Community Solar+

How the Next Generation of Community Solar Can Unlock New Value Streams and Help Communities Pursue Holistic Decarbonization

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About RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

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Executive Summary

The first generation of community solar enabled greater access to solar energy in many states across the United States. Community solar is typically a midsized solar project between 500 kilowatts (kW) and 10 megawatts (MW) connected into the distribution grid. Community members or organizations can then subscribe to a portion of the panels or output. Through innovative subscription programs and policies, community solar offers new opportunities for many residential customers to purchase renewable energy, such as renters, people living in multifamily residential buildings, and those without a viable rooftop for hosting solar.

But community solar has the potential to do far more. Although people often assume that community solar inherently reaches low- to moderate-income (LMI) community members, equitable access to renewable energy generally requires deliberate policy and program design. Further innovation, creativity, and holistic planning are needed for states and local governments to use it to meet their ambitious climate action targets more strategically, comprehensively, and equitably.

In this report, we introduce our vision for a concept we call Community Solar+: community solar projects that are strategically deployed to maximize local value streams and advance community-wide sustainability and equity goals. With deliberate planning, key stakeholders—including state and local governments, utilities, project developers, and community members—can design and deploy community solar projects that provide additional benefits to the communities they serve.

This report outlines four core value streams available to communities through well-planned community solar projects:

- Accelerating investment in EV charging infrastructure
- Increasing energy resilience for critical assets and vulnerable communities
- Aligning evolving grid and customer needs for an electrified future
- Creating a more equitable energy system

While every renewable energy project provides ancillary co-benefits—from construction jobs to increased public awareness and education about renewables—carefully and purposefully designed community solar projects are uniquely well-suited to unlock these additional value streams.

After introducing the concept of Community Solar+ and discussing each of its core value streams, we highlight an additional opportunity to build on these and potentially capture two peripheral value streams available when community solar is combined with parking canopies:

- Providing covered parking and weather protection
- Mitigating the urban heat island effect

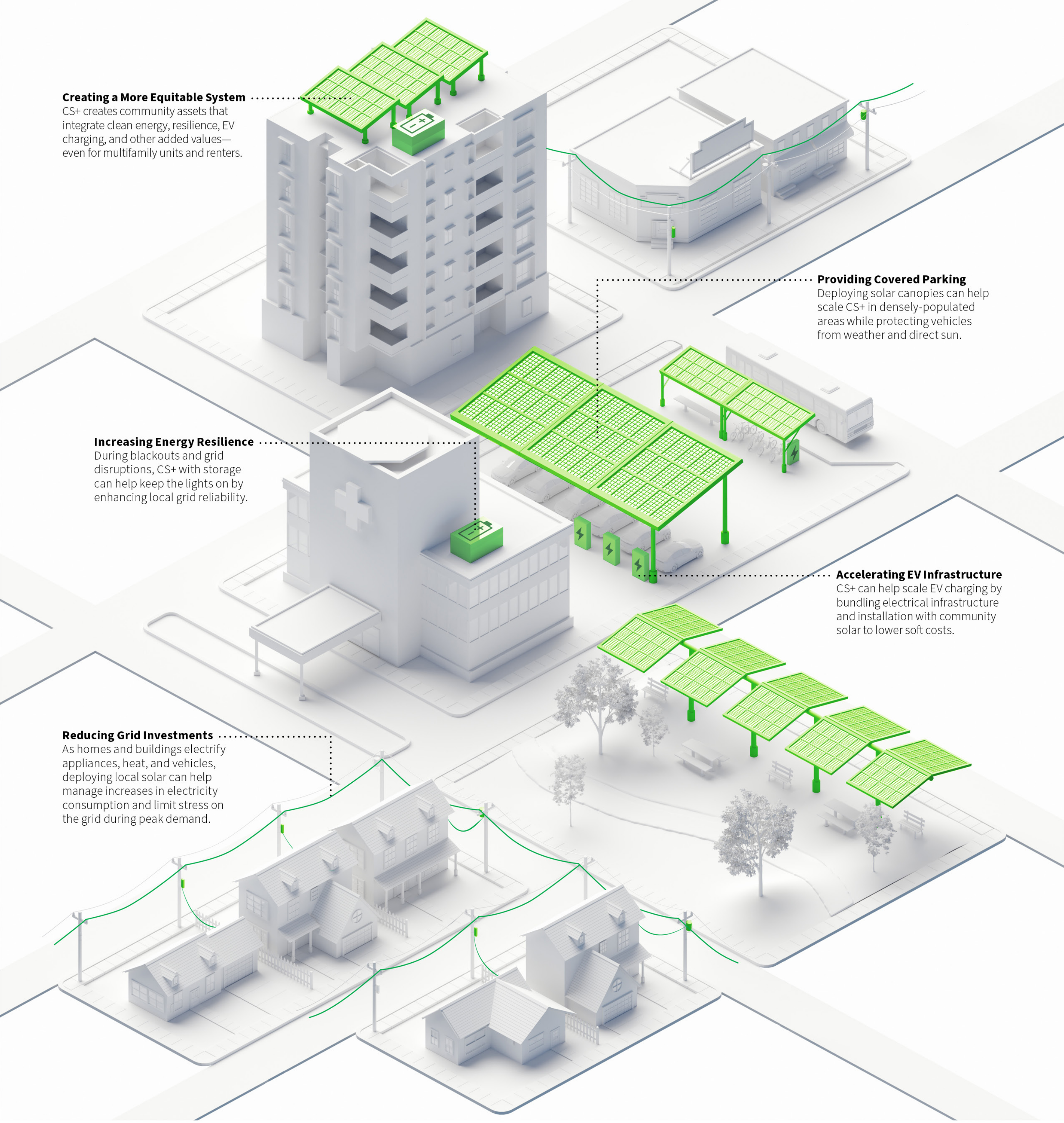
Exhibit ES1 Comparing Value Streams through Three Community Solar Models

