BRIDGES TO NEW SOLAR BUSINESS MODELS:

OPPORTUNITIES TO INCREASE AND CAPTURE THE VALUE OF DISTRIBUTED SOLAR PHOTOVOLTAICS

1820 FOLSOM STREET | BOULDER, CO 80302

PUBLISHED NOVEMBER 2014
DOWNLOAD AT: WWW.RMI.ORG

AUTHORS & ACKNOWLEDGMENTS

Authors

Mathias Bell, Jon Creyts, Virginia Lacy, and James Sherwood

** Authors listed alphabetically. All authors are from Rocky Mountain Institute unless otherwise noted.*

Editorial Director: Peter Bronski
Editor: Laurie Guevara-Stone
Art Director: Romy Purshouse
Graphic Designer: Chris Rowe

Contact

For more information, please contact:
Virginia Lacy (vlacy@rmi.org)
Mathias Bell (mbell@rmi.org)

Acknowledgment: This material is based upon work supported by the Department of Energy under Award Number DE-EE0005353.

Acknowledgments

The authors thank their colleagues at Rocky Mountain Institute who contributed valuable insights and perspectives to the work:

Stephen Abbott
Albert Chan
Mark Dyson
Garrett Fitzgerald
Devi Glick
Lena Hansen
Graeme Hoste
Paul Molta
Jesse Morris
James Newcomb
Graham Provost
Samuel Ramirez
Owen Smith
Lindsay Willman

The authors also thank the following individuals for their review of this report and offering their insights and perspectives on this work:

Galen Barbose, *Lawrence Berkeley National Laboratory*
Lori Bird, *National Renewable Energy Laboratory*
David Feldman, *National Renewable Energy Laboratory*
Stephen Frantz, *Sacramento Municipal Utility District*
Jon Hawkins, *PNM Resources*
Alexandra von Meier, *California Institute for Energy and Environment*
Christina Nichols, *U.S. Department of Energy*
Mark Rathbun, *Great River Energy*
Dan Seif, *The Butler Firm*
Mike Taylor, *Solar Electric Power Association*
James Tong, *Clean Power Finance*

TABLE OF CONTENTS

EXECUTIVE SUMMARY

ES

EXECUTIVE SUMMARY

Over the past decade, distributed solar photovoltaics (DPV) have experienced unprecedented growth. DPV is now on track to achieve significant scale in many segments of the U.S. market. Yet, nationally, solar produces 0.2% of electricity generation, leaving much room for further growth. Distributed solar's continued growth can and should play an integral role in building the affordable, resilient, low-carbon electric grid of the future. For example, the U.S. Department of Energy's SunShot Initiative is targeting 14% of electricity generation from solar by 2030 and 27% by 2050.

Supportive federal, state, and local policies have to date spurred DPV's development in many U.S. markets. However, many of these policies were designed for early market support of an emerging technology, not as long-term solutions. Thus as the DPV market has grown, so too has conflict around early-market policies. In many states, regulators and policy makers are now reexamining the policy environment as solar adoption reaches net energy metering (NEM) market caps or incentive program funding is exhausted. Further, at the federal level, the business investment tax credit is set to decline from 30% to 10% at the end of 2016, and the residential investment tax credit for homeowners is set to expire. The confluence of these pressures could pose a significant barrier to DPV's market growth.

The need has become clear for additional strategies that support DPV's continued growth into the future in line with SunShot targets. Solar policy frameworks to date have typically focused on customer-centric DPV value accruing primarily to the individual customer and/or third-party solar companies who install DPV systems. Meanwhile, under existing business models, utilities have negatively associated DPV with transaction costs, grid operation challenges, and revenue loss.

Creating a sustainable long-term DPV market will require aligning the interests of utilities, solar companies, technology providers, and customers. Aligning those interests means enhancing legacy solar business models or building new ones by creating an expanded value pool—one that makes DPV affordable and accessible to far more customers, bridges beyond individual customer-centric DPV value to include value delivered to the grid and society, and allows the electricity grid's myriad stakeholders to share in that value.

This needed shift in the DPV market is in many ways similar to a nascent shift currently under way with thermostats. For decades, thermostats' value proposition was customer-centric focused on the building occupant only, and manufacturers responded with business models and products that met that need. The more recent advent of smart, connected thermostats and the new opportunities they create has greatly expanded the potential value pool across the utility meter, such as by enabling customers to shift the timing of their load relative to system peak. But as with DPV today, new solutions, including new business models, require broad stakeholder alignment to deploy and then share value among customers, utilities, technology providers, and other participants.

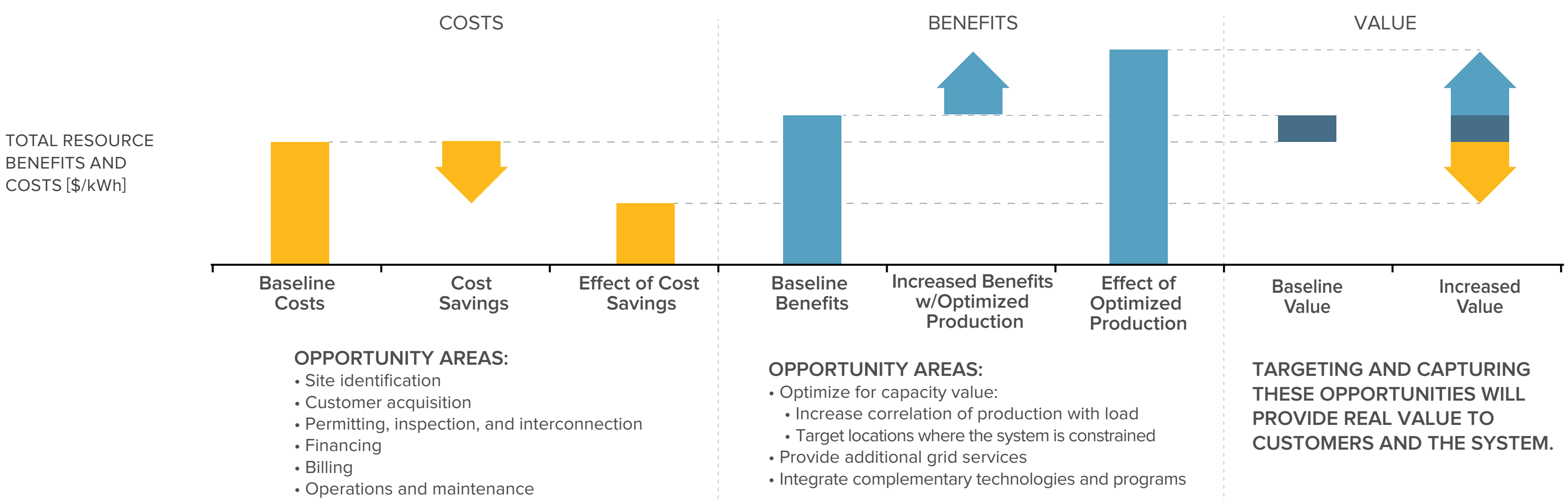
If done well—necessarily bringing both solar companies and utilities together around the table—new solar business models can successfully accelerate, optimize, and sustain DPV adoption.

Aligning the interests of these stakeholders will involve two major threads:

- Maximize the delivered value of DPV to customers *and* the electricity system by further decreasing costs and increasing benefits (see Figure ES1), and
- Create new business models that enable and incent solar companies, utilities, and customers to optimize and capture that expanded pool of DPV value through win-win-win opportunities.

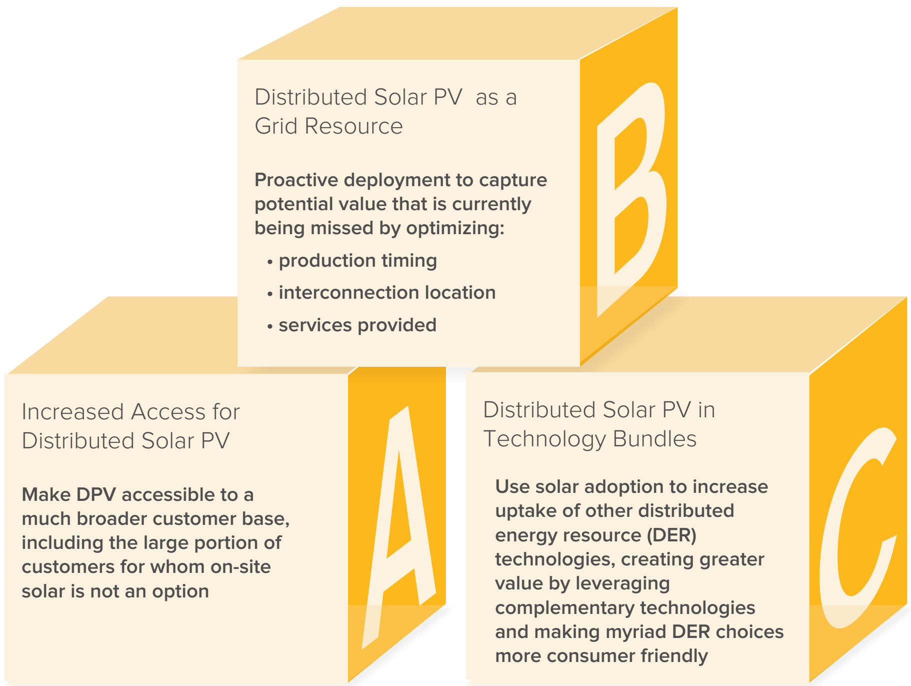
To date, reducing solar's upfront capital cost to achieve low-cost deployment *onto* the grid—without accounting for the operational benefits and costs of integration *into* the grid—has been a significant solar market development strategy. Further cost reductions are possible, especially related to DPV's soft costs, but the most significant of them will require involvement from both solar companies and utilities together to achieve. Similarly, currently untapped operational benefits that occur post-interconnection can create additional value streams for customers, solar companies, and utilities that evolve from maximizing value for individual customers with DPV to optimizing value more broadly across such customers *and* the system as a whole. However, defining, valuing, verifying, and capturing those value streams will require cooperation among stakeholders.

FIGURE ES1: **OPPORTUNITIES FOR INCREASING SOLAR VALUE**



While addressing some of these issues will require both pricing realignment and regulatory model reform, reform will take significant time and resources to unfold. Meanwhile, utilities, solar companies, and regulators can design and implement components of solar business model strategies today that provide a bridge to the future. These "bridge" business model strategies can start to create and capture value, while also providing best practices and lessons learned to inform broader reform efforts.

Figure ES2: **BUILDING BLOCKS FOR BRIDGE BUSINESS MODELS**



PROMISING BUILDING BLOCKS FOR BRIDGE BUSINESS MODEL STRATEGIES

In this report, Rocky Mountain Institute (RMI), with support from the U.S. Department of Energy's SunShot Initiative, investigates opportunities to optimize and demonstrate DPV's value as it is integrated into the grid to utilities, customers, and solar companies alike. The report highlights three promising "building blocks" for bridge business model strategies that can enable stakeholders to increase, capture, and share DPV value (see Figure ES2). These building blocks are not mutually exclusive, and can be combined to create more-comprehensive solar business models. Regulators, utilities, and solar companies will need to adapt and refine components of these concepts, depending on the specific local market and regulatory environment.

Building Block A: Increased Access to Distributed Solar

Objective: ***Make DPV accessible to a much broader customer base***, including the large portion of customers for whom on-site solar is not an option by providing new options for procurement. These options include subscription models where the utility connects solar companies' off-site DPV projects to customers, such as current community solar programs and utility tariff models for large commercial and industrial customers that provide renewable energy for new load.

Utility Role: The utility's value proposition expands, better meeting its societal obligations by giving simple and convenient solar access to all its customers. The utility could become an important part of program marketing, leading customer acquisition efforts, and procuring DPV projects through competitive bidding. The costs and credits on participating customers' bills would reflect the real benefits and costs that the DPV projects create.

Solar Company Role: Solar companies benefit by partnering with a utility to expand customer access to solar, increasing the potential market size. By leveraging the utility's brand and existing customer relationships, the solar company can reduce customer acquisition costs, design and install projects, and perform ongoing operations and maintenance.

Building Block B: Distributed Solar as a Grid Resource

Objective: ***Optimize deployment to capture potential operational value that is currently being missed.*** DPV can support the grid and provide energy services to customers, but project design choices largely determine DPV's potential to deliver such operational benefits to the customer and the larger system. Major opportunities to enhance project design include:

- Optimizing for capacity value by designing DPV projects to better correlate production timing with load and targeting locations where the system is constrained (e.g., shifting panel orientation to better align with peak load or locating projects on substations with high forecasted demand).
- Integrating complementary technologies to strengthen capabilities or provide additional grid services while balancing added costs (e.g., incorporating advanced inverters or storage to ensure that the project can reliably provide grid services when most needed).

Utility Role: The utility takes a more proactive role in DPV deployment, using DPV as a resource to reduce cost to serve and improve service for all customers. The utility identifies optimal system locations for DPV integration and facilitates DPV deployment by engaging solar industry partners.

Solar Company Role: Solar companies coordinate site selection with utilities and design and install projects on the distribution system where they can provide high net value. The solar companies would work in a competitive market for projects, either responding to utilities' RFPs or installing projects based on utility pricing mechanisms.

Building Block C: Distributed Solar PV in Technology Bundles

Objective: ***Leverage DPV adoption to increase uptake of other distributed energy resource (DER) technologies,*** creating greater net value that can be tapped only by leveraging complementary technologies. Technology packages could take different forms, such as a "resilience" package, which bundles solar with storage and advanced controls, keeping the customer's lights on during a power outage.

Utility Role: The utility enables customers to access energy services through DPV—bundled with additional technologies that increase the net value of the project—and helps customers select the best services for their needs. By advising the customer in this process, the utility can speed adoption by making myriad DER choices more consumer friendly. Utilities would evaluate how the technology packages provide value to the grid as well as the economic implications for customers.

Solar Company Role: Solar companies sell broader energy services to customers via technology packages the utility has screened and approved. Revenues could come from the company's ability to package DPV with complementary technologies, increasing revenue per customer and expanding the potential market to include customers who see less risk if the technology package has utility approval.

NEXT STEPS FOR SUPPORTING NEW SOLAR BUSINESS MODELS

Refining and implementing innovative solar business model solutions in specific locales will require direct engagement from regulators, utilities, and solar companies, as well as continued support from other federal and state agencies. These stakeholders will need to:

1. **Assess current abilities to identify value and customer needs.** Solar companies and utilities should collaborate to address knowledge gaps on DPV adoption, while utilities address gaps in DPV operations data, software tools and processes, and internal data organization and communication. In addition, regulators should look to improve data accessibility and transparency for all stakeholders.
2. **Develop a transparent, multi-stakeholder process to create a standardized methodology, evaluate value, and share results.** Solar companies, utilities, and regulators should work together to create a standardized methodology for valuing DPV, including shared data and tools, and then use that methodology to evaluate DPV value and share results.
3. **Determine approaches for optimizing and capturing value.** Where policymakers provide the driving force behind development of solutions, regulators should proactively clarify existing business and regulatory rules affecting business model development. In cases where that top-down push for change does not exist, solar companies, utilities, and other stakeholders should explore opportunities to collaboratively develop solutions. Regardless of who initiates the process, stakeholders will need to establish desired outcomes and criteria for solutions, identify new business model opportunities, remove implementation barriers, and test solutions.
4. **Assess pilots and refine solutions** Federal and state energy and environmental agencies can foster continued innovation by tracking, assessing, and sharing the progress and results of solutions that are proposed and/or implemented.

The rapid improvement of solar's economics offers great opportunity to quickly develop a new resource that can meet growing social and operational needs for clean, reliable, affordable electricity. To fully scale this resource, a multi-party dialogue is required to build new business models that maximize and harness the potential value for all stakeholders.

INTRODUCTION

01

01: INTRODUCTION

Solar photovoltaics (PV) are growing rapidly in the U.S.—by the end of 2013, over 12 GW of PV were in operation, 80% of which was installed since the end of 2010.[1] Customer-sited installations interconnected at the distribution system level have been an important component of that growth, increasing roughly 50% per year from 2004 to 2013 and now totaling more than 50% of nationwide installed capacity.[2] And though nationally, distributed PV (DPV) remains a comparatively small piece of the total generation mix, in select states its contribution is much greater.[3] For example, California installed more than 2.6 GW in 2013 alone.[4] Further, distributed solar has begun to make inroads into markets that have seen little adoption until recently, such as Massachusetts, which saw its total installed DPV climb to nearly 200 MW at the end of 2013.[5]

Supportive federal, state, and local policies—including tax benefits, renewable energy credit (REC) sales, and net-energy metering (NEM)—have combined with dramatic PV cost reductions and innovative financing approaches to spur this significant solar industry growth in the U.S. over the past decade. However, the evolving market environment may be insufficient to sustain continued, rapid, long-term growth as solar scales to significantly higher adoption rates. Many supportive policies, which were designed to support early-stage market diffusion of emerging technologies, are set to step down or expire in the near future. The federal business investment tax credit, for example, is set to reduce from 30% to 10% at the end of 2016, and the personal investment tax credit for homeowners is set to expire.[6] Other programs, such as NEM in California, Delaware, Massachusetts, and Nevada, are approaching their caps.[7]

Neither utilities nor the solar industry are optimally positioned on their own to support solar's continued growth in ways that maximize its potential value to all electricity system stakeholders, including individual customers, utility and solar investors, the electric grid, and society.

Existing electric utilities have evolved from central station electrical supply, transmission, and distribution. Today, they have little experience quantifying, capturing, or optimizing the value streams associated with distributed generation, especially those that are owned and operated outside of the utility's purview, such as customer- and third-party-owned solar DPV. Thus utilities typically associate DPV with increased transaction costs, challenges to system operations, and revenue loss.

