixed at $.014 for 25 years. Currently sold out. Additional solar capacity is anticipated, but no determination has been made about the solar developer selection process.	Program expense (slight subsidy) is equivalent to CPS rooftop solar rebate model. The developer (CEC) co-brands with CPS Energy and manages marketing and administration. Utility is paying 3 or 4 cents more for the power they buy now but this should adjust over the next 25 years. CEC was selected to provide this pilot program, including a 1-MW local project. Supports CPS goal of reducing demand by 770 MW by 2020, through early retirement of coal facilities. This will drive customer satisfaction and avoid customer defection.	Rick Luna rmluna@cpsenergy.com Shannon Wagner SMWagner@cpsenergy.com https://www.cpsenergy.com/en/my-home/savenow/simply-solar.html

Community Solar:
California's Shared Renewables at a Crossroads

Community Solar Value Project
October 2017

Karin Corfee, Navigant
John Powers, Extensible Energy LLC
Andrea Romano, Navigant

About the Community Solar Value Project

The Community Solar Value Project (http://www.communitysolarvalueproject.com) aims to increase the scale, reach, and value of utility-based community solar programs by using strategic solar technologies, siting, and design, and by integrating suitable companion measures, such as demand-response (DR) and storage into broad program designs. Such measures can address grid impacts of rising solar penetration and increase solar net value. Market development for this model also is being addressed. The project is led by Extensible Energy, LLC, with support from Cliburn and Associates, Olivine, Inc., and Navigant Consulting. Utility participants include the Sacramento (California) Municipal Utility District (SMUD), Public Service of New Mexico, and other utilities nationwide. The project is powered by SunShot, under the Solar Market Pathways program of the U.S. Department of Energy.

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Disclaimer

Introduction

California, once considered a leader in community solar, has struggled to implement Senate Bill 43 (SB-43), the promising enabling legislation passed in 2013. This bill mandated the creation of the Green Tariff Shared Renewables (GTSR) Program. As envisioned by SB-43, the California investor-owned utilities (IOU) GTSR Program includes both a Green Tariff (GT) option component and an Enhanced Community Renewables (ECR) component. It provides an opportunity for the three California IOUs combined to procure up to the 600 MW total program cap of new renewable energy under the two program components.[i]

Benefits of Community Solar

- Provides a solar option for renters, customers with shaded roofs, or constrained property sites that cannot meet energy needs with onsite renewables. Also provides a solar option to customers who choose not to install a system on their roof for financial or other reasons.
- Offers economies of scale relative to rooftop solar.
- Enables utilities to retain customers by providing them with a 100% solar alternative to net energy metering (GT program).
- Enables utilities to locate solar on the grid where it provides the more value.
- Provides a new solar market with new business needs, business models, economics, and target customers.

Despite a significant price premium, the GT portion of this bill has attracted some customer interest. However, under the ECR program as of August 2017, no new community solar projects have been built or approved. The ECR program is unsuccessful due to its complex and uncertain bill credits, lack of sufficient financial return for solar developers, and burdensome program administrative requirements. A dramatically different financial model than net energy metering (NEM), the GTSR compensation structure is based on wholesale rates net program fees/charges instead of retail rates. Thus, the program currently does not provide a comparable economic return to NEM.

As customers across California look for green electricity alternatives through the installation of NEM systems and enrollment in GT or community choice aggregator (CCA) programs, it is in the IOUs' best interest to work with the California Public Utilities Commission (CPUC), the California State Legislature, and stakeholders to design a competitive utility shared renewables program that continues to move the dial toward more affordable clean energy in California. With ongoing discussions about a NEM successor tariff in California, the economies of scale that shared renewables offer provide an opportunity to continue to incentivize the construction of clean energy at a lower rate than full NEM retail rates.

In this whitepaper the Community Solar Value Project (CSVP) authors seek to capture the key lessons learned from the development of the California shared renewables market and ongoing discussions around reworking the GTSR Program. The CSVP team encourages CPUC and the California State Legislature to revisit their interpretation of SB-43 to set the foundation for a successful shared renewables market in California.

Early Days in California

Almost a decade ago, the market expected California to emerge as a leader in community solar. While a handful of small municipal utilities and cooperatives in other states built community solar projects prior to 2007 (e.g., Ashland, Oregon Solar Pioneer Program[ii]; Ellensberg, Washington[iii]), these earliest experiments were quite small (typically 100 kW or less) and developed as one-time projects. That situation changed in 2008, when the Sacramento Municipal Utility District (SMUD) rolled out a 1 MW program called Solar Shares; within months, customers fully subscribed the program.

The success of Solar Shares at SMUD led other California communities to begin investigating programs of their own, but it soon became obvious that programs in the service territories of California's IOUs would require enabling legislation. It took nearly 4 years to organize a legislative initiative that would include community solar.