Value Stream Potential	Community Solar	Community Solar+	Community Solar+ Canopy
Generating clean energy	✓	✓	✓
Expanding solar access	✓	✓	✓
Boosting local jobs and economic investments	✓	✓	✓
Accelerating investment in EV charging infrastructure		✓	✓
Increasing energy resilience for critical assets and vulnerable communities		✓	✓
Aligning evolving grid and customer needs for an electrified future		✓	✓
Creating a more equitable energy system		✓	✓
Providing covered parking and weather protection			✓
Mitigating the urban heat island effect			✓

After discussing potential Community Solar+ value streams, we offer a hypothetical financial model to demonstrate how some value streams can be monetized to invest in an integrated, renewable, electrified, and resilient future. Then we highlight case studies demonstrating Community Solar+ strategies already under development in Denver, San Antonio, and Washington, D.C. Lastly, we provide recommendations for local governments, states, utilities, and other key stakeholders seeking to embrace this emerging practice.

It's time for the next generation of community solar—it's time for Community Solar+.

Exhibit ES2 Deploying Community Solar+



Introduction

> **Sometimes a problem can't be solved not because it's too big, but because it was framed so narrowly that its boundaries don't encompass the options, degrees of freedom, and synergies needed to solve it. CS+ aims to fix that by expanding the boundaries.**
>
> – Amory Lovins, RMI Cofounder and Chairman Emeritus

Community solar has enabled homeowners, renters, and businesses alike to access locally generated clean energy. Participants in a community solar project purchase or subscribe to a portion of the electricity generation from a solar array developed within or near their community. In turn, these participants receive electricity bill credits, typically reflecting the cost savings provided by solar energy, for their share of the output. The first generation of community solar already offers advantages over other renewable energy programs:

Expanding solar access: Unlike residential rooftop solar, community solar can be made available to renters, people living in multifamily residential buildings, and those without a viable rooftop for hosting solar.[i] Community solar projects can also capture greater economies of scale because they are larger than residential rooftop projects, which can improve project economics.