Meanwhile, solar industry business models to date have primarily targeted cost reductions in project development, including manufacturing, installation, and financing. While these cost reductions remain critical, focusing on low-cost deployment onto the grid without taking into account the operational benefits and costs of integration into the grid ignores key value drivers in electricity system planning and operations: location, timing, reliability, flexibility, predictability, and controllability. This misses opportunities to recognize the delivered value of solar to support the grid and deliver new energy services to customers and utilities alike.

If accelerating solar adoption is to help sustainably achieve societal goals for the electricity system—to provide reliable and resilient energy services at reasonable cost while meeting standards for fairness and environmental stewardship—it will require improved mechanisms to foster greater alignment.

IDENTIFYING APPROACHES THAT OPTIMIZE AND CAPTURE NET VALUE

This report outlines the findings of Rocky Mountain Institute's Innovative Solar Business Models (ISBM) project, which worked to build scalable business models that provide the critical bridge between technical insight and the business case, and which align the interests of utilities, technology providers, regulators, and customers. Some situations may require significant regulatory change to realign the utility business model with recent electricity sector innovations. The regulatory process, however, is extremely time and resource intensive. While these long-term regulatory solutions are important and necessary, the ISBM project seeks to design business model solutions that can be implemented *now*—within today's regulatory structure—and can bridge the gap to future solutions that may be five or more years away (Figure 1).

FIGURE 1: **CREATING BRIDGES TO THE FUTURE**

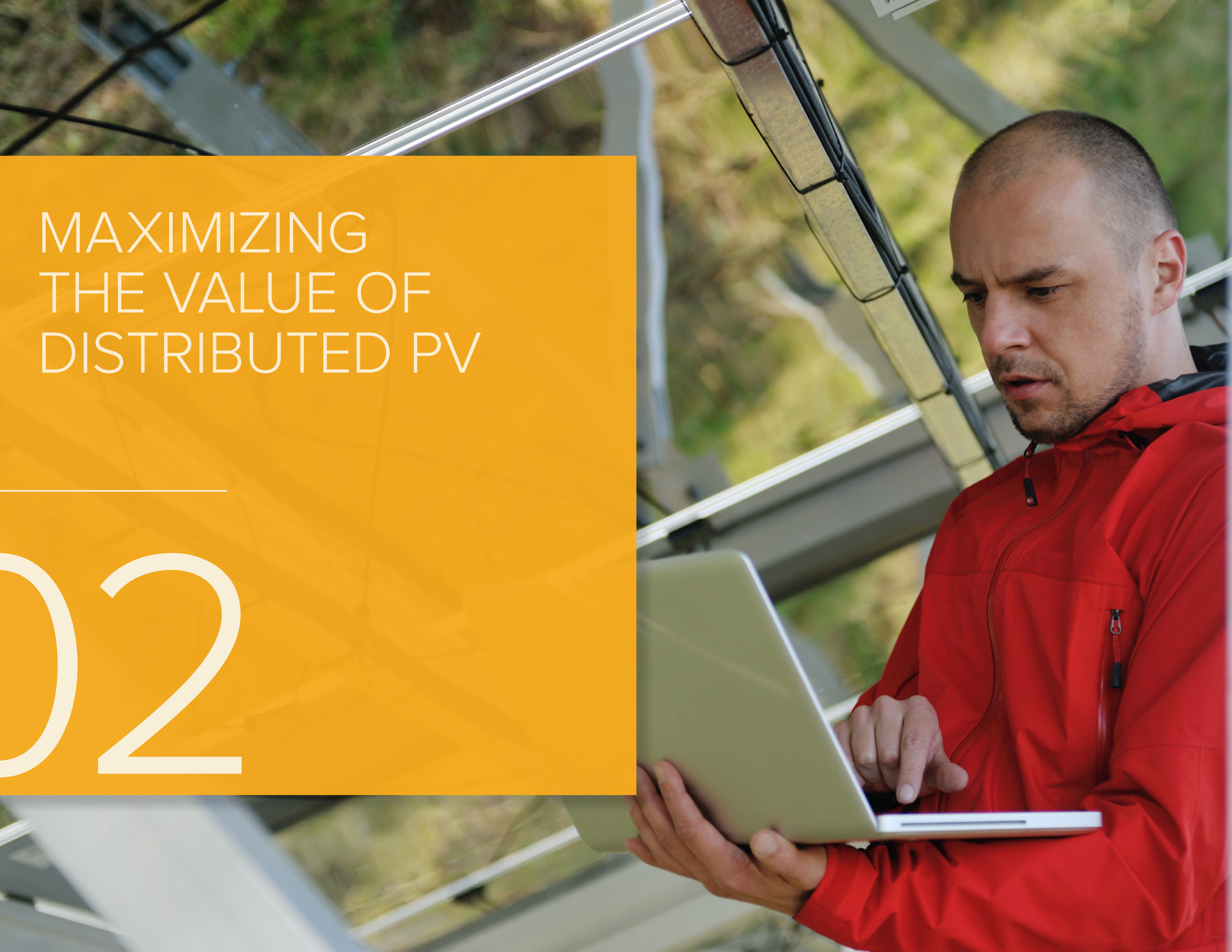
	Pricing Realignment	Bridge Business Models	Regulatory Model Reform
Description	Design pricing models that align customer incentives with the costs and benefits distributed resources provide the grid	Adapt business models that can increase and capture value within the existing regulatory paradigm	Redesign the structure of regulatory and business models to provide a platform for the economic and operational integration of distributed resources
Examples	• Time of use pricing • Energy + capacity pricing • Distribution "hot spot" credits • Real-time pricing • Attribute-based pricing • Distribution locational marginal pricing	• Increased access for distributed resources • Optimized deployment of distributed resources onto the grid • Technologies bundles that provide energy services	• Energy services utility • Smart integrator • Independent distribution network operator • Resource finance aggregator

To develop near-term business model solutions, the ISBM project investigated opportunities to capture and share DPV's unrealized value potential among solar companies, utilities, and customers. The project focused on two distinct, yet interdependent, areas:

1. Identifying opportunities to maximize the net value of DPV. Increasing DPV's net value can involve decreasing project and grid integration costs and/or increasing the benefits that DPV's operation provides the grid and society (Figure 4).
2. Designing business models that enable and incentivize solar companies, utilities, and customers to capture and share the net value of DPV.

Simply understanding and recognizing net value alone will not remedy the barriers to continued DPV adoption. Some benefits are more difficult to capture than others and could require additional effort and cooperation. For instance, even though there could be substantial benefits in DPV's ability to defer or obviate the need for distribution capacity, the stakeholders in the position to capture this value may not be able to monetize these benefits and so these opportunities may be ignored. A prosperous and sustainable market for DPV will require innovative business model approaches designed to address such market failures, and to capture unrealized value potential that could be shared among stakeholders.

This report discusses largely untapped opportunities for increasing DPV's net value. Then, the report highlights promising building blocks for business models that create and capture additional value for utilities, solar companies, and customers. Finally, the report elaborates on the recommendations noted above, drilling down on actions that regulators, utilities, and solar companies should take to develop new business models.



MAXIMIZING THE VALUE OF DISTRIBUTED PV

02

02: MAXIMIZING THE VALUE OF DISTRIBUTED PV

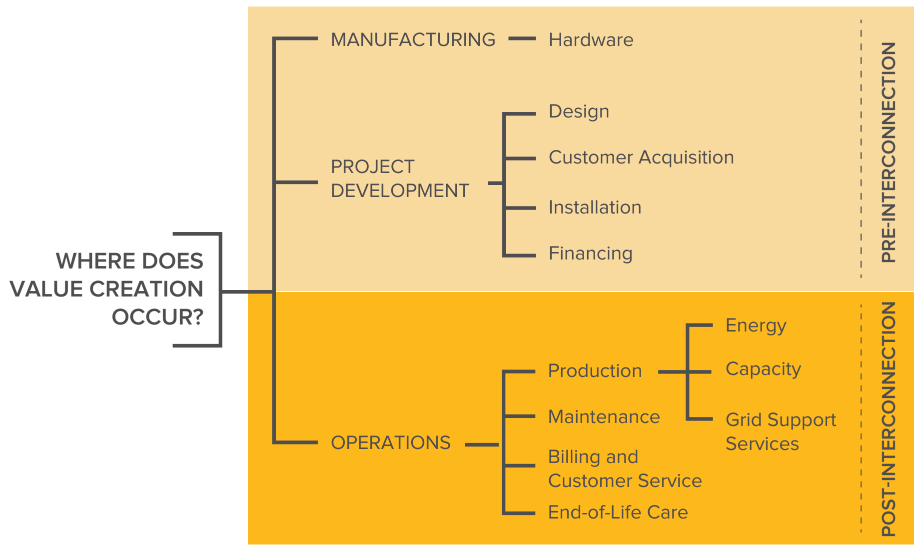
To better identify opportunities for increasing solar's delivered value to multiple stakeholders, it is useful to start with the solar value chain. As with any industry, the solar value chain is comprised of value-creating activities that can be segmented and analyzed individually to determine the areas of high potential for value creation, optimization, or capture (Box 1). Over the past decade, discussions about the solar value chain have been prevalent; the industry has devoted significant investment and attention to dramatically reduce costs, first in manufacturing and more recently in installation and soft costs.

However, focusing only on low-cost deployment *onto* the grid without taking into account the operational benefits and costs of integration *into* the grid misses opportunities to recognize the delivered value of solar to support the grid and deliver new energy services to customers and utilities alike.

This report divides the solar value chain into three primary segments (Figure 2):

- *Manufacturing.* These costs include all project hardware: PV modules, inverters, and installation materials.
- *Project Development.* This segment includes project design through installation.
- *Operations.* Once a DPV project is connected to the grid, the project generates power that contributes benefits (or costs) to the host customer, the grid, and society, and also adds integration-related costs.

FIGURE 2: **DISTRIBUTED SOLAR PV VALUE CHAIN**



BOX 1: THE SOLAR VALUE CHAIN

The solar value chain is the series of activities that entities undertake in the design, installation, and operation of DPV projects, and is an important tool for identifying strategies to improve DPV's net value to customers and the electricity system (Figure 4). Today, the functions in the value chain are performed by a combination of actors, including OEMs, financiers, solar companies, electric utilities, and specialty service providers. There are countless links between the many steps in the value chain, and benefits achieved in one area may have positive or negative repercussions in other areas. Because of the chain's fragmentation, these interconnections, and the absence of a "silver bullet" solution, it is necessary to use a systems approach to strategically consider opportunities from end-to-end across the value chain.[8]

Activities within the DPV value chain can be segmented into two broad categories: *project development* and *operations*.

Project Development

Project development includes all activities that happen before interconnection to the grid, from manufacturing to construction and installation.[9] Major activities include:

- **Hardware manufacturing.** Three types of hardware are critical for a functioning PV system: modules, inverters, and installation materials.
- **Design and customer acquisition.** The entire process of marketing, generating leads and project design, and finalizing sales, up until the customer has signed the contract for the project.
- **Installation.** Details vary widely depending on project-specific considerations (e.g., whether it's rooftop or ground-mount, site accessibility, etc.), but every DPV installation process consists of:
    - *installation labor*—the installation of the PV system including the racking and the wiring; and
    - *supply chain management,* including the procurement of materials and management of the network of installers.
- **Financing.** Today, most DPV projects are financed with a combination of equity and debt, and there are costs associated with these transactions. Solar financing structures have evolved to not only procure capital, but to enable the capture of certain policy incentives as well.[10]

Operations

The operations category is focused on all activities after interconnection, from the point the project begins to generate power through decommissioning. Managing downstream costs will become increasingly important as DPV projects age. Major activities include:

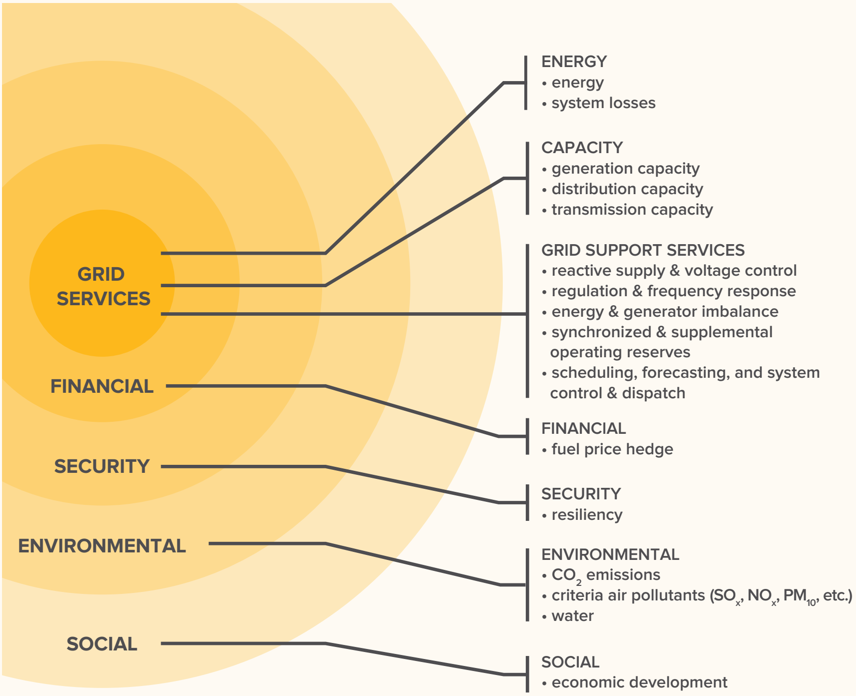
- **Production**. Interconnected DPV projects generate electricity on the grid, creating operational benefits and costs, some of which are currently being monetized.
- **Operations and maintenance**. DPV projects require ongoing monitoring to ensure proper performance, as well as both regular cleaning to maintain module performance, and occasional maintenance to repair or replace malfunctioning equipment.
- **Insurance and warranties.** Projects are typically protected against manufacturer defects, and are insured against possible liabilities, including public safety issues.
- **End-of-life care.** Eventually, aged installations either transfer project ownership or remove equipment from the project site.

Operational Benefits and Costs

Once a DPV installation is interconnected and providing power to the grid, it can create benefits and costs in a variety of ways. In *A Review of Solar PV Benefit and Cost Studies*,[11] Rocky Mountain Institute provided a framework for considering these sources of value that distills them into several key categories (Figure 3). While the exact magnitude of these benefits and costs can vary greatly based on the timing of the DPV system's production, as well as by its location on the grid, there is broad consensus on the types of benefits and costs that DPV can create. These categories are:

- **Energy.** The cost and amount of energy that would have otherwise been generated to meet customer needs, as well as the value of the additional generation that would otherwise be lost due to inefficiencies in delivering energy via the transmission and distribution systems.
- **Capacity.** The value of deferring or displacing other investments in generation, transmission, and distribution infrastructure by providing capacity that can meet demand at the same level of system reliability.
- **Grid support services.** The value of the net change in grid support services (i.e., ancillary services) required to ensure the reliability and availability of energy with the addition of DPV.
- **Financial.** The benefit of DPV providing fixed electricity supply costs, and the value of any net change in electricity and commodity prices that results from market response to DPV.
- **Security.** The value of the net change in system reliability and resilience because of 1) transmission and distribution congestion reductions and therefore likelihood of outages; 2) increased diversity of the generation portfolio with smaller, more dispersed resources; and 3) provision of backup power when DPV is coupled with storage.
- **Environmental.** The value of reducing carbon emissions—therefore mitigating climate change—and from reducing impacts or creating benefits around non-carbon environmental factors, including criteria air pollutants (NO_x, SO_x, and particulate matter), avoided RPS expenditures, land use, and water consumption and pollution.
- **Societal.** The value of the net change in jobs and local economic development (in the form of increased tax revenue).

FIGURE 3: **A BENEFIT AND COST FRAMEWORK**

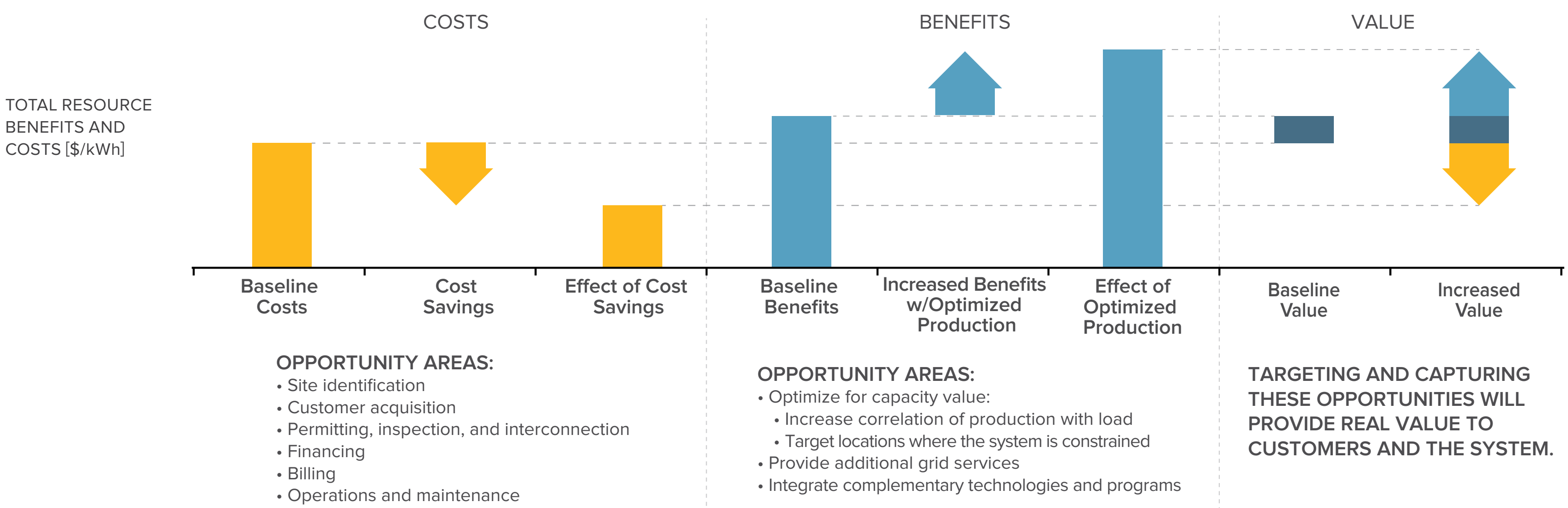


STRATEGIES TO OPTIMIZE VALUE

Today, individual stakeholders are working to increase the value of DPV, but do so largely in isolation. Solar companies, for instance, are actively identifying and pursuing strategies to reduce project installation costs, while module manufacturers look to improve efficiency and minimize hardware costs. There remains significant potential throughout the value chain.