California Legislation: SB-43

In 2012, with the backing of mayors from cities in IOU service territories, Senator Lois Wolk (Democrat, 3rd Senate District) introduced a bill in the California legislature that would encourage the development of community solar projects. The bill received widespread backing from community development and environmental advocates, but died in committee.

In 2013, with a broader coalition including unions and additional city governments, Senator Wolk introduced a new bill: SB-43. The intention of the bill was clear, as stated in Section (g):

> *It is the intent of the Legislature that a green tariff shared renewables program be implemented in such a manner that facilitates a large, sustainable market for offsite electrical generation from facilities that are eligible renewable energy resources, while fairly compensating electrical corporations for the services they provide, without affecting nonparticipating ratepayers.*

In addition, the bill explicitly provides instructions to serve "low-income and minority communities and customers," which have been largely unaddressed to this point.[iv]

On September 11, 2013, after months of contention in committees, various amendments, and considerable debate, the bill passed exclusively with Democratic support on a straight party-line vote.[v]

High Hopes

The passage of SB-43 prompted forecasts of rapid growth in the community solar market in the United States, led by California's 600 MW commitment.[vi] This optimism was based in part on the apparent simplicity of the bill (under 3,000 words in total) and the fact that the bill included a straightforward set of instructions with a timeline for California's IOUs and CPUC:

> *(a) On or before March 1, 2014, a participating utility shall file with the commission an application requesting approval of a green tariff shared renewables (GTSR) program to implement a program that the utility determines is consistent with the legislative findings and statements of intent of Section 2831 …*
>
> *(b) On or before July 1, 2014, the commission shall issue a decision on the participating utility's application for a green tariff shared renewables (GTSR) program, determining whether to approve or disapprove it, with or without modifications.*

SB-43 set California on course to have CPUC rulings by July 1, 2014 on both shared renewables programs, followed by rollout of the program to customers.

CPUC Rulemaking

While other states (e.g., Colorado, Massachusetts, Minnesota, etc.) pressed forward in turning enabling legislation into workable community solar programs, California's IOU process was burdened by regulatory delays. The GT and ECR programs are described as follows:

- **Green Tariff (GT):** Customers purchase energy from a portfolio of sources with a greater share of renewables compared to the local IOU standard mix. The IOUs procure this new renewable energy using CPUC-approved tools like those required by the California Renewables Portfolio Standard Program. The customer pays the difference between their current generation charge and a charge that reflects the cost of procuring 50%-100% solar generation for their electric needs. For example, for Pacific Gas and Electric (PG&E), the GT premium for 2017 ranges from 1.49 to 3.34 cents per kWh, depending on customer rate class.[vii]

- **Enhanced Community Renewables (ECR):** A customer agrees to purchase a share of a local solar project directly from a solar developer in exchange for a credit from their utility for the customer's avoided generation procurement and their share of the benefit of the solar development. ECR projects are limited in size to between 500 kW and 20 MW. No price premium specifics are available for the ECR program, as projects have not been completed.

Table 1 outlines the program capacity allocation for both program components across the IOUs and the program-specific reservation carveouts.

Table 1: Allocation of Capacity (MW) Green Tariff Shared Renewables[viii]

Utility	Percentage of Total IOU Bundled Sales	Total (MW)	Environmental Justice*	Davis (MW)**	Unreserved (MW)
PG&E	45.25%	272	45	20	207
San Diego Gas & Electric (SDG&E)	9.87%	59	10	N/A	49
Southern California Edison (SCE)	44.88%	269	45	N/A	224
Total GTSR	100%	600	100	20	480

***Environmental Justice Reservation:** SB-43 requires that 100 MW of the GTSR Program be reserved for facilities that are no larger than 1 MW and are located in "the most impacted and disadvantaged communities," as identified by the California Environmental Protection Agency (CalEPA).
****City of Davis Reservation:** Section 2833(d)(3) reserves 20 MW "for the City of Davis." Decision 15-01-051 discusses the significance of this reservation.
Source: California Public Utilities Commission

SB-43's mandates for community solar attributes required significant interpretation. The bill specifies programs must preserve "nonparticipating ratepayer indifference," a sound principle of utility ratemaking. Simultaneously, the legislature also declares without quantifying the financial value that, "Building operational generating facilities that utilize sources of renewable energy within California, to supply the state's demand for electricity, provides significant financial, health, environmental, and workforce benefits to the State of California."[ix] However, CPUC does not take these externalities or social benefits into consideration, as no standard set of accounting for these externalities exists. Other bills that have moved through the legislature have had the same issues and are also not quantifying these qualitative benefits. Thus, CPUC proceedings quickly became focused on "nonparticipating ratepayer indifference" without identifying, quantifying, or valuing the specific externalities or social benefits of shared renewables.