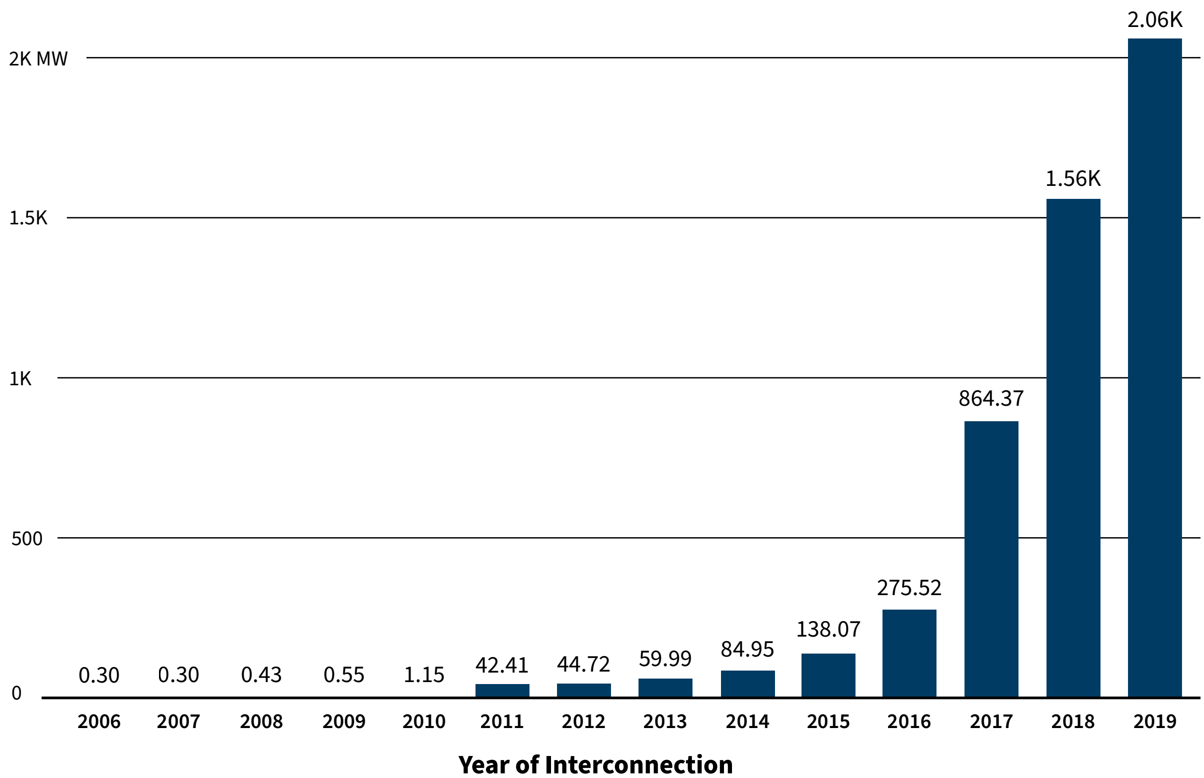
Boosting local jobs and economic investments: Community solar projects are typically located closer to the communities they serve (most likely within the utility service territory), providing local job growth, income for landowners, and other benefits.[ii]

Over the past decade, community solar has gained considerable momentum as states have authorized and utilities have launched more programs. Since 2015, the installed community solar capacity in the United States has increased tenfold—from just under 200 MW in 2015 to over 2 gigawatts in 2019 (Exhibit 1).

i Intentional policy and program design can also enable community solar to be inclusive of LMI communities.

ii Just four years after the 2014 launch of Minnesota's community solar policy, community solar employed 4,000 Minnesotans, generated land leases worth $5 million, and captured $1 million in direct tax revenue. Moreover, over 25 years, roughly 350 landowners are projected to receive a total of $182 million in leases from projects currently operating or under construction.