The largest remaining opportunities to increase the net value of DPV will require targeting areas of the value chain that neither solar companies nor utilities can address alone. Rather, to maximize the potential net value of DPV to all electricity system stakeholders—including individual customers, utility and solar investors, the electric grid, and society—utilities and solar companies will need to cooperate and coordinate efforts to harness their unique skillsets.[12] To tap this additional value, utilities and solar companies can collaborate to reduce DPV project costs and increase the operational benefits that projects create (Figure 4).

FIGURE 4: **OPPORTUNITIES FOR INCREASING VALUE**



CONTINUE DRIVING DOWN COSTS

Project Development

Hardware costs—the main driver of PV costs as recently as 2010[13]—now account for less than 37% of the total installed cost of residential projects.[14] Although additional hardware cost reductions may be possible, recent work has identified significant opportunities to reduce DPV project costs by focusing on non-hardware (or "soft") costs.[15] Key remaining opportunities to further reduce project costs can be captured through utility and solar company collaboration:

- ***Site identification.*** Customer data is disaggregated, with utilities, solar companies, technology companies, and energy service providers each having access to different information, including interested customers, site suitability, electricity consumption, and ability to access financing. As a result, each stakeholder company has been forced to build its own datasets, driving up costs. Though many important concerns—including security and customer privacy—will need to be addressed, site identification and lead generation would become a much simpler, faster, and less-expensive process if all actors could access key data.
- ***Customer acquisition.*** Customer acquisition can represent up to 30% of the installed project cost for residential customers (including general and administrative expenses such as personnel costs).[16] The customer market is still developing, as 48% of U.S. residential customers in a recent survey said they had not considered adding solar to their homes.[17] By working together, utilities can leverage their access to customers to help educate them on the opportunities and options for DPV, while solar companies can improve their marketing efforts by using the utilities' brand to decrease customer concerns (e.g., about the long-term reliability of PV or the longevity of solar companies).
- ***Permitting, inspection, and interconnection (PII) processes.*** The inspection and interconnection process is often complex and time intensive, with the average application process taking four weeks.[18] This time lag between installation and interconnection causes solar companies to incur significant costs.[19] Solar companies also often have little insight into which interconnection requests will require an extensive interconnection study. Processing applications online, establishing clear equipment standards, and providing access to information about which locations need detailed studies would reduce lag time and signal which locations are more attractive for solar companies. Southern California Edison, for instance, has created interconnection maps that increase transparency and highlight where interconnections can be expedited.[20]
- ***Financing.*** Solar companies have focused on creating a range of new mechanisms to reduce the cost of capital for DPV projects, such as solar leases that utilize third-party financing.[21] Right now, these mechanisms target highly credit-worthy customers, which leaves out a large portion of possible customers. Many solar companies' earnings are tied to financing, and utility financing would directly compete with them,[22] but there are opportunities where utility and solar company partnerships could share the value of increasing customer access to low-cost financing. For example, the Hawaii Energy Bill Saver Program uses on-bill repayment to reduce financing costs to customers by providing greater certainty of repayment, expanding the solar market and benefiting all stakeholders.[23]

Operations

Downstream project development activities have not yet become a focal point for cost reduction because the majority of DPV projects have not been operating long enough to require many of these activities. However, managing downstream costs will become increasingly important for maintaining or increasing net value as projects age, and there are clear opportunities for utilities and solar companies to collaborate to minimize these costs. Specific areas where collaboration can unlock additional value are:

- *Billing.* Today, third-party financed solar customers receive two separate bills: one from the utility and one from the solar company. Customers could experience better service if there was one party accountable for all billing and questions. A "one bill" mechanism could also reduce the overall administrative costs of managing two billing systems and help protect against customer default.[24]
- *Operations and maintenance.* In each utility's territory, DPV projects are diverse with many different technologies and ownership structures. DPV owners need a party that can continuously monitor equipment to ensure the project is performing properly, and that can provide support if it is not. Though some customers have a direct line of support from their solar provider, many do not. Utilities could offer maintenance services to DPV owners to gain additional visibility into DPV performance on their system,[25] or could collaborate with solar companies to point customers to qualified maintenance providers.

TARGET UNTAPPED OPERATIONAL BENEFITS

Once a DPV project is interconnected, it generates electricity and interacts with the grid as soon as the sun begins to shine. These interactions can create both benefits and costs, regardless of whether the installation is connected on the utility or customer side of the meter. Today, a behind-the-meter DPV installation that never exports power to the grid (i.e., is smaller than its host customer's minimum daytime load, which is customary with larger commercial and industrial building solar PV projects) will primarily function as a simple load reduction from the utility perspective. But DPV installations that do export power are more complicated—the interactions between power-exporting DPV installations and the grid depend on the specific needs of the electricity system in a given place, at a given time.[26] Thus, DPV that provides "the right service, at the right place, at the right time" will create the greatest value. Although monetizing that value is contingent on other factors (such as regulatory framework and pricing structures), DPV projects can be designed to maximize their potential to deliver operational value.

Considering these grid interactions, three categories of design choices determine a DPV project's potential to deliver operational benefits and costs to the customer and the larger system:

- *Location.* The location of the installation's interconnection to the grid (e.g., in a congested urban core or a lightly loaded rural area) affects whether the DPV will provide services where they are most needed.

- *Timing.* The time at which the DPV installation produces power, and the controllability of that generation, affects whether it provides services when they are most needed (e.g., providing power on summer afternoons to align with peak demand).
- *Services.* The specific service(s) the installation is capable of (e.g., energy, reactive power, voltage support, etc.) affect its versatility in helping to provide what is needed—by both the grid and the host customer.

The effect these design choices have on net value is contingent on wide-ranging external factors, such as the timing of peak load on the system and local substation, the amount of DPV capacity installed system-wide, the local grid power quality, and the variability of local weather patterns. For example, a high penetration of DPV on a given distribution feeder may approach the feeder's PV hosting capacity, and additional DPV at that location could adversely impact grid operations unless upgrades are made (e.g., by creating protection coordination issues, voltage regulation problems, etc.).[27]

With these factors in mind, there are certain design strategies that will direct DPV deployment to maximize its operational benefits:

- *Optimize for capacity value*
- *Provide additional grid services*
- *Integrate complementary technologies and programs*

Each of these strategies alone can increase the operational benefits of a DPV portfolio in many situations, but they are not mutually exclusive.

OPTIMIZE FOR CAPACITY VALUE

A DPV project derives its capacity value for the grid from deferring or eliminating the need for other new capacity investments to maintain reliability.[28] Because most current incentive mechanisms only encourage DPV installations to maximize the total annual energy they provide, few projects are designed with capacity value in mind.

Capacity value is a function of two main variables: the project's capacity credit (the actual fraction of the DPV installation's capacity that could reliably be used to offset conventional capacity)[29] and the cost of the alternative capacity investment being offset—including generation, transmission, and distribution capacity. Because these types of investments tend to be both expensive and inflexible in size (e.g., a new power plant or a new distribution substation), deferring or obviating the need for an investment typically results in significant cost savings.[30]

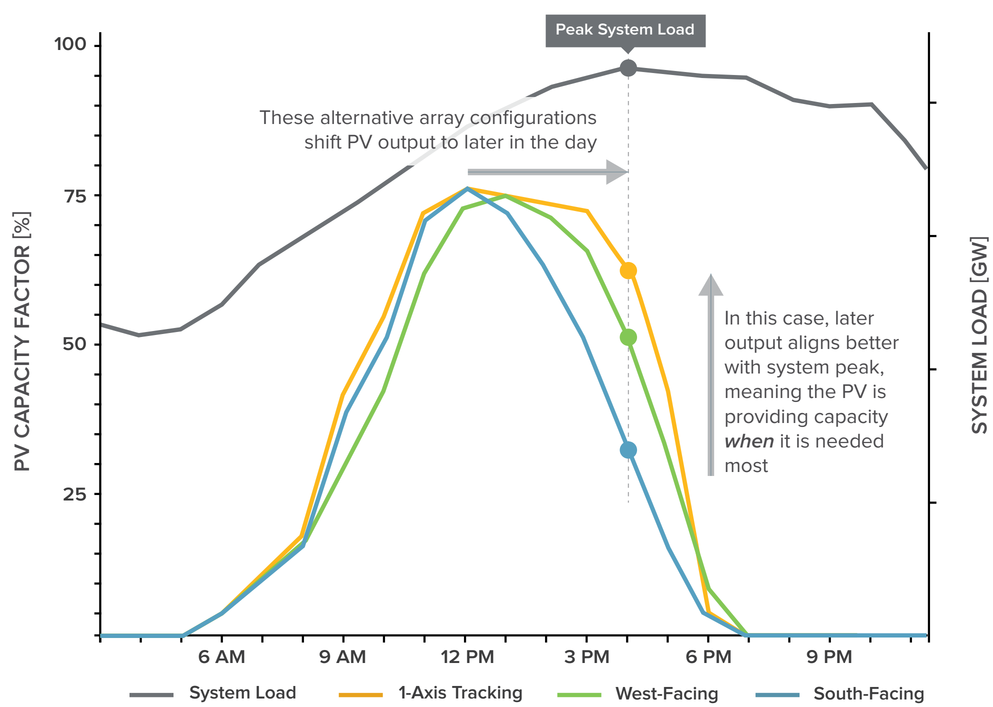
Strategic DPV project design can increase capacity value by influencing either of its primary variables:

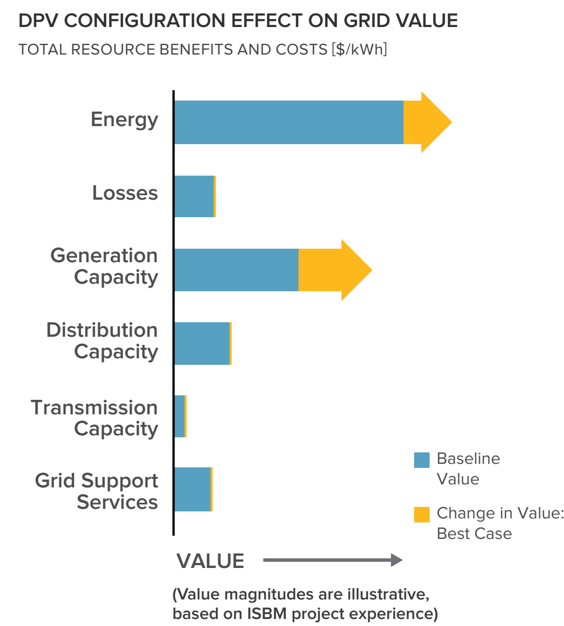
1. *Design to increase correlation of production with load*
   Variable: capacity credit

   Most electricity system infrastructure is built to meet the expected peak demand for its service, and many rates assess demand charges against peak consumption. As a result, DPV production that is temporally aligned with the appropriate peak demand will provide the most capacity value, at all levels of the system—on site, locally, and system-wide. In some cases, the peak output from a fixedtilt, south-facing PV array may align perfectly with peak load. In others, the relevant peak demand may occur later in the afternoon or evening. In this case a DPV installation would provide more value if designed to shift production later in the day by, for example, using a single-axis tracker or west-facing modules (Figure 5).[31] DPV project design still must consider differences between load profiles at each level of the system.

For example, a customer's load (which affects whether the DPV exports power to the grid at all) may peak at noon, while local distribution system loading peaks at 5:00 p.m., and system-wide load peaks at 3:00 p.m. In such a situation, an understanding of potential tradeoffs in capacity value between each level of the system is clearly important.

FIGURE 5: **OPTIMIZING CAPACITY VALUE THROUGH TEMPORAL CONSIDERATIONS**





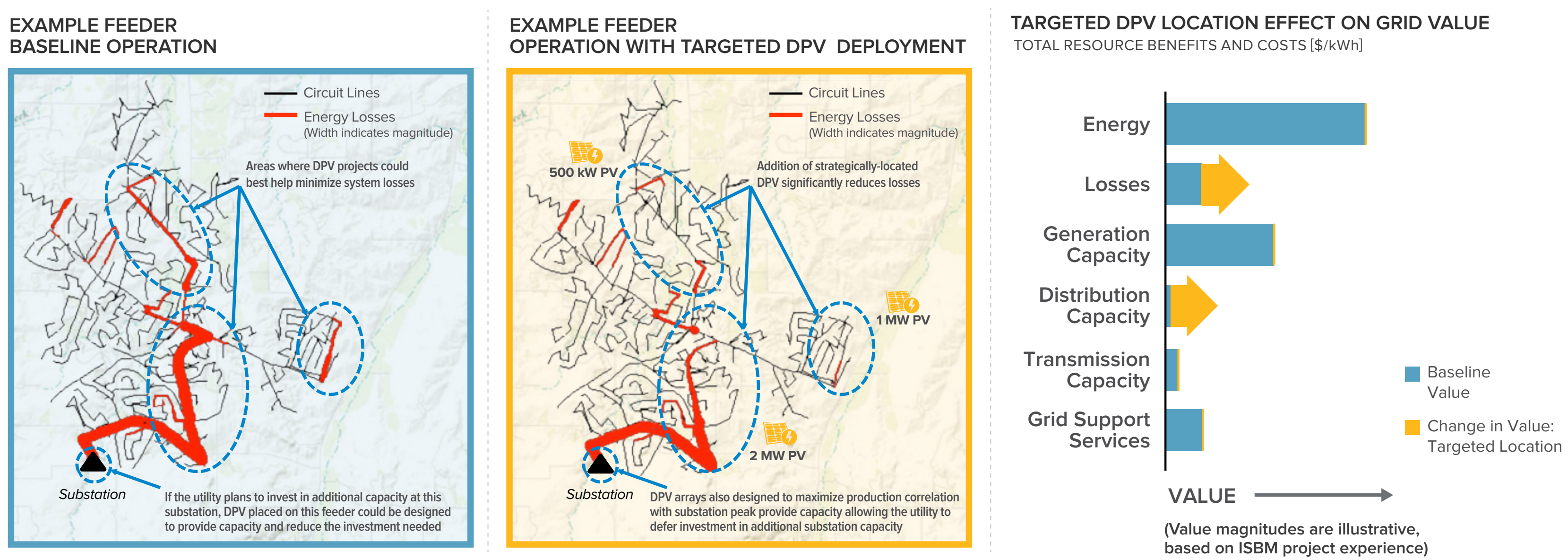
2. *Target locations where the system is constrained*

Variable: cost of alternative capacity

Capacity expansion needs vary across a utility territory, at all levels of the system. Generation capacity needs vary geographically depending on transmission constraints, which may limit the flow of electricity to areas of greatest demand. These constraints can make generation capacity much more valuable if located in a congested load pocket. Capacity expansion needs tend to be particularly variable at the distribution level. For example, a rapidly growing suburban neighborhood could be projected to exceed the capacity limit of its substation transformers. Meanwhile, an industrial area with a recently upgraded substation and a stable set of manufacturing plants may have minimal forecasted load growth and not need additional capacity investment for decades.

DPV projects can increase capacity value if sited in locations with the greatest need for investment (Figure 6). In the previous example, if the project was deployed on a feeder in a growing suburban neighborhood, the DPV could reduce the peak demand that would otherwise drive the need for equipment upgrades. Similarly, the DPV could be used to help alleviate congestion that would otherwise be addressed through transmission or generation capacity expansion.

FIGURE 6: **OPTIMIZING CAPACITY VALUE THROUGH LOCATIONAL CONSIDERATIONS**



While there are opportunities to increase the capacity value that DPV can provide through strategic deployment, there are also challenges to ensuring that a project is able to translate theoretical benefits into actual delivered value. The project must be able to provide reasonable physical assurance that it will perform as expected, and that it will achieve the expected net load reduction on the facilities where capacity is needed. Otherwise, the DPV may not provide reliable capacity that can defer the need for an investment, forcing the utility to make the planned capacity investment in order to meet its service obligations. Similarly, a project (or a group of projects) must provide enough capacity—relative to a given investment—to appreciably defer the need for additional capacity. These challenges are particularly important at the customer- and distribution-level, whereas at the system-level DPV installations may be considered in aggregate, and geographic diversity reduces risk.[32]

A DPV project does not have to be in a constrained area or have production that perfectly aligns with system peak in order to have value. However, projects designed with capacity value in mind will likely increase their production benefits, creating additional value both to the customer and to the system at large.