As illustrated in Figure 1, rather than adhering to the deadlines required by SB-43, the filings, hearings, and rulings stretched on for years. In January 2015, CPUC issued Ruling D.15-01-051, describing an implementation of SB-43 in three phases:

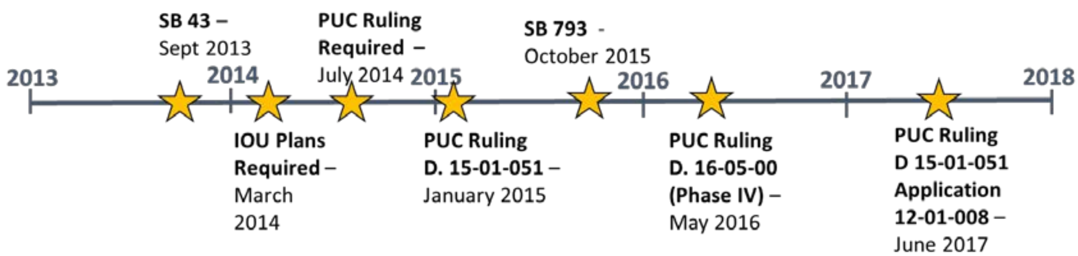
- Phase I: SDG&E and PG&E Green Tariffs
- Phase II: SCE Green Tariff
- Phase III: Enhanced Community Renewables

This ruling, which minimized the value of shared renewables, incorporated multi-part complex tariffs that resulted in a premium of more than 3 cents per kWh for residential customers on the GT portion of the utility programs; an exact premium on ECR cannot be calculated until project bids are accepted—which has still not occurred as of August 2017. In October 2015, the passage of SB-793 further clarified the bill credits and charges issue:

> *This bill would require the commission to additionally require that a participating utility's green tariff shared renewables program permit a participating customer to subscribe to the program and be provided with a nonbinding estimate of reasonably anticipated bill credits and bill charges, as determined by the commission, for a period of up to 20 years.*[x]

With additional changes and clarifications clearly required, the parties began a series of Phase IV hearings to iron out final details. CPUC issued Ruling D.16-05-006 in May 2016—some 32 months after passage of SB-43—with numerous clarifications but no change in the basic structure of the complex tariffs or program requirements. The decision did increase the ECR project size from 3 MW to 20 MW. This substantive change may be the only real win from the decision in an effort to make the program more economically viable.[xi]

Figure 1: Shared Renewables Implementation Timeline



Source: Navigant Consulting, Inc.

Yet, the resulting programs reflected a conservative interpretation of "nonparticipating ratepayer indifference," with a renewables value credit lower than in many other jurisdictions. From the utilities' perspective, this interpretation is understandable, particularly considering the ongoing NEM payments to rooftop solar customers, upcoming NEM policy changes, and the need to maintain consistency with prices paid by CCAs. From the perspective of communities and developers, this interpretation left little incentive to create a "large, sustainable market" for shared renewable projects. Shared renewables can play a huge role in California as NEM policy changes. However, with the current rate structure and GTSR Program designs, it is highly unlikely that this will be the case.

Developer Experience with ECR Program

The first request for offer (RFO) for the ECR program launched in August 2016, with awards planned for March 2017. However, no power purchase agreements (PPAs) were awarded in the first RFO under the ECR community solar program. Of the 15 bids submitted, all bids failed to meet the program eligibility criteria, with 11 bids being eliminated due to failure to submit a Phase 2 interconnection study and documentation demonstrating project site control. The other main barriers identified are discussed in the following section. The second RFO is currently underway, with the market anticipating similar results in the fall of 2017.

Table 2: ECR RFO Round 1 Results[xii]

Utility	Number of Bids Received	Number of Bids Shortlisted	Number of PPAs Awarded
PG&E	8	3	0
SDG&E	2	1	0
SCE	5	0	0
Total	**15**	**4**	**0**

Source: "California Community Solar Forum Points to Needs for Reform, Renewable + Law," with numbers revised based on conversations with the IOUs.

ECR Program Design Components: Barriers to Participation

Based on conversations with leading solar developers in the market,[xiii] the following barriers have emerged as the largest roadblocks to the early success of the ECR program:

- **Low and uncertain bill credit:** Unlike many successful community solar programs, the California rules only credit customers for the wholesale generation value of the power, which is about one-third of the customer's electric bill, and utilities add in layers of program fees. When compared to community solar bill credits in other states and NEM rates in California, the current bill credit cannot compete. All developers described this as the largest barrier to program success. Further, the power charge indifference adjustment (PCIA) and wholesale generation credit value will vary depending on when customers sign long-term contracts throughout the life of the project, adding additional uncertainty and risk for the developer.[xiv]
- **Demonstration of community interest:** The developer must provide documentation within 60 days of being notified of a contract award that: (1) customers have either submitted "expressions of interest" sufficient to cover 51% of the project's capacity or "committed to enroll" in 30% of the project's capacity; and (2) a minimum number of customers have subscribed to the project depending on the project size (e.g., minimum of 3 subscribers for 3 MW projects and 20 subscribers for a 20 MW project). Additionally, at least 50% and one-sixth of project load should come from residential customers.[xv] From the CSVP team's conversations with developers, this requirement requires them to develop the project out of order and frontload huge customer acquisition costs prior to being notified of contract award. It can take months for a developer to obtain enough customer commitments and expressions of interest to meet the thresholds required.
- **AmLaw 100[xvi] securities opinion:** The developer must include a securities opinion from an AmLaw 100 law firm stating that the arrangement complies with securities law and that the IOU and its ratepayers are not at risk for securities claims associated with the project. Developers have expressed concern over the costs associated with this requirement. An AmLaw100 firm interviewed indicated that determining whether a project complies with securities laws can and should be handled by working with a law firm, but providing an official opinion to the utility is a costly and time-consuming requirement that should not be necessary. After much debate regarding the necessity of the AmLaw 100 securities opinion, CPUC recently revised the requirement in June 2017; while a securities opinion is still required, it can now be from a qualified California lawyer.[xvii] Although a victory for the program, some developers view this as a subtle change indicating the difficulty of modifying other requirements currently viewed as more significant barriers.

Potential market participants identified these same barriers shortly after the release of D. 15-01-051 in January 2015.[xviii] While some improvements have been made around the edges of these programs (e.g., through the Phase IV process[xix]), the securities opinion and requiring the demonstration of community interest after issuance of a PPA instead of before a project could enter the queue are the only major barriers that have been modified after more than 2 years of negotiations and hearings. From recent conversations with the IOUs and the market participants, the CSVP team does not expect any other fundamental changes to be put in place in 2017. Major changes to the underlying program economics will not likely take place until 2018, if they occur at all. Additionally, SB-793 removed the January 2019 GTSR Program sunset date, making the program even more complicated to improve in the short term.

Other Community Solar Activity in California

While no developer has built a solar project under the ECR program at any of the California IOUs, successful models for community-scale distribution sited solar have emerged in California. Such models make it clear that concerns regarding the GTSR Program are related to the structure and enforcement of the program and are not due to the IOU implementation of the flawed program. CCAs, including those in Marin,[xx] Sonoma,[xxi] San Francisco,[xxii] and Lancaster,[xxiii] are developing community-scale solar projects and providing their customers with the option of going 100% renewable.

Similarly, SMUD, the Los Angeles Department of Water and Power (LADWP), the City of Palo Alto Utilities (CPAU), and other municipals have announced new community solar programs with multi-megawatt targets, although their program tariffs are still not set. While the Solar Shares program held steady at 1 MW for several years, SMUD expanded the program to include nearly 11 MW of additional local shared solar capacity for commercial customers.[xxiv] It has announced additional solar resource procurement to support further expansion of the program in early 2018.[xxv] LADWP announced its own community solar program, beginning with a 2 MW Phase I, with additional development likely following.[xxvi] While each municipal utility and CCA program has its own positives and negatives and the possibility of delays exists in any new program expansion, these examples illustrate that nothing specific to California prevents a successful community solar program.

Call to Action – What Is Next?

The intent of SB-43 was to establish a viable GTSR Program in the IOU territories and to procure 600 MW of new renewable energy under the two (GT and ECR) program components. Due to project economies of scale and potential locational benefits, shared renewables can play a large role in filling the gap as NEM policy changes in California. The key challenge in California is to develop a viable regulatory framework for promoting clean energy through a shared renewables business model, while at the same time balancing the objective of maintaining nonparticipating ratepayer indifference.

CPUC and the California State Legislature, in partnership with the IOUs and the industry stakeholders, should work together to realize the original intention of SB-43:

(1) Balance key policy objectives.
    a. Achieve 600 MW of new clean energy through the GTSR Program.
    b. Test new shared renewables business models to promote clean energy.
    c. Maintain nonparticipating ratepayer indifference.

(2) Revisit the GT and ECR rate structure, streamlining the complexities of the credit structure to reduce the variability and provide adequate stimuli to move the market to achieve the 600 MW policy goal.

(3) Streamline other programmatic requirements and approval mechanisms (e.g., demonstration of community interest, marketing requirements, etc.).

(4) Design programs to address the low income and environmental justice market segments.

The gap in pricing between NEM and the current California shared renewables programs is so wide that small changes acceptable to all parties could, without abandoning the principle of nonparticipating ratepayer indifference, result in a lower price premium or higher credit that would stimulate the market. Similar analysis such as the best practice work of the CSVP and others indicates that there is reason for optimism.[xxvii] By addressing these challenges, California's vision for shared renewables as articulated in SB-43 could be achieved.

Endnotes

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