Exhibit 1 **Cumulative Community Solar Installed (MW-AC)**



Source: **NREL**

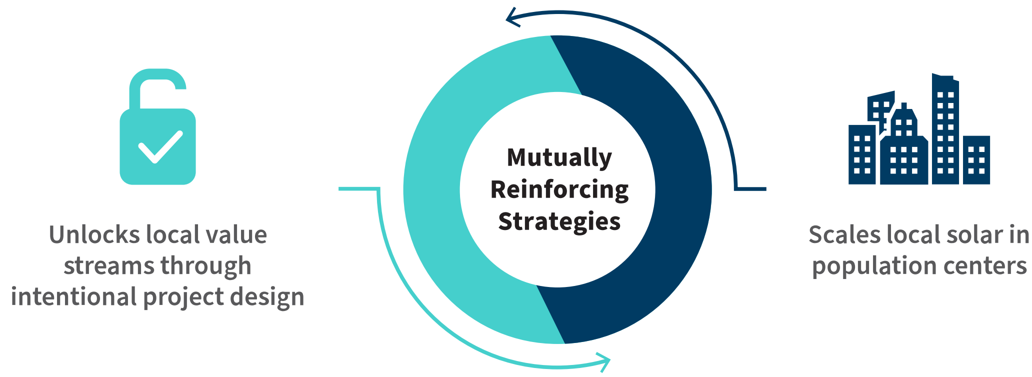
Communities and developers are now deploying new community solar designs and innovations that provide additional value by supporting community-wide goals. Two of these new strategies reinforce each other and define what we now deem to be Community Solar+ (hereafter referred to as CS+):

1. **CS+ can strategically unlock local value streams through intentional project design to advance community-wide sustainability and equity goals.** Projects sited in the heart of cities and communities can be planned to capture value streams beyond expanding access to solar and broad economic benefits. Some of these can even be directly monetized to reduce the overall cost of the project, while others add value that may not be fully realized in existing markets.

2. **CS+ aims to scale local solar in population centers.** Siting projects in population centers, rather than in remote fields, may not seem to be as cost-effective up front. However, by leveraging community solar subscription models, projects won't be constrained by a specific building's consumption, and they'll be able to serve more consumers and types of consumers (i.e., residents, small businesses, municipal facilities, vehicle-charging facilities, etc.) in denser areas. Accordingly, these projects can leverage underutilized sites such as arenas, airports, hospitals and health centers, schools, malls, parking facilities, **landfills**, or multifamily housing to capture better economies of scale.

By creating and capturing additional value, CS+ project managers can more strategically finance a project at scale in population centers. Similarly, by scaling in population centers, projects may be able to further create and capture additional value and economic efficiencies that smaller urban projects may not have been able to achieve.

Exhibit 2 How Community Solar+ Seeks to Scale Community Solar



If local governments are going to reduce emissions while preparing for increasing extreme weather threats that disproportionately impact marginalized communities, they will need to think beyond least-cost, electricity-only procurements. This may require revising mainstream procurement practices, which typically prioritize projects based on lowest cost, as opposed to the total value that projects can offer.[1, iii]

The analysis, guidance, and recommendations provided in this report aim to encourage state and local governments, utilities, developers, and community members to think more deliberately about full project value when planning, designing, and deploying new community solar projects so that projects capture additional value streams and deliver greater benefits to the communities they serve. Accordingly, this report highlights four core CS+ value streams available to communities:

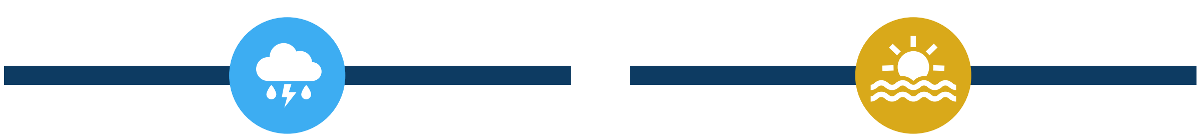
Accelerating investment in EV charging infrastructure

Increasing energy resilience for critical assets and vulnerable communities

Aligning evolving grid and customer needs for an electrified future

Creating a more equitable energy system

In addition, the report details two additional peripheral value streams available by applying a CS+ approach to parking canopy projects:



Providing covered parking and weather protection

Mitigating the urban heat island effect

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iii The lowest-cost rationale is at the heart of energy and utility regulation, but increasingly, regulatory bodies are looking for methods to consider value-based utility regulation and compensation mechanisms for distributed energy resources.