PROVIDE ADDITIONAL GRID SERVICES

Though technologically feasible today, DPV's ability to provide additional grid services—beyond energy and capacity—have yet to be widely harnessed.[33] But, with appropriate standards and controls in place, DPV projects can be installed with advanced inverters to offer additional grid support services (Table 1). Some of these services could even be provided at times when the sun is not shining (e.g., reactive power at night).[34] These capabilities would allow project designers to potentially increase value in two ways:

1. ***Reduce system operating costs***
   A DPV installation operated to provide a grid service like voltage regulation would directly replace the need to use an alternative resource for that service, offsetting the resource's variable operating costs. In some cases, these cost reductions could accrue at multiple levels of the system. For example, a DPV installation providing voltage regulation service could reduce distribution costs by enabling less-frequent load tap-changer operation (reducing wear and tear), and reduce generation costs by allowing a gas-fired unit to run at a higher power factor (since the DPV installation is providing reactive power).
2. ***Reduce future capital expenditures***
   DPV projects designed to provide additional grid services could reduce the need for capital investment in other types of assets beyond generation, transmission, and/or distribution capacity. For example, a DPV installation set to provide local voltage regulation could defer or obviate a distribution capacitor bank investment. Similarly, an installation with controllable output could offset the need for investment in an alternative fast-ramping generation resource.

When determining whether to design a DPV project to deliver additional grid support services, the relative magnitude of these cost reductions—which may be less than other grid services[35]—must be considered. If DPV is designed to provide these services, it will remain important to optimize project deployment based on both temporal considerations and locationally-specific system needs.

TABLE 1: **TECHNICALLY FEASIBLE PV GRID SUPPORT SERVICES**

FERC-DEFINED SERVICE CATEGORY*	SPECIFIC GRID SUPPORT SERVICE	COULD BE PROVIDED BY:			
		PV + STANDARD INVERTER	PV + ADVANCED INVERTER	PV + DEMAND RESPONSE**	PV + BATTERY STORAGE
Energy imbalance	Load following	Cannot provide	Limited ability to provide (only via curtailment)	Can provide	Can provide
Generator imbalance	Ramp mitigation	Cannot provide	Limited ability to provide (only via curtailment)	Can provide	Can provide
Operating reserve - supplemental	Contingency reserve	Cannot provide	Cannot provide	Can provide	Can provide
Operating reserve - synchronized	Spinning reserve	Cannot provide	Limited ability to provide (only via curtailment)	Can provide	Can provide
Reactive supply & voltage control	Reactive power	Cannot provide	Can provide	Can provide	Can provide
	Voltage support	Cannot provide	Can provide	Can provide	Can provide
Regulation and Frequency Response	Frequency support	Cannot provide	Can provide	Can provide	Can provide
Backup supply	Automated islanding and reconnection	Cannot provide	Cannot provide	Cannot provide	Can provide
Dynamic scheduling	Real-time load monitoring	Cannot provide	Can provide	Can provide	Can provide
	Real-time network monitoring	Cannot provide	Can provide	Can provide	Can provide
	Enhanced fault detection/location	Cannot provide	Can provide	Can provide	Can provide
Restoration	Blackstart	Cannot provide	Cannot provide	Cannot provide	Can provide

* FERC ancillary services and interconnected operations services as defined in orders 888 and 890
** Assumes demand response in the form of direct load control

(white)	Cannot provide
(light orange)	Limited ability to provide (only via curtailment)
(orange)	Can provide

INTEGRATE COMPLEMENTARY TECHNOLOGIES AND PROGRAMS

Bundling DPV with complementary technologies and/or additional program participation may maximize the project's operational benefits by strengthening its existing capabilities, or by providing additional grid services beyond those available with an advanced inverter (Table 1). The exact services that would be most beneficial are highly dependent on an installation's specific context, and would need to be determined through holistic project planning. If beneficial in a given situation, a bundle could even be designed to provide more capacity than could PV alone, helping to reach the amount needed to defer a capacity investment. This strategy is technology-agnostic, and could incorporate any complementary technology—existing or future. Potential bundles could include:

- *PV + Battery Storage*
  - Adds the ability to shift generation to times it is most needed, and to reduce peak load by aligning the installation's net production profile with system peak to strengthen capacity value
  - Mitigates solar resource variability and uncertainty by charging/discharging storage to smooth output
- *PV + Energy Efficiency + Demand Response*
  - Uses strategic investment in efficiency to reduce energy use during peak periods
  - Employs direct load control demand response to influence net load profile to minimize operating costs, for example by shifting load to reduce peak demand and utilize low-cost generation resources

In addition to increasing production benefits, including complementary technologies typically increases total project cost. Some emerging technologies may also increase project risk due to uncertain lifespans or performance, or unexpected maintenance costs. While both capital and operations and maintenance costs for many technologies are projected to decline,[36] each strategy would need to compensate for additional costs by increasing revenue.

Integrating DPV with complementary resources holds promise for collaboration between utilities and technology or energy service providers (e.g., demand response aggregators, storage vendors, and energy management system developers). While utilities may be best able to holistically plan to determine the value of a project, other stakeholders (including solar companies, technology vendors, and project developers) typically have superior knowledge of the technology landscape, as well as hands-on experience with cutting-edge technologies.

While there are significant opportunities to optimize operational benefits and costs, there is ongoing debate regarding how to calculate and monetize them. The lack of a standard analytical methodology and the considerable data and analytical granularity needed to perform accurate calculations are contributing factors. Some sources of value (e.g., environmental and societal) have also been contested on philosophical grounds, or because they are currently unmonetized. Even for established, widely recognized value sources like energy, the use of questionable assumptions can inject significant uncertainty. Because DPV's benefits and costs are sensitive to input assumptions such as natural gas price forecasts, solar power production profiles, and power plant heat rates, assumptions must be heavily vetted; transparency is critical.

EMERGING SOLUTIONS TO CAPTURE VALUE

03

03: EMERGING SOLUTIONS TO CAPTURE VALUE

Today, stakeholders do not capture the full potential value of DPV due to a series of market failures and misalignments. Current rate structures generally incentivize DPV owners to maximize total energy production rather than accurately translating the benefits and costs associated with integrating DPV.[37] Meanwhile, prevailing regulatory models generally cause utilities to associate DPV with revenue loss and give them little incentive to increase the value of DPV. These issues limit stakeholders' ability to recognize and monetize the value of DPV.

The electricity industry widely recognizes these market failures, and the need to reform institutional infrastructure to align regulatory and market rules with societal goals.[38] The numerous proposed solutions represent a broad spectrum that could take many forms, depending on the specific market and regulatory context. For instance, on one end of the spectrum, regulatory institution of a service-based model might force a utility to overhaul its approach to solar. But, at the other end of the spectrum, utility collaboration and information sharing with other stakeholders (e.g., via bilateral data exchange, open access data, price signals, etc.) could have tremendous impact with minimal regulator involvement. Activities along this spectrum include:

- ***Pricing realignment.*** Pricing structures—including both retail rates and incentive tariffs—can act as signals that can translate the benefits and costs of DPV investments. If used effectively, these can provide incentives for deployment and operation of DPV at the times and locations with the greatest benefits. Pricing can become more sophisticated and granular, shifting from flat or block rates that do not account for location to structures that differentiate time-based value of generation and consumption (e.g., hourly) or provide geographically differentiated incentives.[39] Pricing realignment will require making tradeoffs, recognizing that more granularity could reduce simplicity for customers and some structure could be disruptive for existing solar company business models.
- ***Bridge business models.*** Utilities, solar companies, technology vendors, and energy service providers have opportunities to create and capture value within the existing regulatory paradigm with new business models. These business models can augment existing ones, and possibly provide mutually beneficial outcomes for service providers, customers, and utilities. Today, many utilities and service providers are investigating these opportunities, and several are considering or have launched pilots and programs. Community solar offerings, for instance, have been introduced in at least seventeen states.[40] Other examples include zonal targeting of DPV (like New York's Solar Empowerment Zones) and utility procurement of DPV through request for proposals and power purchase agreements.[41]
- ***Regulatory model reform.*** Incremental changes to existing utility models can enable net value to be increased and captured, but continuing to layer new remedies on existing models could eventually create unmanageable complexity. At some point, a transformative regulatory model may be a better, simpler, and more elegant solution.[42] Shifting from traditional cost-of-service regulation toward alternative

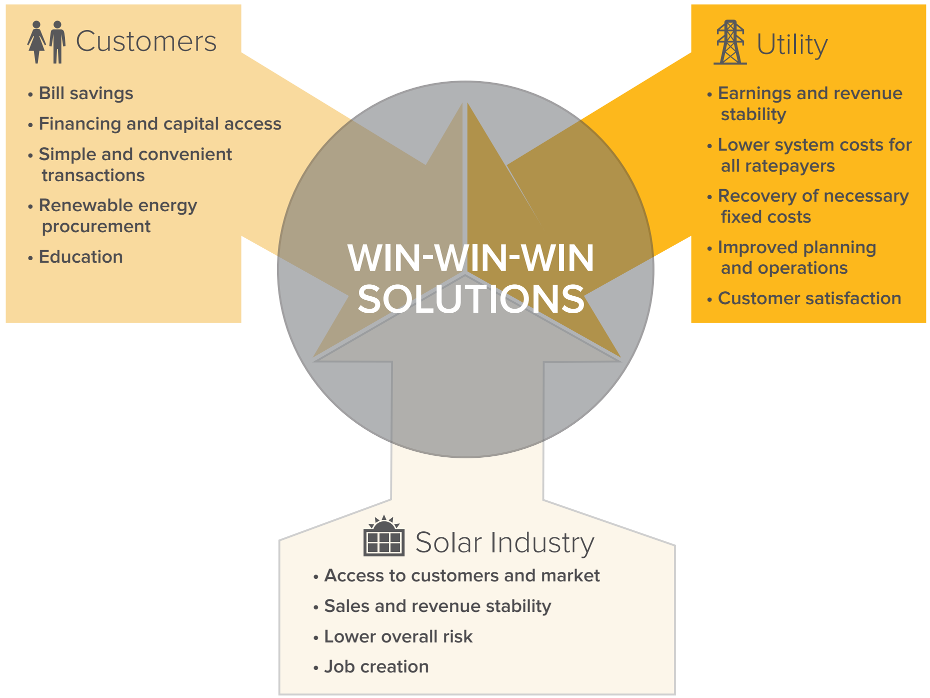
approaches such as performance-based ratemaking, independent distribution network operators, or service-based energy models, could open the door toward innovation across the electricity industry.[43] While some states, like New York and Hawaii, are exploring regulatory reform today, reform will likely occur slowly and gradually throughout the country as the current business and regulatory constructs remain viable in the short-term.

This report focuses on the bridge business model solutions for solar that can be implemented today and that provide a path to future reform. In particular, this report highlights possible building blocks for bridge business models that could create economic value and address the needs for customers, utilities, and solar companies, creating a "win-win-win" outcome (Figure 7).

In this report, a business model describes the rationale for how an organization creates, delivers, and captures value.[44] Every business model is comprised of several distinct, interrelated components, including the value proposition, operations, customer services and marketing, and finances and earnings (Figure 8).

To date, the utility business model has focused on providing customers with power from power plants across transmission and distribution lines and collecting payments for the service on a utility bill.[45] But utilities do not measure performance in economic terms alone. As regulated monopolies, utilities must also be evaluated in terms of their regulatory compact, which includes: service to the customers and communities they serve, equity among customer classes, environmental and other societal costs and benefits, and compliance with legislative and

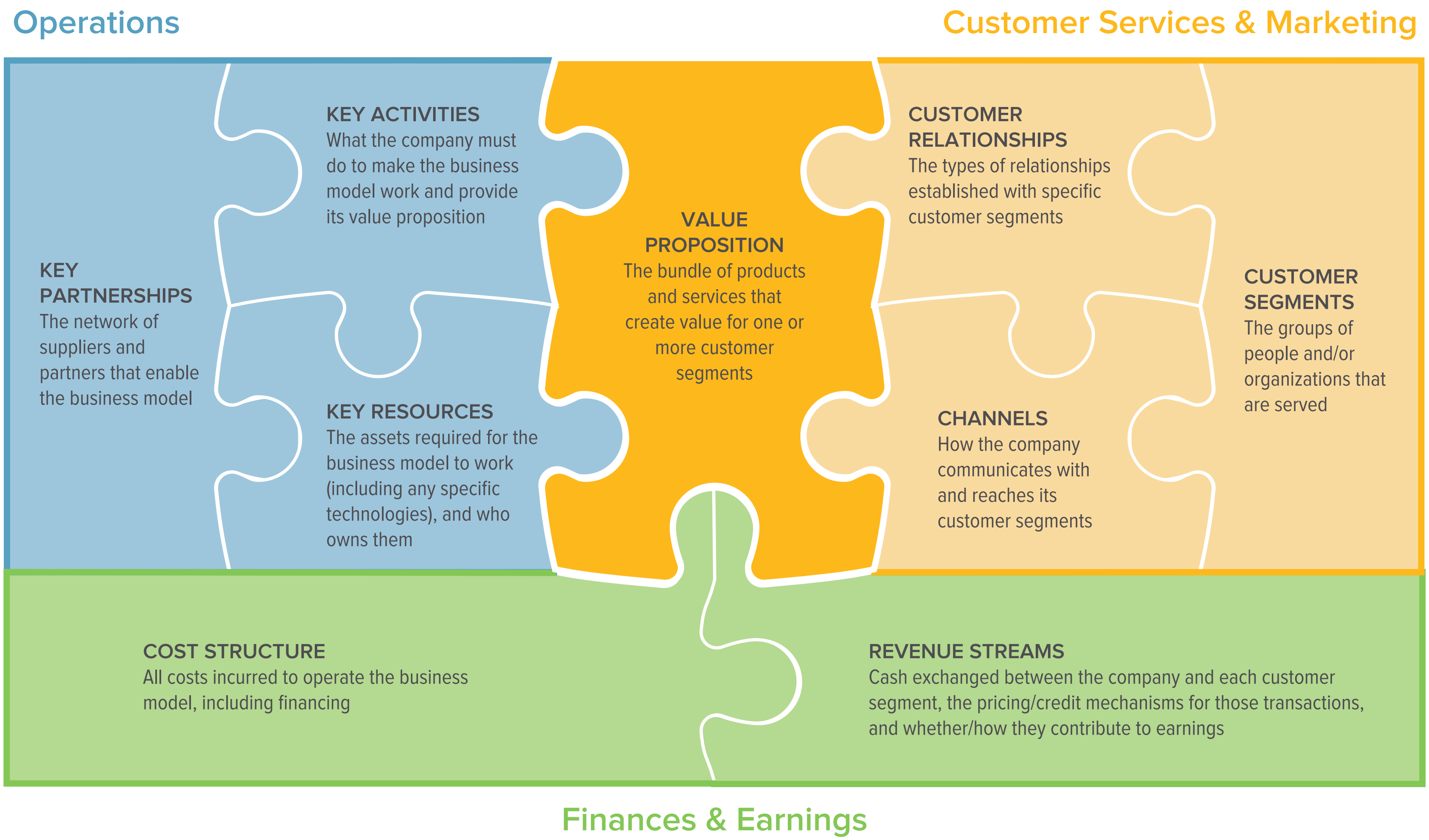
FIGURE 7: **FRAMING "WIN-WIN-WIN" SOLUTIONS**



regulatory mandates.[46] With the growth of DPV, this model must adapt to ensure that utilities can still keep this social compact intact while encouraging customer participation (sometimes with assistance from third-party service providers) in meeting their own energy needs.

Solar business models, specifically, refer to the collection of actions that utilities and third-party actors—primarily solar companies—take that relate to DPV deployment. As discussed

FIGURE 8: **BUSINESS MODEL FRAMEWORK AND DEFINITIONS**



SOURCE: BUSINESSMODELGENERATION.COM

earlier, the development of a DPV project—from conception to commissioning and beyond—requires a number of actions and services across the value chain, both customer-facing and grid-facing.[47] Utilities and solar companies have evolved to provide these services within current regulatory models and market dynamics. Typical utility activities vary considerably depending on the particular type of utility (Box 2), but center on offering interconnection services, tariffs, billing, and system integration to DPV customers. Solar companies have filled in the gaps by taking on a variety of roles to create value, ranging from sales and financing to project installation and maintenance (Table 2), and are a diverse group as a result (Box 3).

Many of the opportunities for increasing and creating value go unrealized because utilities and solar companies have been unable to leverage each other's core competencies. However, the solar business model space is dynamic, and these competencies can evolve as mergers and acquisitions occur. Companies can also identify new opportunities to create value, including approaches where solar companies and utilities work together more closely. In fact, the bridge business models will generally rely on greater collaboration.

To develop bridge business models solutions, it will be critical for these solutions to create additional value and then compensate customers, solar companies, and utilities based on their contribution to the increase in net value. If these solutions create sufficient net value then each stakeholder can see positive outcomes—in other words a "win-win-win" from a revenue and profit perspective as well as on other important metrics, such as public relations and customer satisfaction, and the utility's ability to uphold its regulatory compact.[48]

TABLE 2: **KEY ACTIVITIES FOR ACTORS TODAY**

KEY ACTIVITIES	*TODAY*		
	UTILITY	SOLAR COMPANY	CUSTOMER
PROJECT DEVELOPMENT			
Identify DPV sites		■	
Solicit & enroll DPV program participants		■	
Vet technologies & service providers		■	■
Engineer & design DPV projects		■	
Finance projects (or procure financing)		■	■
Procure hardware & materials		■	
Install DPV projects		■	
Permitting, inspection, & interconnection	■		
Own DPV projects		■	■
OPERATIONS			
Metering & billing	■	■	
Provide DPV customer support services	■	■	
Perform DPV maintenance		■	■
Manage DPV operations		■	■
GRID INTEGRATION			
Manage market transactions	■		
Forecasting, scheduling, dispatch, & system control	■		
Outage restoration & resiliency	■		
System planning & long-range forecasting	■		
Perform grid maintenance	■		

BOX 2: ELECTRIC UTILITY TYPOLOGIES

The 3,000 electric utilities in the U.S. are far from homogenous.[49] While end-user experience is similar across the country (i.e., plug-in, turn-on, use electricity), regulatory and business models for electric utilities can be distinct. Key dimensions of utilities in the context of solar business models include:

- **Ownership.** Models include investor-owned utilities (IOUs), member-owned cooperatives (co-ops), and publicly-owned utilities (POUs).
- **Functions.** An electric utility generates, transmits, or sells electricity. Vertically-integrated utilities perform all three functions, while others may perform just one or two (e.g., distribution-only utilities), particularly in competitive retail environments where regulators have restructured the industry.