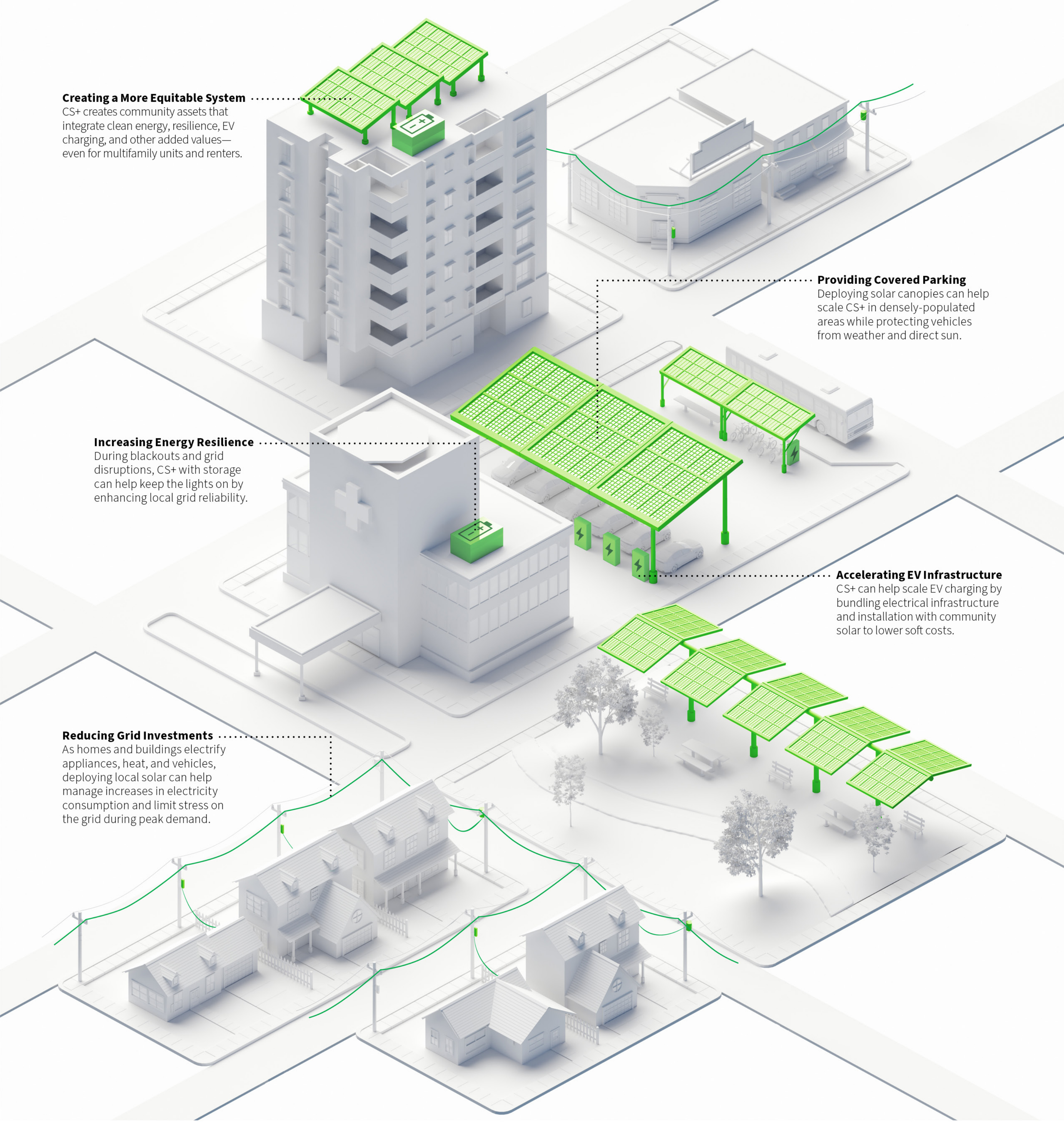
While none of the value streams are inherently unique to community solar, CS+ projects provide significant potential to capture these sources of additional value and scale these benefits in densely populated areas to become true grid and community assets.

Exhibit 3 Comparing Value Streams through Three Community Solar Models

Value Stream Potential	Community Solar	Community Solar+	Community Solar+ Canopy
Generating clean energy	✓	✓	✓
Expanding solar access	✓	✓	✓
Boosting local jobs and economic investments	✓	✓	✓
Accelerating investment in EV charging infrastructure		✓	✓
Increasing energy resilience for critical assets and vulnerable communities		✓	✓
Aligning evolving grid and customer needs for an electrified future		✓	✓
Creating a more equitable energy system		✓	✓
Providing covered parking and weather protection			✓
Mitigating the urban heat island effect			✓

CS+ provides value streams that can be monetized to scale investment in an integrated, renewable, electrified, and resilient future. This is already happening in places around the country, such as in three cities highlighted in this report: Denver, San Antonio, and Washington, D.C. Accordingly, local governments, states, utilities, and other key stakeholders should think beyond the fundamental structure of community solar and embrace recommendations from this report to implement and scale this emerging CS+ practice.

Exhibit 4 Deploying Community Solar+



Enhancing the Value of Community Solar Projects

Community solar has the potential to support ambitious, community-wide priorities. Whereas some value streams may be able to be monetized directly, others bring value to the community without being easily accounted for in a financial statement because they are future-oriented, related to climate action plan goals, or are distributed among multiple parties. Below, we describe four core value streams that CS+ projects can capture if designed accordingly:

- Accelerating investment in EV charging infrastructure
- Increasing energy resilience for critical assets and vulnerable communities
- Aligning evolving grid and customer needs for an electrified future
- Creating a more equitable energy system

Accelerating Investment in EV Charging Infrastructure

In addition to mitigating increased electricity demand from EV charging, CS+ projects can play a crucial role in reducing upfront EV charging infrastructure costs. An inclusive electric mobility future will require rapid expansion of affordable community charging infrastructure, particularly those serving low- to moderate-income (LMI) residents.[2] But this will not have to happen in a vacuum. CS+ projects deployed on or adjacent to schools, libraries, grocery stores, recreation centers, transit centers, and multifamily housing complexes can be paired with EV charging infrastructure to reduce upfront costs and provide accessible EV charging in public spaces where demand is concentrated.

Reducing soft costs in project development

Unlike an on-site solar system that just connects into the building meter, community solar projects developed in population centers involve electrical work and integration with the existing distribution system. With many of these projects being integrated in the same areas where EV demand is growing, there are significant opportunities for synergy in design and soft cost reductions.

While hard costs for EV charging infrastructure have decreased in recent years, a concerted effort is needed to reduce soft costs. Soft costs often constitute the largest proportion of total EV infrastructure costs and are typically three to five times greater in the United States than in Europe.[3] Soft costs include obtaining building permits, easements, and utility interconnections—all of which are not only costly but often delay projects. Many of these delays are due to a lack of clear understanding of the available local distribution grid's hosting capacity. Evaluating the network load or projected demand for EVs concurrently with the CS+ interconnection process can streamline this process and reduce redundancies.

Bundling "make-ready" EV charging infrastructure into CS+ project development

The "make-ready" costs for charging infrastructure are paid directly by the project developer or absorbed by the utility and passed through to the rate base. Installing these upgrades at the same time and in complementary locations with community solar is more cost-effective and far less disruptive to existing operations.

These costs include hardware and site design prior to EV charger installation plus upgrades to distribution feeders, transformers, meters, and the service drop (i.e., wiring, conduit, trenching, meter, switchgear, ICT/communications, and service panel). The total for all of this can range from $1,000 to $100,000 per site depending on the size of the project, type of charging (i.e., Level 2 commercial or direct current [DC] fast charging), and the electrical upgrades required.[4] Evaluating and installing both upgrades at the same time reduces interconnection costs and provides the opportunity for the distribution utility to evaluate non-wires grid benefits that come with solar plus storage.