These models affect utility solar business models in two ways:

- **Motivation.** All utilities serve the public interest in their service territory, delivering safe, reliable, and affordable electricity. However, ownership models can create additional incentives for utilities. IOUs also seek to create value for their shareholders, while co-ops and POUs are inherently responsive to the priorities of their member/customer owners.
- **Capability.** Utilities do not have the same tools and resources to assess value and participate in new business models. For instance, advanced meter infrastructure data is an essential tool, but many utilities have not made investments in upgrading their meters. Some utilities have dedicated significant resources for building up customer service staff and demand-side management programs while others have not had the opportunity or chosen not to do so.

BOX 3: TYPES OF SOLAR COMPANIES

As discussed earlier, the DPV value chain includes numerous steps. Solar companies take on one or more of these steps to create value, but there is no single model that defines all companies in the industry. With new companies entering the market and others consolidating, the industry landscape continues to evolve.

The majority of companies specialize in a targeted set of value chain components, and may look to grow by acquiring competitors or forming partnerships across the value chain. However, vertical integration has recently gained the spotlight as prominent companies like SolarCity and Sunrun have moved toward this model to manage supply uncertainties and to enable scale.[50] While most companies show little interest in full vertical integration, some have pursued more limited integration, as exhibited by recent acquisitions such as developer NRG Residential Solar Solutions' purchase of installation company Roof Diagnostics Solar.

BUILDING BLOCKS FOR INCREASING AND CAPTURING VALUE

In the pursuit of bridge solar business models that enable "win-win-wins," this report highlights three promising building blocks that can increase the likelihood of achieving a mutually beneficial outcome:

A. *Make DPV accessible to a much broader customer base,* including the large portion of customers for whom on-site solar is not an option.

B. *Optimize deployment to capture potential operational benefits* that are currently being missed.

C. *Leverage solar adoption to increase uptake of other DER technologies,* creating greater net value that can be tapped by leveraging complementary technologies and making myriad technology choices more consumer friendly.

These building blocks are possible approaches for capturing the opportunities to increase net value laid out earlier in the report. Each building block can augment existing solar business models to increase value and support greater DPV adoption.[51] But, these building blocks can also be complementary. Certain elements from one may support another, or they could all be combined. For instance, a business model could seek to target deployment in high value locations (building block B) and increase access by enabling customers to subscribe to the generation (parts of building block A).

The following descriptions highlight the shifts in activities between actors, and explain the logic for those shifts from the perspectives of both the utility and solar companies. Each description also includes examples of existing programs that have incorporated elements of the building block. While pricing realignment and regulatory reform could help support these building blocks, they are not mandatory, and are not a focal point in the descriptions below.

Building Block A: Increase Access to Distributed PV

Overview

Today, many customers are limited in their ability to install on-site DPV. Factors limiting installation include physical issues, like rooftop and land space availability, but also nonphysical issues, like landlord-tenant concerns while renting, lack of upfront capital, and creditworthiness.

To address these issues, building block A (Table 3) expands access to DPV generation to all interested customers by providing new options for procurement. This approach incorporates successful concepts from many community solar programs and subscription-based models in the U.S. today. Solar companies and utilities locate DPV installations near customers, and interested customers then subscribe to a portion of the DPV projects' power and receive a bill credit based on the value the project provides.

While other programs of this type have yet to find mass-market success, solar companies and utilities can work together to enable models that increase access to scale. To drive down project costs—improving affordability and encouraging subscriptions—building block A promotes competition using an RFP process. The process could include encouraging solar companies to develop portfolios of DPV installations that minimize cost, ranging from MW-scale projects at a single site to rooftop-scale projects across numerous customer sites (Figure 9). An RFP process could further reduce project costs by including a multi-year contract (e.g., three to five years) for DPV installations, which would provide volume certainty for solar companies. This type of contract would need to ensure

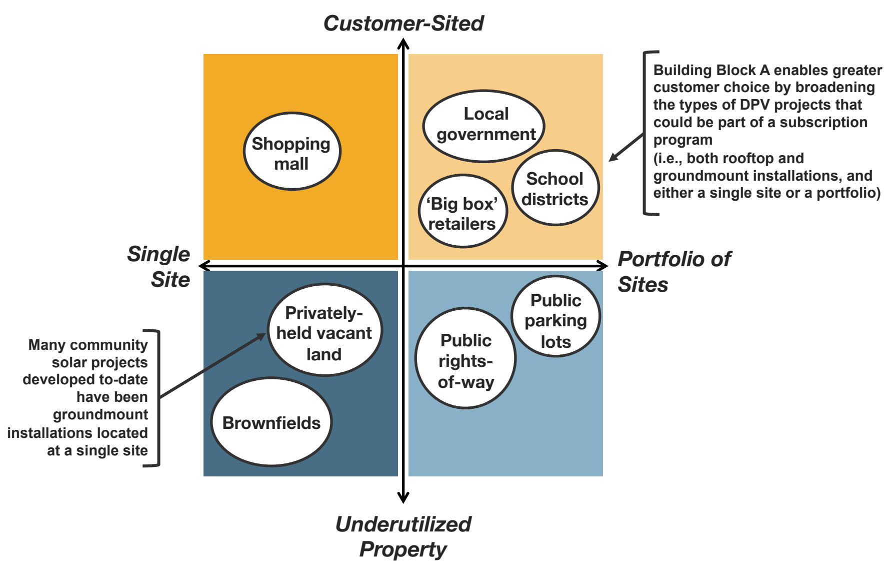
TABLE 3: **BUILDING BLOCK A SUMMARY**

Objective
Make DPV accessible to a much broader customer base, including the large portion of customers for whom on-site solar is not an option

KEY ACTIVITIES	UTILITY	SOLAR COMPANY	CUSTOMER
PROJECT DEVELOPMENT			
Identify DPV sites		Minimal change	
Solicit & enroll DPV program participants	Increased focus	Decreased focus	Increased focus
Vet technologies & service providers	Increased focus	Minimal change	Minimal change
Engineer & design DPV projects		Minimal change	
Finance projects (or procure financing)		Minimal change	Decreased focus
Procure hardware & materials		Minimal change	
Install DPV projects		Minimal change	
Permitting, inspection, & interconnection	Minimal change		
Own DPV projects		Minimal change	Decreased focus
OPERATIONS			
Metering & billing	Minimal change	Decreased focus	
Provide DPV customer support services	Minimal change	Decreased focus	
Perform DPV maintenance		Minimal change	Decreased focus
Manage DPV operations		Minimal change	Decreased focus
GRID INTEGRATION			
Manage market transactions	Minimal change		
Forecasting, scheduling, dispatch, & system control	Minimal change		
Outage restoration & resiliency	Minimal change		
System planning & long-range forecasting	Minimal change		
Perform grid maintenance	Minimal change		

CHANGE IN ACTIVITIES: Decreased focus | Minimal change | Increased focus

FIGURE 9: **EXAMPLES OF DPV PROJECT SITING AND PORTFOLIO OPTIONS**



continued cost-competitiveness, possibly by making contract length contingent on the solar company meeting specified cost benchmarks over time.

Building block A would also reduce customer acquisition costs and encourage subscriptions by using the utility to lead program marketing efforts. The program would harness the utility's access to customers, and could be co-branded to leverage both the solar company's association with DPV and the utility's established trust with customers.

Highlights for market players

- *Utility*
  - Leads customer acquisition efforts, marketing subscriptions to customers.
  - Bills customer, crediting generation and charging for subscription for the DPV project as part of their electric utility bill.
  - Solicits solar projects through an RFP process, with possible multi-year commitment to solar companies.
- *Solar Companies*
  - Respond to utility RFPs for projects.
  - Design and install DPV projects.
  - Conduct operations and maintenance over the life of the projects.
- *Customers*
  - Contract with the utility for purchases from DPV projects.
  - Help marketing efforts, possibly rewarded for referrals into the program.

Business Model Functions
Utility

- *Value Proposition:* This model expands the utility's value proposition beyond customers who can install on-site DPV systems. Instead, the utility is better able to meet its societal obligations by giving solar access to all its customers. Customers then can capture similar economic benefits from DPV, in terms of subscription costs and credits for generation.
- *Customer services and marketing:* The utility shifts to become an important part of enabling customer access, as it actively procures low-cost DPV projects, encourages enrollees, and manages billing. To advertise the program and increase demand for subscriptions, the utility can reach a broad swath of customers using existing channels, including bill inserts, customer account managers, and media (e.g., newspaper ads, billboards, television commercials, and online ads). The utility can also provide online resources, like calculators that offer customized advice about bill impacts, to help inform customers. The utility would harness enthusiastic participants who are willing to champion the subscription program as an additional marketing channel, possibly providing rewards for referrals.
- *Operations:* Activities shift as the utility leads customer acquisition efforts. While many utilities have relevant experience from management of demand-side programs, most will need to strengthen their capabilities and dedicate resources to ensure high customer enrollment. The procurement process could also change to encourage cost reductions over time, shifting away from an RFP for single DPV projects to establishing a multi-year commitment dependent on the solar company meeting cost benchmarks over time. The utility could also manage all billing, streamlining the process for customers.
- *Financial (earnings, revenues, and costs):* The revenue streams and costs could be structured to pass through the utility, with customers credited for generation via their utility bill. Utilities would need to be allowed an alternative performance incentive to share the value created by DPV, for instance through a commission fee incorporated into pricing as a project cost.

Solar Companies

- *Value proposition:* Solar companies still offer DPV generation, but to a larger pool of possible customers via collaboration with the utility.
- *Customer services and marketing:* Solar companies would market their services to the utility, supplying new capacity over time and potentially agreeing to meet cost reduction benchmarks. To acquire customers and manage relationships in this model, solar companies would largely rely on the utility, leveraging the utility's brand strength and marketing team.
- *Operations:* Key activities in this model involve responding to utility RFPs, carrying out installations, and performing operation and maintenance for the DPV projects. In many ways, project development looks similar to utility-scale projects, but installations could be spread throughout the territory rather than concentrated at one large site.
- *Financial:* Revenues would come through payments by the utility for the installations' output. Cost structures would include all installation and development costs.

Examples of Concepts in Practice

- ***Salt River Project - Community Solar Program.*** Customers sign up for kW blocks and buy the output at a fixed rate, which represents a near-term premium of ~10% but also provides a hedge. More than 1,000 residential customers and 100 schools have participated in the program.[52]
- ***Duke Energy (North Carolina) - Green Source Rider.*** Duke's pilot program enables nonresidential customers to displace new load with renewable energy. Duke handles customer applications and then arranges power purchase agreements with renewable energy suppliers. Customers buy the generation at the power purchase agreement rate and receive a credit based on avoided energy and capacity rates.[53]
- ***SolarCity and Direct Energy – Solar Energy for Businesses.*** SolarCity and Direct Energy partnered to create a program offering DPV installations to Direct Energy's commercial and industrial customers. The partnership includes creation of a dedicated investment fund to finance projects, with Direct Energy handling marketing responsibilities and SolarCity managing DPV project design, installation, and maintenance.[54]

Discussion

Enabling Success

To increase participation beyond levels common today, building block A needs to emphasize simplicity and convenience. Simplicity could come through offering the customer a streamlined decision-making process. For example, a customer could be given three options to choose between: a lower tier representing a small portion of their demand (e.g., 10%), a middle tier that offsets half of their demand, and an upper tier that offsets all of their demand. Procurement of off-site DPV is convenient for customers because it removes the need for house visits and crews to install equipment on the customers' premises. The customer also would not be involved with any on-site operations and maintenance, and could change locations without the hassle of relocating any physical equipment. Further, customers could be given the opportunity to play an active role in marketing, which should boost participation, as peer-to-peer influence has been found to significantly increase DPV adoption.[55] These customers could advertise their participation through traditional channels, like lawn signs and decals, and could receive rewards for referrals. For example, a customer could receive a discount on their subscription for enrolling additional customers, or could be entered in a lottery to receive a large prize.

Policymakers and regulators can ensure that both solar companies and the utility are able to capture a fair share of the value they help to create. While solar companies have the opportunity to profit in the roles of ownership, financing, and installation, the utility may need an alternative incentive mechanism to capture value. Utilities could receive compensation through commission fees, or by meeting specific performance metrics for enrollment and customer satisfaction (which could be part of concurrent regulatory reform). In some situations, utility ownership of DPV projects may be possible as well, if the arrangement is cost-competitive. Utilities and solar companies will, however, need to establish a pricing mechanism for generation that ensures full recovery of fixed costs and minimizes cross-subsidization by customers who are not subscribing to the DPV projects.

Most utilities' procurement processes are based on soliciting single projects through RFPs, rather than contracting service for several years. The RFP process for a multi-year service commitment will need significant scrutiny from state regulators, city councils, and cooperatives' boards of directors. To maintain fairness, utilities must be required to select solar companies best positioned to achieve program objectives, whether the focus is on cost reductions, economic development, or both. Stakeholders will need to ensure that the process is transparent in order to verify that these criteria are met, which may require supporting parallel data accessibility efforts.

Questions to Address

- How should utilities and solar companies design the offering, particularly subscription fees and generation credits, with terms that customers find attractive?
- What is the mechanism to transparently determine the appropriate share of value creation that each stakeholder may capture?
- In a scenario where projects are undersubscribed, who ultimately bears the cost of the DPV project?

Building Block B: Optimize Deployment to Capture Operational Benefits

Overview

Current solar business models do not incentivize deployment of DPV to maximize the operational benefits of the resource. This leads many utilities to evaluate DPV negatively, associating it with increased transaction costs, challenges to system operations, and revenue loss. Meanwhile, today's policies and pricing mechanisms typically incent DPV customers to maximize energy production rather than net value to the system.

Building block B (Table 4) focuses on increasing net value by enabling utilities to see DPV as a beneficial system resource, and by incentivizing all stakeholders to deploy DPV to provide increased value to the grid and society, rather than only the individual customers who install DPV on-site. This is accomplished by leveraging the utility's competency as the distribution grid planner to simultaneously optimize DPV resource integration and reduce costs to serve. For example, a utility could identify grid locations where a DPV project would be the lowest cost resource for needed capacity or improving system operations, and then facilitate development of DPV projects at those locations.[56] Or the utility could motivate DPV deployment through time- and location-differentiated price signals to encourage solar generation to be coincident with substation or system peak.

While the utility facilitates the strategic deployment of DPV to provide benefits to the grid, many other roles are contingent on the local market and regulatory context. Key factors will include the current degree of utility regulation (or deregulation), and the existence, capabilities, and efficiency of the local solar industry.

TABLE 4: **BUILDING BLOCK B SUMMARY**

Objective
Optimize deployment to capture potential operational benefits that are currently being missed

KEY ACTIVITIES	UTILITY	SOLAR COMPANY	CUSTOMER
PROJECT DEVELOPMENT			
Identify DPV sites	Increased focus	Decreased focus	
Solicit & enroll DPV program participants	Increased focus	Minimal change	
Vet technologies & service providers		Minimal change	Minimal change
Engineer & design DPV projects		Minimal change	
Finance projects (or procure financing)		Minimal change	Minimal change
Procure hardware & materials		Minimal change	
Install DPV projects		Minimal change	
Permitting, inspection, & interconnection	Minimal change		
Own DPV projects	Increased focus	Minimal change	Minimal change
OPERATIONS			
Metering & billing	Minimal change	Minimal change	
Provide DPV customer support services	Minimal change	Minimal change	
Perform DPV maintenance	Increased focus	Decreased focus	Decreased focus
Manage DPV operations	Increased focus	Decreased focus	Decreased focus
GRID INTEGRATION			
Manage market transactions	Minimal change		
Forecasting, scheduling, dispatch, & system control	Minimal change		
Outage restoration & resiliency	Minimal change		
System planning & long-range forecasting	Minimal change		
Perform grid maintenance	Minimal change		

CHANGE IN ACTIVITIES: Decreased focus | Minimal change | Increased focus

Highlights for market players

- *Utility*
    - Takes an active role in DPV deployment, identifying optimal locations and production timing
    - Manages grid integration and ensures DPV projects meet physical assurance requirements (when applicable)
    - Monitors project performance to ensure projects meet performance specifications and increase net value
    - May issue a request for proposal (RFP) for individual projects, or send pricing signals to direct development
- *Solar Companies*
    - Work with the utility to identify specific sites, including properties with existing load, undeveloped sites, or utility-owned properties
    - Either respond to utility RFPs, or develop projects based on economic returns given utility pricing signals
    - Design, procure equipment for, and install DPV projects
- *Customers*
    - May host DPV projects

Business Model Functions

Utility

- *Value Proposition:* The utility takes on a more proactive role in DPV deployment, using DPV as a resource to reduce costs to serve and improve service, benefiting all customers. In addition, the utility could offer an expanded value proposition to customers and property owners located in areas where DPV has particularly high value, or for generating power at certain times. Benefits could include favorable rebates or additional performance-based incentives tied to generation credits.
- *Customer Services & Marketing:* To operate this business model, the utility will proactively seek out sites in identified high value areas. The utility could also educate customers and solar companies on project design features to optimize the temporal aspects of DPV generation. Possibilities range from direct outreach to specific customers, to developing maps that highlight the targeted areas and soliciting applications from interested parties.
- *Operations:* This building block is predicated on the utility's ability to identify optimal system locations and temporal needs for DPV integration. This will require integrating DPV into system planning decisions across all levels of system operations—load forecasting, integrated resource planning, transmission, and distribution capacity planning. The utility will collect detailed distribution-level data and perform avoided cost analyses, using tools that enable holistic planning and operational management of DPV resources.