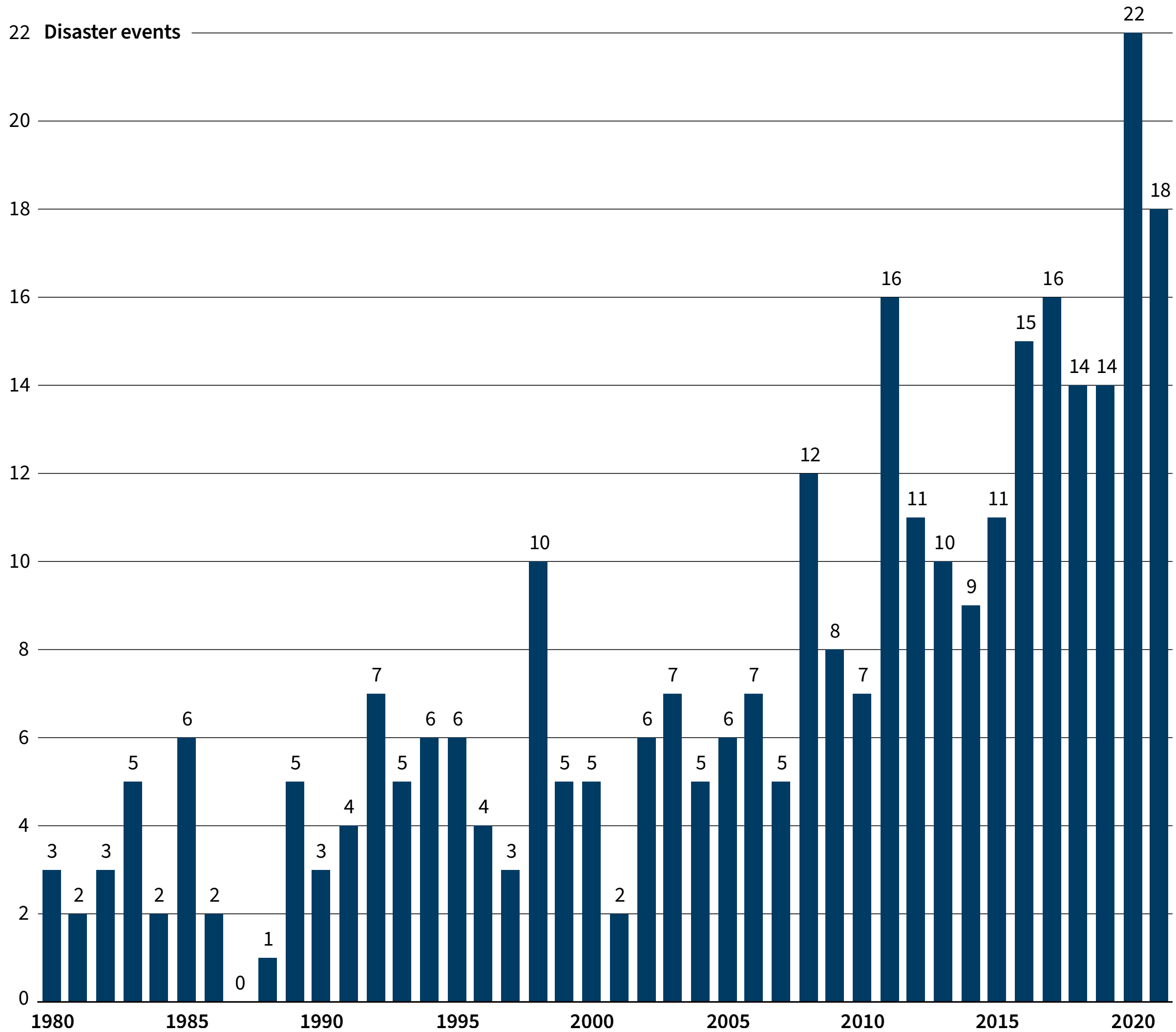
Requests for proposals (RFPs) for CS+ can require solar developers to design their projects to include charging infrastructure to be "EV ready." Whether those hard costs are best paid for with the financing for the CS+ project should be examined on a case-by-case basis. However, including the design, permitting, and interconnection processes for "EV readiness" in the RFP can help accelerate timelines and decrease overall costs for charging infrastructure long term.