The utility must engage with a broader network of solar industry partners. Depending on the specific market and regulatory situation, the utility will need to form key partnerships with solar companies, or with equipment vendors. Where possible, the utility could work with solar developers to install projects, issuing RFPs for DPV projects deployed in priority locations or optimized for production timing. Either the utility or solar companies could carry out operations and maintenance to ensure that DPV projects are providing maximum value.

- ***Financial: Earnings, Revenues, and Costs:*** In general, the types of cash flows between parties may not differ from current business models. The utility could enter power purchase agreements with solar companies collecting payments through customer bills, or, with utility DPV ownership, the utility could treat the DPV projects like other assets in their rate base.

The utility will incur additional overhead costs to perform planning and program management tasks. If the utility owns the project assets it will incur capital and financing costs. If it provides ongoing operations and maintenance of the installation it will also incur staff and equipment costs.

Solar Companies

- ***Value Proposition:*** Solar companies coordinate site selection with utilities and design and install projects on the distribution system, helping to reduce cost to serve and improve service.
- ***Customer Services and Marketing:*** Solar companies would help to screen possible host sites to determine which locations are most viable for DPV projects to provide high net value. In cases where a customer hosts the project, the solar company markets the benefits of installing the project on-site, including revenues, public relations, and educational opportunities.
- ***Operations:*** Key activities focus largely on ensuring that DPV projects meet the requirements necessary to deliver expected benefits and monetize the net value. Solar companies would continue to work in a competitive market for projects, either responding to utilities RFP or installing projects based on utility pricing mechanisms, and would continue to carry out many of the same functions in the value chain, including project design, equipment procurement, and installation.
- ***Financial:*** Solar company revenues would come from utility credits that are tied to the net value the DPV projects provide to the grid. Cost structures would be similar to projects installed today, with likely lower customer acquisition costs due to utility coordination of site selection.

Examples of Concepts in Practice

- ***Consolidated Edison Company of New York - Solar Empowerment Zones.*** This program designates strategic areas where DPV is viable and most beneficial to the grid. Con Edison selects zones based on a number of technical factors, including the time of peak loading, planned system upgrades, and the ability to offset fuel consumption (and emissions) at local peaking plants. Customers in these zones receive assistance navigating technical considerations and available incentive programs, as well as expedited permitting. They also receive a bonus state incentive, which in 2013 amounted to a 25% increase over the standard incentive.[57]
- ***NV Energy – Targeted Demand Side Management.*** In 2008, NV Energy needed to make a decision for serving a constrained area of its territory: either run an expensive, inefficient local power plant more frequently, or build a new transmission line and substation to import power from a more-efficient non-local plant. Given permitting concerns and the cost of these plans, the Nevada regulators ordered NV Energy to concentrate on demand-side management efforts before going forward with either of the proposed plans. NV Energy implemented a wide range of programs tailored to the needs of customers in that region, and achieved significant success with commercial retrofit and refrigerator recycling programs. Since implementing the targeted demand-side management programs, NV Energy has not had to build a new substation and transmission lines or increase the runtime of the inefficient power plant.[58]

Discussion

Enabling Success

This model leverages the utility's competency as distribution grid manager to transparently provide clear, location-specific signals to stakeholders about DPV's grid value. The planning process for determining how to increase net value should be transparent and inclusive, seeking input from all relevant stakeholders, and ensuring all interested parties have equal access to information, tools, methodologies, and models. To ensure that DPV installations deliver expected benefits, both utilities and solar companies can provide guidance to regulators regarding rules to govern reasonable physical assurance (which may include penalties for operational nonfeasance). In addition, regulatory mechanisms will need to be implemented to incentivize the utility to prioritize DPV where it is the least-cost option, and must do so in a way that ensures the utility optimizes both grid value and customer value together. Stakeholder collaboration and input will be critical in enabling these steps to implementation.

To implement this model, utilities must be able to perform integrated system planning that can accurately identify high value opportunities for DPV deployment. They will need to develop or procure new tools that enable holistic planning and operational management of DPV resources, and must take steps to work across internal silos. Rather than keeping distribution planning and integrated resource planning (IRP) processes separate, utilities can conduct these efforts in a coordinated fashion where teams work together to co-develop plans. Because the utility must perform several additional and unfamiliar functions, it may also need to either hire additional personnel or retrain existing employees.

Further, in situations where several stakeholders carry out different system planning functions, targeted DPV deployment will require additional collaboration across external silos. Because the integration of DPV affects—and is affected by—each planning process, these stakeholders should work to identify clear areas where coordination with other entities is needed. For example, in some areas an independent system operator performs resource adequacy assessments, while generation-and-transmission utilities create integrated resource plans, and distribution utilities develop distribution plans. Coordinated planning between these entities that also incorporates input from external stakeholders could help in collectively recognizing the benefits of DPV deployment and identifying opportunities to use DPV to maximize value across all planning processes (e.g., both defer distribution capacity investment and reduce marginal prices at an expensive transmission node).

Questions to Address

- Should the utility issue RFPs for projects, or provide a pricing mechanism to direct deployment to high value areas?
- What data needs to be collected and shared, and what analysis methodologies determined, to enable a transparent planning process?
- Are projects owned by the utility or by customers and/or other third parties?
- Who performs long-term operation and maintenance of the DPV installations?

Building Block C: Use Technology Bundles to Provide Expanded Energy Services

Overview

A growing list of technologies, like advanced inverters, smart building controls, and energy storage, can be combined with solar to unlock additional value from customer-sited DPV projects. However, customers are often overwhelmed when presented with a high number of options, which can impede adoption.[59] Customers need a streamlined list of choices that help them meet their objectives, and need to be able to trust that any technologies included with DPV will perform as described. In many cases, customers would benefit from the help of an advisor who vets options and helps to procure financing.

With building block C (Table 5), solar companies and other technology providers offer expanded energy services based on technology packages—with PV at the core—that meet customer needs and objectives. For instance, customers concerned about extreme storms knocking out their power could pay for a "resiliency" service, where PV combined with storage and advanced controls (minimizing non-critical power draws) would keep their lights on during a system outage. Different customers might opt for a "green" service, which uses efficiency to dramatically reduce their electricity consumption, and procures their energy from on-site PV first and from off-site renewable sources when solar is unavailable.

The utility, meanwhile, advises customers as they select services. As an advisor, the utility provides quality assurance by vetting service providers and technology options, and would show customers how a technology package affects their utility bill. In some situations, the utility could also make the process easier for customers by offering on-bill financing for technology packages.

TABLE 5: **BUILDING BLOCK C SUMMARY**

Objective
Leverage solar adoption to increase uptake of other DER technologies, creating greater net value that can be tapped only by leveraging complementary technologies and making myriad DER choices more consumer friendly, thus speeding adoption

KEY ACTIVITIES	UTILITY	SOLAR COMPANY	CUSTOMER
PROJECT DEVELOPMENT			
Identify DPV sites		Minimal change	
Solicit & enroll DPV program participants		Minimal change	
Vet technologies & service providers	Increased focus		Decreased focus
Engineer & design DPV projects		Minimal change	
Finance projects (or procure financing)	Increased focus	Minimal change	Minimal change
Procure hardware & materials		Minimal change	
Install DPV projects		Minimal change	
Permitting, inspection, & interconnection	Minimal change		
Own DPV projects	Increased focus	Minimal change	Minimal change
OPERATIONS			
Metering & billing	Minimal change	Decreased focus	
Provide DPV customer support services	Minimal change	Decreased focus	
Perform DPV maintenance		Minimal change	Decreased focus
Manage DPV operations		Minimal change	Decreased focus
GRID INTEGRATION			
Manage market transactions	Minimal change		
Forecasting, scheduling, dispatch, & system control	Minimal change		
Outage restoration & resiliency	Minimal change		
System planning & long-range forecasting	Minimal change		
Perform grid maintenance	Minimal change		

CHANGE IN ACTIVITIES: Decreased focus | Minimal change | Increased focus

Highlights for market players

- ***Utility***
    - Screens technologies and service providers to ensure that proposed projects perform as expected.
    - Manages integration of technology packages into the grid.
    - May act as financier for technology packages, to extend access beyond just highly-creditworthy customers, and to leverage the utility's low cost of capital.
    - Manages billing, facilitates payments to solar companies and technology providers, and invoices customers for both monthly financing payments and energy and demand charges.
- ***Solar Companies***
    - Market energy services and technology packages to customers.
    - Install technology packages, including PV, energy efficiency, demand response, advanced inverters, storage, and other resources.
    - Conduct operations and maintenance over the life of the technologies.
    - Operate technology packages, meeting physical assurance requirements and interfacing with grid operators.
- ***Customers***
    - Sign up for energy services and technology packages.
    - Choose whether to opt-in to financing.
    - Pay for energy services via their utility bill.

Business Model Functions
Utility

- ***Value Proposition:*** Rather than focusing on solar alone, the utility's value proposition enables customers to access a broad suite of energy services with DPV at the core. Additionally, the utility provides tailored advice to help customers select services and technologies, and manages the integration of these services and technology packages into the grid.
- ***Customer Services and Marketing:*** Utilities would not lead marketing efforts, but increase the likelihood of uptake of energy service offerings and technology packages by verifying performance and showing customers how they could benefit. The utility could use many channels to access customers as their advisor, including house visits, a web portal, and/or a dedicated customer phone service.
- ***Operations:*** Utilities will have to familiarize themselves with a suite of technologies, analyzing the value that the technology packages provide the grid as well as the impact the technologies have on customer bills. If they also become project financiers, the utility will have to increase their capacity to offer financing to consumers and to show how monthly payments with those financing options will compare to energy and demand savings.
- ***Financial: Earnings, Revenues, and Costs:*** The utility could generate revenue through commission fees, as well as by financing the technology packages. Further, with implementation of an incentive similar to shared savings, regulators could tie compensation to the utility's performance as customer advisor using metrics like customer satisfaction or uptake of technology packages.

Solar Companies

- ***Value Proposition:*** Solar companies and other service providers would sell energy services to customers via technology packages that have been screened and approved by the utility.
- ***Customer Services and Marketing:*** Solar companies offer products that are streamlined, but that are also tailored for meeting objectives of different types of customers. The marketing channels look similar to those used today, including billboards, print and web advertisements, and peer-to-peer information sharing.
- ***Operations:*** Solar companies will need to meet pre-established criteria for serving customers, including safety and reliability of technologies in proposed technology packages. Also, solar companies will manage customer acquisition and technology package installations.
- ***Financial: Earnings, Revenues, and Costs:*** Revenues would come from a solar company's ability to sell solar with complementary technologies (increasing revenues per customer), and possibly reaching a greater number of customers who see less risk if the technology package has utility approval.

Examples of Concepts in Practice

- ***Sacramento Municipal Utility District (SMUD) - 2500 R Midtown:*** A pilot for 34 homes with solar panels and a combined lithium-ion battery pack, inverter, and power control system, all contained in a closet-sized box built by startup Sunverge Energy. SMUD is determining the value these technology packages provide by enabling demand response and peak load shifting, regulation, and spinning reserves, among other services.[60]
- ***Public Service Electric and Gas Company (NJ) - SREC Loan Program:*** PSEG provides loans to customers and also third-party solar developers. Customers can repay the loan with either cash or by surrendering their solar renewable energy certificates (SRECs). The loan generally covers 40–60% of total projects and is treated like other utility assets, with the utility earning a return and applying depreciation and amortization charges to the loans.[61]

Discussion

Enabling Success

Many utilities have taken on aspects of the customer advisor role already. Bill stuffers and online portals analyzing customer energy use are commonplace, and customer account managers regularly market demand-side management programs. Regulators, utilities, and solar companies will need to further define the customer advisor role, but can use insights from these existing utility efforts. They should also continually engage customers and incorporate their feedback on existing programs as well as new proposals.

The criteria and guidelines for offering technology packages must be clear. Service providers will need to demonstrate that their technologies perform as described and provide physical assurance over time. To fairly vet solar companies and other technology providers, regulators and policymakers will need to work with the utility to set up a process that prevents bias or favoritism. Applications may need to be submitted in a double-blind process.

For lending, the utility must ensure that any financing options they offer comply with consumer lending laws and minimize legal risk. Depending on the financial situation for the utility, there may be little desire to provide financing, or the utility may not be able to provide low-cost financing. In these cases, a third-party lender would be a more appropriate source of capital for technology packages. The utility will also need to demonstrate that its financing is not anti-competitive with solar companies' offerings. The utility financing should be tailored to market segments that are currently underserved, and should have clear operating parameters, like income or customer creditworthiness, to ensure that the financing is only being provided to the targeted segments.

Building block C can benefit by incorporating elements from the other two building blocks. In particular, a solar business model could tailor certain energy services based on locational or temporal needs. In addition, an energy service offering could include subscriptions to other DPV installations in the utility territory.

Questions to Address

- How can solar companies work with utilities to minimize complexity for energy services and technology packages?
- What does the advisor model look like in order to be effective but without creating significant lag time and incurring substantial costs to run?

FOUNDATION TO ENABLE SOLAR VALUE OPTIMIZATION AND CREATION

04

04: FOUNDATION TO ENABLE SOLAR VALUE OPTIMIZATION AND CREATION

Refining and implementing solutions in specific locales will require direct engagement from regulators, utilities, and solar companies, as well as continued support from other federal and state agencies. Table 6 summarizes the actions that these stakeholders will need to undertake.

TABLE 6: **SUMMARY OF RECOMMENDATIONS**

	SOLAR COMPANIES	UTILITIES	REGULATORS	FEDERAL & STATE AGENCIES
1. ASSESS CURRENT ABILITIES TO IDENTIFY VALUE AND CUSTOMER NEEDS.				
Address gaps in DPV operations data		■		
Address gaps in tools and processes		■		
Prioritize internal data organization and communication		■		
Improve data accessibility and transparency			■	
2. DEVELOP A TRANSPARENT, MULTI-STAKEHOLDER PROCESS TO CREATE A STANDARDIZED METHODOLOGY, EVALUATE VALUE, AND SHARE RESULTS.				
Create a standardized methodology for valuing DPV, including shared data and tools	■	■	■	
Evaluate value and share results	■	■	■	
3. DETERMINE APPROACHES FOR OPTIMIZING AND CAPTURING VALUE				
Clarify existing business and regulatory rules			■	
Explore collaboration opportunities	■	■		
Establish desired outcomes and criteria for solutions	■	■	■	
Identify new business model opportunities	■	■	■	
Remove implementation barriers and test solutions	■	■	■	
4. ASSESS PILOTS AND REFINE SOLUTIONS				
Foster continued innovation by tracking, assessing, and sharing the progress and results of solutions that are proposed and/or implemented				■

To enable action within each of these categories, stakeholders will need to have sufficient motivation and capability to act. Regulators and policymakers can facilitate this process.

1. Assess current abilities to identify value and customer needs.

Regulators
Improve data accessibility and transparency:
To better deploy DPV to increase its net value, utilities and solar companies need access to information about the grid, the resources connected to it, and customer behavior. Today, these datasets are fragmented and closely held by individual stakeholders. For instance, utilities maintain and guard data about grid operations and planned infrastructure maintenance or investment, while solar companies control DPV project configuration data and expected output characteristics.

Regulators can address this fragmentation and lack of communication by establishing protocols for data that should be made public, that should be shared among the key stakeholders, and that should remain private and then provide a standardized channel to exchange data relevant to DPV project planning and operation. Regulators should seek stakeholder input to determine the best channel for data exchange, but options include online portals to submit and access DPV project data (similar to the California Solar Initiative application database), or inclusion in a broader data repository (that may include many types of data beyond simply DPV projects) that each stakeholder can upload to and download from (similar to the CPUC's Energy Data Center).

In most cases, regulators will need to clarify requirements for and/or limitations on data exchange. Because past attempts to share data through voluntary actions have been met with limited success, regulators should require data sharing by utilities, solar companies, and other technology and energy service providers. While security issues and customer privacy concerns are important factors that any regulator-mandated data sharing must consider, viable workarounds, such as aggregating and anonymizing data, have been proposed. For example, load profiles for individual customers can be stripped of personally-identifiable information and aggregated by location, or across time periods.[62]

Utilities
Address gaps in DPV operations data:
Most utilities' existing monitoring infrastructure provides insufficient spatially- and temporally-granular insight into system operations, which limits the ability to analyze and understand DPV operational impacts. Utilities should identify gaps in their monitoring capabilities, such as real-time customer consumption and generation data, and develop a set of proposed least-cost options to fill those gaps. Evaluation of possible solutions needs to assess the technical and economic feasibility of many options, including new infrastructure deployment (e.g., synchrophasors, wide-area networks, etc.), software modifications (e.g., to existing inverters), and partnerships with other technology or energy service providers. Results should determine which option(s) would provide the most useful information and functionality, and can be practically implemented at an acceptable cost. Utilities can work with other stakeholders, including solar companies and technology vendors, to identify these options, and may look to submit an application to regulators to approve investment.

Address gaps in tools and processes:
Current utility processes and software tools are well-suited to operations, forecasting, and planning analyses of traditional electricity systems. However, they do not holistically assess the integration of DPV and complementary technologies across all sources of operational value. Tools are needed to enable insights about value in both short- and long-term timeframes, while also integrating locational dynamics (i.e., distribution-level and transmission-level). A number of software vendors are working to create tools that provide this type of functionality, but these nascent tools are developing and need to be tested at scale (for a list of these tools, see www.rmi.org/isbm_tools). As a first step, utilities should bring in software vendors and developers to identify their current capabilities, and work to refine a viable tool that provides needed functionality. As a second step, this could be conducted as part of a working group to leverage the perspective and support of multiple stakeholders, potentially with national labs and industry groups.

Prioritize internal data organization and communication:
Department silos and an inability to access data can hinder a utility's ability to holistically understand how DPV integrates with the company's operations by making it difficult for staff to see and access data across department walls. As mentioned earlier, 83% of utilities still process interconnections with paper applications and this data is not digitized until after a project is interconnected.[63] Meanwhile, customer account managers may have information about which key accounts could be interested in pursuing DPV, but this knowledge may not be transferred to program designers (let alone to solar companies and other service providers).

To ensure that all staff has access to key DPV-related information when making decisions, a utility can foster inter-department communication by creating a central platform to systematically integrate scattered data sources. This platform could include a database housing the full array of the utility's solar-related knowledge, but its use by staff would need to be prioritized so that DPV integration and strategy becomes proactive, rather than reactive. These data sources may include information that program managers and interconnection staff collect from customers and solar developers (e.g., program applications, participating customer demographics, etc.), and from customer account manager experience (e.g., customer interest in, or plans to install DPV). These efforts would also serve as an opportunity to codify institutional knowledge about the system and specific projects that individuals may know, but that is not currently recorded (for example, potential development of an agricultural parcel that was considered when creating the local distribution capacity expansion plan). Utility staff will need to survey and catalog relevant existing data sources and work with each department manager to outline and then compile the data they have available.

2. Develop a transparent, multi-stakeholder process for methodology

Regulators, Solar Companies, & Utilities

Create a standardized methodology for valuing DPV, including shared data and tools:
Most jurisdictions in the U.S. lack a well-defined, transparent methodology for evaluating the benefits and costs of DPV. This frequently creates tension between utilities and solar companies who may not agree on the valuation techniques in place, and poses a barrier to stakeholder acceptance of new solar business models. Complicating the issue is the fact that some stakeholders—particularly the utility—have greater access to the software tools and grid data that, as outlined above, are needed to calculate the value of DPV (and other DERs).

Regulators should facilitate the development of a standard methodology for calculating the benefits and costs of DPV in their jurisdiction. To address transparency concerns, methodology development should be conducted in an open, public forum with input from all stakeholders. This has been attempted in Minnesota, where the Public Utilities Commission and the Department of Commerce received comments from a broad range of stakeholders as the State determined the methodology for evaluating the benefits and costs of solar.[64] While data issues can be addressed as outlined above, a collaborative methodology development process should explicitly consider the accessibility of needed analysis tools, potentially requiring that open source software tools be used. Open access to tools and data would provide additional credibility and increase buy-in by enabling independent stakeholders to conduct or verify value analyses, similar to how third party program evaluators provide impartial energy efficiency potential and measurement and verification studies today.

Evaluate value and share results:
In addition to understanding value assessment methodologies, stakeholders need to have access to analysis results. Regulators can enable this by convening stakeholders to determine the communication channels that would best facilitate sharing of value analysis results, and how frequently they need to be updated. Potential channels include public reports summarizing findings and map-based interfaces that intuitively display results alongside other relevant information (e.g., planned system upgrades, or presence of existing DPV capacity), which have been successfully used elsewhere to communicate results. To expedite the process, regulators could convene a representative subset of stakeholders (through an industry working group, for example) to propose preferred communication mechanisms that could be tested with a broader audience (potentially even in parallel with methodology development and analysis).

3. Determine and pilot approaches to optimize and capture value

Though overhauling the regulatory and business model for utilities may be necessary in the-long-term, moving forward on these bridge business models now can provide best practices and lessons learned for larger reform efforts. There are multiple pathways for designing and implementing these solutions, which will depend on whether the drivers of change are *top-down*, such as legislation or a proactive utility commission, *bottom-up*, with utilities, customers, or solar companies taking the lead, or both. While the processes used to design solutions are unlikely to be uniform across the U.S., there are important common elements that should be addressed to enable value optimization and creation.

3.1 Top-Down Drivers for Change

Frequently, legislative action or a proactive regulatory commission has catalyzed efforts to resolve situations challenging the electricity industry.[65] Recent examples include Colorado and Minnesota's community solar legislation, California's AB 327 Section 8 requirement to consider distributed resources in planning and integration, and the NY REV proceeding.[66] Regardless of which body initiates the process, regulators will need to interpret the laws and then lead implementation of solutions.

Regulators

Clarify existing business and regulatory rules:

In many jurisdictions, there is uncertainty among utilities and solar companies over specific rules and regulations that pertain to DPV. In particular, regulators need to clarify limitations on utility ownership of assets on the customer-side of the meter, determining where competition would provide the best societal outcome, and where natural monopolies exist. Regulators could consider allowing utility ownership in market segments where solar companies have not been able to gain traction, such as low-income housing. Utilities could also consider pursuing new business models through a deregulated arm, and regulators will need to establish clear rules to prohibit anti-competitive actions.

Other rules that may need clarification include the acceptability of shared utility and DPV billing, and the ability to modify existing incentive mechanisms for energy efficiency to incorporate DPV in instances where the utility enables adoption.

3.2 Bottom-Up Drivers for Change

In other situations, policymakers may not lead the development of solutions. Instead, other stakeholders can propose models that create and capture additional value. For many of the most successful proposals, stakeholders have worked together, such as utilities meeting customers' demands like Duke's Green Source Rider tariff, which started with a white paper from Google, or a solar company coming to utilities with a proposed business model solution, like Clean Energy Collective with its community solar projects. A stakeholder coalition might convene utilities, solar companies, environmental groups, and consumer advocates to negotiate and create solutions prior to seeking regulatory approval or legislative action.

Utilities, Solar Companies, & Advocates
Explore collaboration opportunities:
Stakeholders should collaborate outside of a regulatory proceeding to explore potential solutions. As with a regulator-driven process, these actors will need to define shared objectives and the set of solution criteria important to each stakeholder. From this, the group can prioritize specific opportunities to create value by focusing on areas where there is both a need and alignment between stakeholders. One option for facilitating this process is creating a working group, such as the e21 initiative in Minnesota, which has brought together the state's utilities, NGO's, and academics to find new business and regulatory model solutions.[67]

3.3 Common Elements

Regulators, Solar Companies, & Utilities
Establish desired outcomes and criteria for solutions:
Regardless of who initiates the process, solutions should be designed to ensure that the benefits of DPV deployment will exceed its costs. Stakeholders will also need to define the specific criteria for evaluating proposals to ensure that outcomes are aligned with goals for their local situation. Possible criteria include economic returns for utilities and solar companies as well as the impacts on local economic development, fairness among utility customers, carbon reductions, and reliability and resiliency, among others.

While solutions should seek to provide "win-win-win" outcomes, the total potential value will always be finite. Stakeholders will likely need to make difficult compromises, particularly on sharing and distributing revenues based on the value that the solution creates. Depending on the situation, the dialogue to establish criteria could take place in a stakeholder working group, or as part of a regulator-driven process. But, in either case, the finalized set of criteria should be adopted as part of a regulatory proceeding or application or legislative bill.

Identify new business model opportunities

Once solution criteria have been established, stakeholders will need to identify potential solutions that meet those criteria. As with the building blocks presented in this paper, proposed solutions should:

- Define utility, solar company, and technology/energy service provider activities, and evaluate each actor's ability to create and capture additional value (in both the short- and long-term). New activities should be predicated on the ability to unlock additional value and increase the size of the market while encouraging healthy competition.
- Identify the specific mechanisms that will enable and incentivize additional value creation, such as an increase in return on equity for utilities or multi-year contracts for delivering DPV projects.

If the regulators or policymakers are leading the process, they could direct staff to draft a straw proposal and request stakeholders to evaluate the economic and practical effects of the proposal on their business. Alternatively, a stakeholder working group could propose mutually agreeable models that create and capture additional value.

Remove implementation barriers and test solutions

The complexities and differences between market and regulatory situations across the U.S. will result in a broad spectrum of challenges to implementation—in terms of both number and significance. In all cases, stakeholders should look to finalize solutions as quickly and efficiently as possible by first implementing the solution components that require little (or no) regulatory action. In situations where there are additional barriers to implementing a solution, stakeholders can work in parallel to address those barriers and enable full implementation of the solution.

Initially, stakeholders should determine whether there is enough flexibility within existing laws and regulatory statutes to accommodate the proposed solution. For example, Duke Energy's Green Source Rider moved forward with a letter of approval (rather than through a full proceeding) by limiting the tariff to a specific customer segment (large customers with new load) and assuring the regulators and customer advocates that non-participants would be unaffected.[68] Where necessary, regulators may identify and make any minor changes to rules and regulations that are needed to enable implementation, such as enabling third party ownership of DPV. Utilities and solar companies might engage regulators by submitting proposed changes through an existing proceeding, or opening a new proceeding.

These activities should culminate in an initial pilot of the proposed solution at a sufficient scale to test hypotheses and enable success. One of the major challenges with pilots has been that they are small in scope (e.g. MW installed or proposed participants) and have not been able to test key hypotheses, like enabling cost reductions through increased scale. Pilots could be administered in phases, starting with a small test case group (for instance, 50–100 residential customers) to establish a burden of proof for regulators, utilities, and solar companies, and then rolled out to a larger subset (more than 1,000) to test marketing and sales approaches and systematize processes to unlock cost savings.

Subsequent efforts may be necessary to address more-challenging barriers to value creation opportunities. In particular, such challenges may involve:

1. *Grid Infrastructure.* Regulators may need to consider approving additional capital expenditures. For example, this might involve the installation of needed monitoring equipment on a utility's distribution system.
2. *Enabling Regulation.* Regulators may need to provide new mechanisms for stakeholders to monetize additional value. For example offering performance incentives to solar companies for "high value" projects, or offering utilities opportunities to own DPV assets (or shared savings and other performance-based mechanisms).

4. Assess pilots and refine solutions

Regulators, Solar Companies, & Utilities

As pilots launch, continued engagement will be essential, as stakeholders should work together to adapt and fine-tune the solution over time. Additionally, if the piloted solution is successful, stakeholders should consider how they can build on the pilot to create additional value—tailoring approaches to other customer classes or locations—or to inform both local and national reform efforts.

Federal & State Energy and Environmental Agencies

Foster continued innovation by tracking, assessing, and sharing the progress and results of solutions that are proposed and/or implemented:

As regulators, utilities, and solar companies develop and test new solar business models, it will be critical to share successes and best practices with stakeholders across the industry. As part of this effort, federal and state agencies can help foster continued innovation by tracking, assessing, and sharing the progress and results of solutions that are proposed and/or implemented.

1. *Track.* Agencies can establish meaningful metrics to analyze each model's level of success, which utilities and solar companies can share publicly, and require regular progress reports (e.g., quarterly, annually) to regulatory staff, made available to public stakeholders.
2. *Assess.* Analyze results to determine value creation, which can inform the regulatory process to ensure determine adequate compensation for each stakeholder. Example metrics might include the number of installations and capacity installed, cost per project, or the magnitude of increased value. Assessment results and stakeholder feedback should be used to continuously improve models over time.
3. *Share.* Create forums for documenting experiences and sharing best practices and lessons learned. One possible approach would be to pull together information and provide a public database of ongoing pilots and new business models. Another could be actively promoting sharing of best practices by hosting workshops with stakeholders from across the country. While workshops are abundant for utility and solar company executives, program managers would benefit from learning what others are doing first-hand and being able to ask questions. Further, synthesizing information and then providing guidelines can create a helpful foundation for stakeholders looking to implement solutions.[69]

CONCLUSION

05

05: CONCLUSION

The current business model environment is causing rising conflict between utilities and solar companies as DPV adoption increases. Highly contentious proceedings have become common, and an increasing number of proposals are coming before regulators that could slow DPV's growth. Further, value creation opportunities, like optimized locational deployment or generation output highly correlated with peak load, remain largely uncaptured, resulting in an inefficient use of society's capital and resources.

With continued DPV cost reductions likely to exacerbate these conflicts, there is an increasingly urgent need for new approaches that can unlock and capture the full value of DPV. While regulatory reform may be necessary in the long term, utilities and solar companies today can build the types of bridge business models laid out in this report, combining the suggested building blocks in a way that best meets their needs. Regions as diverse as New York, North Carolina, and Arizona have already started to implement elements of these building blocks, helping to answer the key questions that need to be addressed, as well as provide best practices and lessons learned for future reform.

Building these bridges to the future will require increased coordination and collaboration between utilities and solar companies, as well as leadership from regulators and policy makers. This will mean venturing into unchartered territory, which introduces new risks to utilities, solar companies, and customers alike. However, these new risks are likely to be much less costly than a continuation of the inaction seen today. Implementing bridge business models will also mean establishing a new set of incentives for activities that create verifiably additive value, and then incorporating mechanisms for sharing that value between utilities, solar companies, and their customers.

Business models designed to optimize DPV deployment and capture the additional value created will increase the likelihood of positive outcomes for all, producing the win-win-wins that this report outlines and enabling a robust and sustainable market for DPV. These outcomes will not only benefit utilities, solar companies, and customers, but society as well—providing communities with economic development opportunities, cleaner air, and enhanced resiliency.

ENDNOTES

EN

ENDNOTES

[1] Larry Sherwood, "U.S. Solar Market Trends 2013," Interstate Renewable Energy Council, July 2014.
[2] Stefan Linder, "H1 2014 US PV Market Outlook," Bloomberg New Energy Finance, March 2014.
[3] In this report, we define distributed PV as all resources connected to a utility distribution system. This includes both rooftop and ground-mount installations, as well as both customer-sited and utility-sited projects. At year-end 2013, residential and commercial DPV accounted for roughly 4% of retail electricity sales in Hawaii, 2% in New Jersey, and 1% in California, Massachusetts, and Arizona. See Andrew Satchwell, Andrew Mills, and Galen Barbose, *Financial Impacts of Net-Metered PV on Utilities and Ratepayers: A Scoping Study of Two Prototypical U.S. Utilities*, Lawrence Berkeley National Laboratory, September 2014.
[4] Andrew Satchwell, Andrew Mills, and Galen Barbose, *Financial Impacts of Net-Metered PV on Utilities and Ratepayers: A Scoping Study of Two Prototypical U.S. Utilities*, Lawrence Berkeley National Laboratory, September 2014.
[5] Sherwood, U.S. Solar Market Trends 2013
[6] "Residential Renewable Energy Tax Credit," DSIRE USA, October 6, 2014. http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US37F.
[7] Jenny Heeter, Rachel Gelman, and Lori Bird, *Status of Net Metering: Assessing the Potential to Reach Program Caps*, National Renewable Energy Laboratory, Golden, CO, September 2014.
[8] Bony, Doig, Hart, Maurer, and Newman, *Achieving Low-Cost Solar PV: Industry Workshop Recommendations for Near-Term Balance of System Cost Reductions.*
[9] Alan Goodrich, Ted James, and Michael Woodhouse, *Residential, Commercial, and Utility-Scale Photovoltaic (PV) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities*, National Renewable Energy Laboratory, Golden, CO, TP-6A20-53347, February 2012, and Friedman, Ardani, Feldman, Citron, Margolis, and Zuboy, *Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Using a Bottom-Up Approach and Installer Survey – Second Edition*, and Ardani, Seif, Margolis, Morris, Davidson, Truitt, and Torbert, *Non-Hardware ('Soft') Cost-Reduction Roadmap for Residential and Small Commercial Solar Photovoltaics, 2013-2020.*
[10] Many developers and possible hosts for DPV projects do not have the tax burden to capture the investment tax credit and accelerated depreciation benefits, so they often bring in a third-party, called a "tax-equity investor" that can capture these benefits.
[11] Lena Hansen and Virginia Lacy, *A Review of Solar PV Benefit and Cost Studies*, Rocky Mountain Institute, 2013.
[12] Mike Taylor, Nadav Enbar, Lindsey Rogers, and Steven Coley, *Assessing Opportunities for Utilities and Third Party Owned Solar Developers to Collaborate*, Solar Electric Power Association, Washington, D.C., December 2013.
[13] Lionel Bony, Stephen Doig, Chris Hart, Eric Maurer, and Sam Newman, *Achieving Low-Cost Solar PV: Industry Workshop Recommendations for Near-Term Balance of System Cost Reductions*, Rocky Mountain Institute, September 2010.
[14] B. Friedman, K. Ardani, D. Feldman, R. Citron, R. Margolis, and J. Zuboy, *Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Using a Bottom-Up Approach and Installer Survey – Second Edition*, National Renewable Energy Laboratory, Golden, CO, NREL/TP-6A20-60412, October 2013.
[15] PV soft costs include customer acquisition; permitting, inspection, and interconnection; installation labor; financing; and other miscellaneous costs (e.g., profit, overhead, etc.). K. Ardani, D. Seif, R. Margolis, J. Morris, C. Davidson, S. Truitt, and R. Torbert, *Non-Hardware ('Soft') Cost-Reduction Roadmap for Residential and Small Commercial Solar Photovoltaics, 2013-2020*, National Renewable Energy Laboratory, NREL/TP-7A40-59155, August 2013.
[16] Friedman, Ardani, Feldman, Citron, Margolis, and Zuboy, *Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Using a Bottom-Up Approach and Installer Survey – Second Edition.*
[17] Enviromedia, *U.S. Study: Interest In Residential Solar Jumps With Leasing Option.*
[18] Miriam Makhyoun, Becky Campbell, and Mike Taylor, *Distributed Solar Interconnection Challenges and Best Practices*, Solar Electric Power Association, Washington, DC, October 2014.
[19] Ibid.
[20] Taylor, Enbar, Rogers, and Coley, *Assessing Opportunities for Utilities and Third Party Owned Solar Developers to Collaborate.*
[21] A variety of types of third parties—meaning entities other than a utility or homeowner—have participated in ownership or finance of DPV projects, including solar developers, venture capital, private equity investors, and large public corporations (Linder, "H1 2014 US PV Market Outlook").
[22] Ibid.
[23] Satchwell, Mills, and Barbose, *Financial Impacts of Net-Metered PV on Utilities and Ratepayers: A Scoping Study of Two Prototypical U.S. Utilities*, and "Residential Renewable Energy Tax Credit," DSIRE USA
[24] James Tong and Jon Wellinghoff, "Rooftop Parity: Solar for Everyone, including Utilities," *Fortnightly Magazine*, August 2014.
[25] Taylor, Enbar, Rogers, and Coley, *Assessing Opportunities for Utilities and Third Party Owned Solar Developers to Collaborate.*
[26] This distinction assumes that the DPV installation's output is maintaining a steady voltage and power factor. As advanced functionality enables dynamic control of DPV output characteristics, both power exporting and non-exporting installations may have increasingly complex interactions with the grid.
[27] Michael Coddington and Robert Broderick, "Mitigation Measures for Distributed Interconnection," presented at the Distributed Generation Interconnection Collaborative, July 9, 2014.
[28] Andrew Mills and Ryan Wiser, *An Evaluation of Solar Valuation Methods Used in Utility Planning and Procurement Processes*, Lawrence Berkeley National Laboratory, December 2012. The appropriate methodology that resource planners should use to calculate capacity value is a topic of ongoing debate. While a full treatment of PV capacity credit methodologies and capacity value calculations is beyond the scope of this report, for a discussion of the pros and cons of various capacity credit algorithms, refer to Andrew Mills and Ryan Wiser, *An Evaluation of Solar Valuation Methods Used in Utility Planning and Procurement Processes*, Lawrence

Berkeley National Laboratory, Dec. 2012, and Seyed Hossein Madaeni, Ramteen Sioshansi, and Paul Denholm, *Comparison of Capacity Value Methods for Photovoltaics in the Western United States*, National Renewable Energy Laboratory, Technical Report TP-6A20-54704, July 2012. For a discussion of the application of these algorithms in the context of broader DPV value methodologies, refer to Paul Denholm, Clayton Barrows, Robert Margolis, Bryan Palmintier, Eduardo Ibanez, Lori Bird, and Jarett Zuboy, *Methods for Analyzing the Value of Distributed Photovoltaic Generation*, National Renewable Energy Laboratory, September 2014.

[29] Paul Denholm, Clayton Barrows, Robert Margolis, Bryan Palmintier, Eduardo Ibanez, Lori Bird, and Jarett Zuboy, *Methods for Analyzing the Value of Distributed Photovoltaic Generation*, National Renewable Energy Laboratory, September 2014.

[30] There are many examples of utilities reducing cost by using DERs to defer capacity investment. For example, beginning in 2003 Consolidated Edison (Con Ed) used targeted demand-side management (DSM) to cost-effectively defer expensive investments at several substations, showing total resource cost test results of 2.2–2.8 for the DSM program (Chris Gazze, Steven Mysholowsky, Rebecca Craft, and Bruce Appelbaum, "Con Edison's Targeted Demand Side Management Program: Replacing Distribution Infrastructure with Load Reduction," presented at the ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D.C., 2010, pp. 5–117–5–129, and Chris Neme and Rich Sedano, "US Experience with Efficiency As a Transmission and Distribution System Resource," Regulatory Assistance Project, February 2012). More recently, Con Ed submitted plans to use DSM to defer investment at its Brownsville substations in the Brooklyn and Queens area of New York City (Daniel W. Rosenblum, *Petition of Consolidated Edison Company of New York, Inc. for Approval of Brooklyn Queens Demand Management Program.* 2014). The Maine Public Utilities Commission created the Boothbay Smart Grid Reliability Pilot project in 2012 to avoid an $18 million transmission project using 2 MW of DERs ("Boothbay Sub-Region Smart Grid Reliability Pilot Project: Interim Report," GridSolar, March 2014).

[31] For example, in California—where the CAISO system peak typically occurs in the late afternoon ("California ISO Peak Load History 1998 through 2013." California Independent System Operator, 02-Jan-2014)—policymakers, in an attempt to encourage peak-aligned DPV production, recently chose to offer additional incentives for west-facing DPV on new homes (Albert Lundeen, "California Moves to Improve Solar Incentive Program for New Homes." California Energy Commission, September 3, 2014).

[32] Andrew Mills and Ryan Wiser, *Implications of wide-area geographic diversity for short-term variability of solar power,* Lawrence Berkeley National Laboratory, September 2010.

[33] J. H. Enslin, "Integration of photovoltaic solar power-the quest towards dispatchability," I*nstrum. Meas. Mag. IEEE*, vol. 17, no. 2, pp. 21–26, 2014.
The primary barrier to using DPV resources to provide additional grid services has been the lack of technical standards to govern the integration of advanced inverters (which are needed to unlock many of these additional services) (Aminul Huque, "IEEE 1547a and 1547.1a – Removing the Barriers to Smart Inverters," presented at the Sandia/EPRI 2014 PV Systems Symposium, 06-May-2014).

[34] "Q at Night." SMA, November 2013.

[35] Lena Hansen and Virginia Lacy, *A Review of Solar PV Benefit and Cost Studies*, Rocky Mountain Institute, 2013.

[36] Shu Sun, "Lithium-ion battery cost forecast." Bloomberg New Energy Finance, July 3, 2013.

[37] Costs associated with integrating variable generation resources are not directly incorporated into pricing and credits. Many benefits are inconsistently quantified and valued, making DPV appear less valuable than it really is. Split incentives between tenants and building owners constrain the deployment of DPV.

[38] "Net Energy Metering, Zero Net Energy and the Distributed Energy Resource Future." Rocky Mountain Institute, March 2012, and Petrill, D. Thimsen, Snuller Price, J. Nimmons, J. Torpey, and R. Weston, "Creating Incentives for Electricity Providers to Integrate Distributed Energy Resources," Electric Power Research Institute, Palo Alto, CA, CEC- 500- 2008- 028, Nov. 2007, and "EEI/NRDC Joint Statement to State Utility Regulators." Natural Resources Defense Council, February 12, 2014.

[39] Owen Smith, Matt Lehrman, and Devi Glick, *Rate Design for the Distribution Edge: Electricity Pricing for a Distributed Resource Future*, Rocky Mountain Institute, August 2014.

[40] C. Siegrist, B. Barth, B. Krishnamoorthy, and M. Taylor, *Utility Community Solar Handbook Understanding and Supporting Utility Program Development.* Solar Electric Power Association, December 2013.

[41] John Nimmons and Mike Taylor, *Utility Solar Business Models: Developing Value in Solar Markets*, Solar Electric Power Association, 04-10, Oct. 2010, and Margarett Jolly, David Logsdon, and Christopher Raup, "Capturing Distributed Benefits: Factoring customer-owned generation into forecasting, planning, and operations," *Public Utilities Fortnightly*, August 2012.

[42] *New Business Models for the Distribution Edge: The Transition from Value Chain to Value Constellation*, Rocky Mountain Institute, Boulder, CO, April 2013.

[43] Sonia Aggarwal and Eddie Burgess, "New Regulatory Models," Energy Innovation: Policy and Technology LLC, March 2014.

[44] Alexander Osterwalder and Yves Pigneur, *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. Wiley, 2010.

[45] R. L. Lehr, "New Utility Business Models: Utility and Regulatory Models for the Modern Era," Electr. J., vol. 26, no. 8, pp. 35–53, 2013.

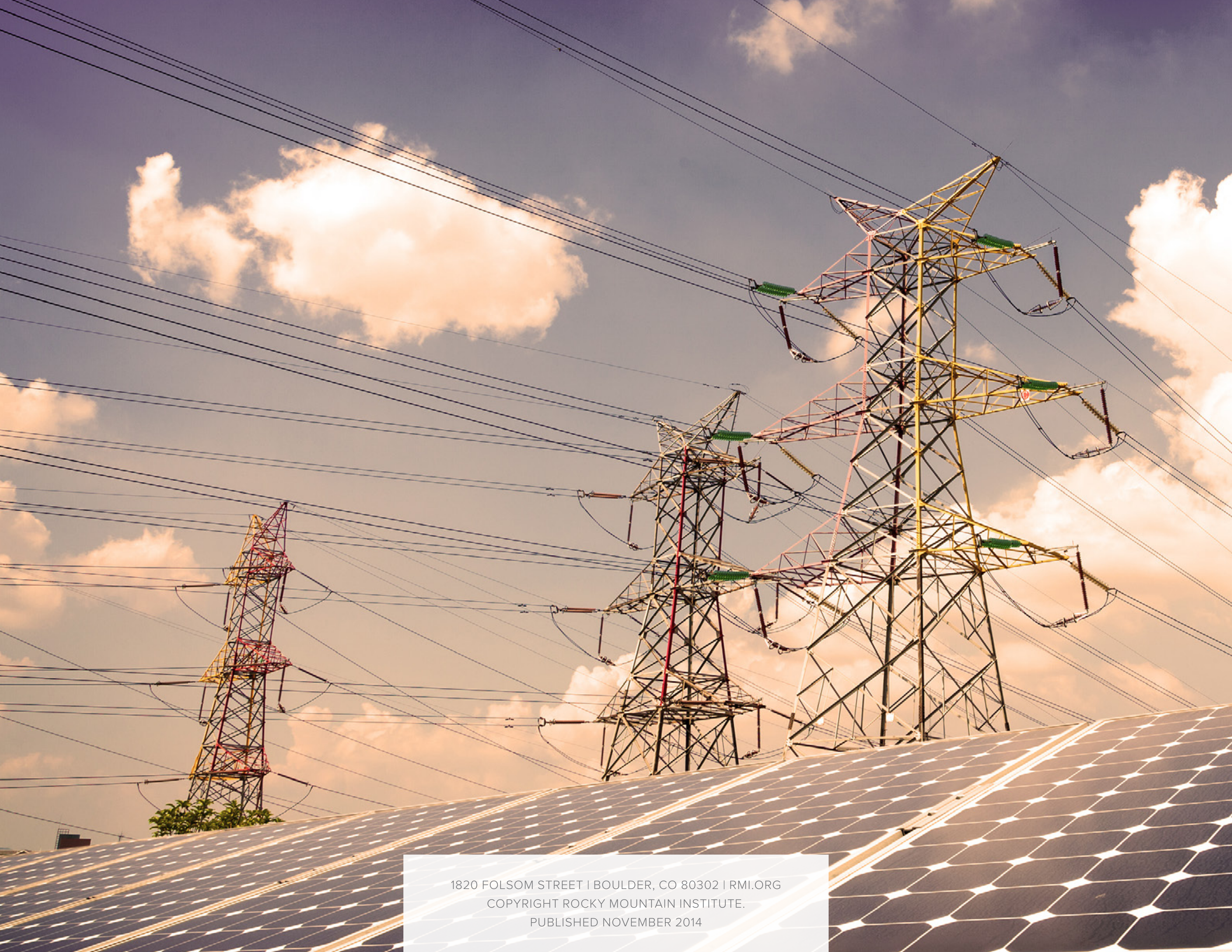
[46] John Nimmons and Mike Taylor, *Utility Solar Business Models: Emerging Utility Strategies & Innovation,* Solar Electric Power Association, 03-08, May 2008.

[47] For example, a customer that wants to install DPV will need a sales consultation and site assessment, followed by DPV project design and installation, and finally metering, billing, and customer support services. Behind the scenes, someone must maintain grid infrastructure and modify the system by incorporating the new DPV resource into operation and planning decisions.

[48] Documentation of models that produce "win-win-wins" in practice are scarce, but numerous research efforts have investigated how this outcome could be achieved:

- California Energy Commission's *Creating Incentives for Electricity Providers to Integrate Distributed Energy Resources* (which was prepared by the Electric Power Research Institute) evaluates possible "win-wins" for utilities and customers and summarizes efforts to create utility business model pilots in Massachusetts and California.
- SEPA's *Utility Solar Business Models: Emerging Utility Strategies & Innovation* lays out best practices for evaluating business model cost-effectiveness.
- SEPA's *Utility Solar Business Models: Developing Value in Solar Markets* summarizes how utilities could provide additional value and summarizes current examples.
- e-Lab's *Integrated Utility Services: A New Business Model for Fort Collins Utilities* explores a

new business model to help customers access a broader range of energy services offered as a bundled package of integrated utility services. (James Mandel and Martha Campbell, Rocky Mountain Institute, 2014.)
[49] "Form EIA-861 2012." Energy Information Administration, October 29, 2013.
[50] Nicole Litvak, "Is the SolarCity Model the Only Way to Scale Residential Solar?" *Greentech Media*, March 31, 2014, and Herman Trabish, "SolarCity, SunPower lead solar industry towards vertical integration," Utility Dive, July 9, 2014.
[51] We offer these building blocks as suggestions that regulators, utilities, and solar companies should consider as they explore new solar business model designs. However, each illustrates only one approach to addressing its stated goal, and they are not intended to comprehensively represent the myriad solar business models that have been piloted or suggested to date.
[52] "Salt River Project: Integrating Community Solar PV into Green Power Programs," North Carolina Solar Center, 2013.
[53] Duke Energy Carolinas, *Petition for Approval of Rider GS (Green Source Rider)*. 2013.
[54] Ucilia Wang, "How Utilities Use Solar Energy To Woo Customers," *Forbes*, September 10, 2013. http://www.forbes.com/sites/uciliawang/2013/09/10/how-utilities-use-solar-energy-to-woo-customers/, and Molly Canales, "Direct Energy and SolarCity Sign Multimillion Dollar Deal to Provide Solar Electricity to Businesses," SolarCity, September 10, 2013. http://www.solarcity.com/newsroom/press/direct-energy-and-solarcity-sign-multimillion-dollar-deal-provide-solar-electricity, and Eric Wesoff, "SolarCity and Direct Energy Form $124M Fund for Commercial and Industrial Solar," *Greentech Media*, September 10, 2013. http://www.greentechmedia.com/articles/read/SolarCity-And-Direct-Energy-Form-124M-Fund-For-Commercial-and-Industrial-S
[55] Marcello Graziano and Kenneth Gillingham, "Spatial patterns of solar photovoltaic system adoption: the influence of neighbors and the built environment," *J. Econ. Geogr.*, October 2014.
[56] Ryan Edge, Mike Taylor, Nadav Enbar, and Lindsey Rogers, *Utility Strategies for Influencing the Locational Deployment of Distributed Solar*, Solar Electric Power Association, October 2014.
[57] David Logsdon and Alison Kling, Conversation with Con Edison," January 9, 2014, and Jolly, Logsdon, and Raup, "Capturing Distributed Benefits: Factoring customer-owned generation into forecasting, planning, and operations," and Alison Kling, Tate Rider, Margarett Jolly, and Steven Caputo, "New York City Solar Empowerment Zones," presented at the NYC Solar Summit, June 8, 2010, and "New York Sun Competitive PV Program Program Opportunity Notice (PON) 2589." NYSERDA, 2012, and "New York Solar Power Rebates and Incentives," *SolarReviews*. http://www.solarreviews.com/solar-power/rebates-and-incentives-solar-power-systems-usa/state-incentives/new-york/. [Accessed: October 1, 2014].
[58] Chris Neme and Rich Sedano, "U.S. Experience with Efficiency As a Transmission and Distribution System Resource," Regulatory Assistance Project, Feb. 2012, and Daniel Jarvis, Julia Larkin, Karen McGinley, David Wyllie, and Ian Guerry, "Targeting Constrained Regions: A Case Study of the Fort Churchill Generating Area," presented at the Summer Study on Energy Efficiency in Buildings, 2010, pp. 5-178–5-189.
[59] Barry Schwartz and Andrew Ward, "Doing better but feeling worse: The paradox of choice," *Posit. Psychol. Pract.*, pp. 86–104, 2004.
[60] Jeff St. John, "Sacramento's Path to Battery-Backed Solar Homes," *Greentech Media*, October 16, 2013, and Lupe Jimenez, "2500 R Midtown: Sacramento Municipal Utility District," presented at the Smart Grid Customer Education Symposium, April 28, 2014.
[61] Nimmons and Taylor, *Utility Solar Business Models: Developing Value in Solar Markets,* and *Utility Solar Business Models Database*. Solar Electric Power Association, January 28, 2013.
[62] "Working Group Report: R.08-12-009 Phase III Energy Data Center," California Public Utilities Commission, July 2013.
[63] Makhyoun, Campbell, and Taylor, *Distributed Solar Interconnection Challenges and Best Practices.*
[64] Order Approving Distributed Solar Value Methodology. 2014.
[65] For example, recent efforts in New York were undertaken as the result of NYPSC direction, while recent efforts in California were the result of the state legislature's passing of AB 327.
[66] Claire Levy and Suzanne Williams, Community Solar Gardens Act. 2010, and Tim Mahoney, Omnibus jobs, economic development, housing, commerce, and energy bill. 2013, and Henry Perea, Rate Payer Equity Act. 2013, and Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. 2014.
[67] "e21 Initiative: Project Description." Great Plains Institute.
[68] Order Approving Application by Duke Energy Carolinas, LLC, for Approval of Rider GS (Green Source Rider) Pilot. 2013.
[69] For example, SEPA's *Utility Community Solar Handbook* goes beyond highlighting case studies and includes a sample RFP. Carl Siegrist, Bianca Barth, Bart Krishnamoorthy, and Mike Taylor, *Utility Community Solar Handbook Understanding and Supporting Utility Program Development.* Solar Electric Power Association, December 2013.



1820 FOLSOM STREET | BOULDER, CO 80302 | RMI.ORG

PUBLISHED NOVEMBER 2014