Increasing Energy Resilience for Critical Assets and Vulnerable Communities

CS+ projects can enhance local community resilience by providing reliable electricity during grid disruptions.[5] Solar projects at critical facilities or community resilience centers with storage and islanding capabilities can provide essential services, such as air conditioning, heating, basic health care, or cell phone charging for communities that cannot afford to invest in privately owned backup systems.[6] CS+ projects at these locations can be structured to allow local residents to purchase shares in the system's output during normal operations while also providing the ability for the system to switch to powering critical loads during emergencies. The first Washington, D.C., case study in this report shows how community solar is already being deployed to pair solar and storage for resilience on a multifamily apartment building.

Communities are being forced to prioritize resilience as natural disasters—including hurricanes, flooding, tornadoes, and wildfires—are increasing in frequency, intensity, and cost. According to the Intergovernmental Panel on Climate Change, between 2010 and 2019, the United States experienced 119 disaster events exceeding $1 billion in damages—more than twice the number that occurred between 1990 and 1999 (see Exhibit 5).[7] Hurricane Sandy, which left 8.2 million people without power for weeks, epitomizes the massive disruptions these events can create for local power systems.[8]

Exhibit 5 **Annual Disaster Events Exceeding $1 Billion in Damages**



Note: Disaster damage is CPI-Adjusted and includes droughts, flooding, freezes, severe storms, tropical cyclones, wildfires, and winter storms[9]

Source: **NOAA**

Although including storage, microgrid, and grid sectionalization technology adds costs to these projects, communities should also consider their value. This value typically equates to the avoided cost of grid outages and will vary depending on the services that are powered and the expected frequency and duration of outages.[10] Few avenues currently exist to monetize the added value of resilience in solar and storage projects, but Anderson, et al., demonstrate how insurance premium reductions for resilient solar could help lower project costs.[11] As cities become increasingly aware of the need to adapt to climate change, they should incorporate the value of resilience into energy infrastructure investments and policy decisions, especially for public facilities that are well suited for community solar, energy storage, and microgrids.

Aligning Evolving Grid and Customer Needs for an Electrified Future

CS+ can prepare communities for an electrified future by using local solar coupled with storage or EV charging as an innovative grid asset rather than projects contingent upon (and often limited by) a specific building's electricity load. Proactively scaling flexible distributed energy resources (DERs) can improve grid reliability and minimize grid costs, especially when installed in areas of high future demand. However, flexible DER installations in population centers are falling short of the scale necessary to support the transition to a renewable, electrified future. Because community solar projects are not tied to a specific load, CS+ can leverage subscription models to reduce obstacles for communities to scale DERs. This flexibility offers optimal value to both consumers and the grid in the future.

Scaling flexible DERs can decrease the costs of deep electricity system decarbonization

Distributed storage and demand flexibility at all scales will be needed to address anticipated load growth. The system-level value of DERs, including community solar, depends significantly on grid location and whether it includes storage or demand flexibility.[12] Vibrant Clean Energy (VCE) recently studied the opportunity for distribution planning to optimize local DER deployment. Its extensive analysis found that optimizing distribution planning could reduce the cost of a clean energy future by $500 billion relative to a more centralized deployment of renewables in the grid.[13, iv] This potential was largely attributable to the scaling of flexible strategies, such as storage or demand response. Neither of the most common incentives for DERs (CS or rooftop net metering) provide an incentive to scale and locate flexible DER resources. CS+ offers promising opportunities to scale flexible DERs in distribution systems, where enabled.

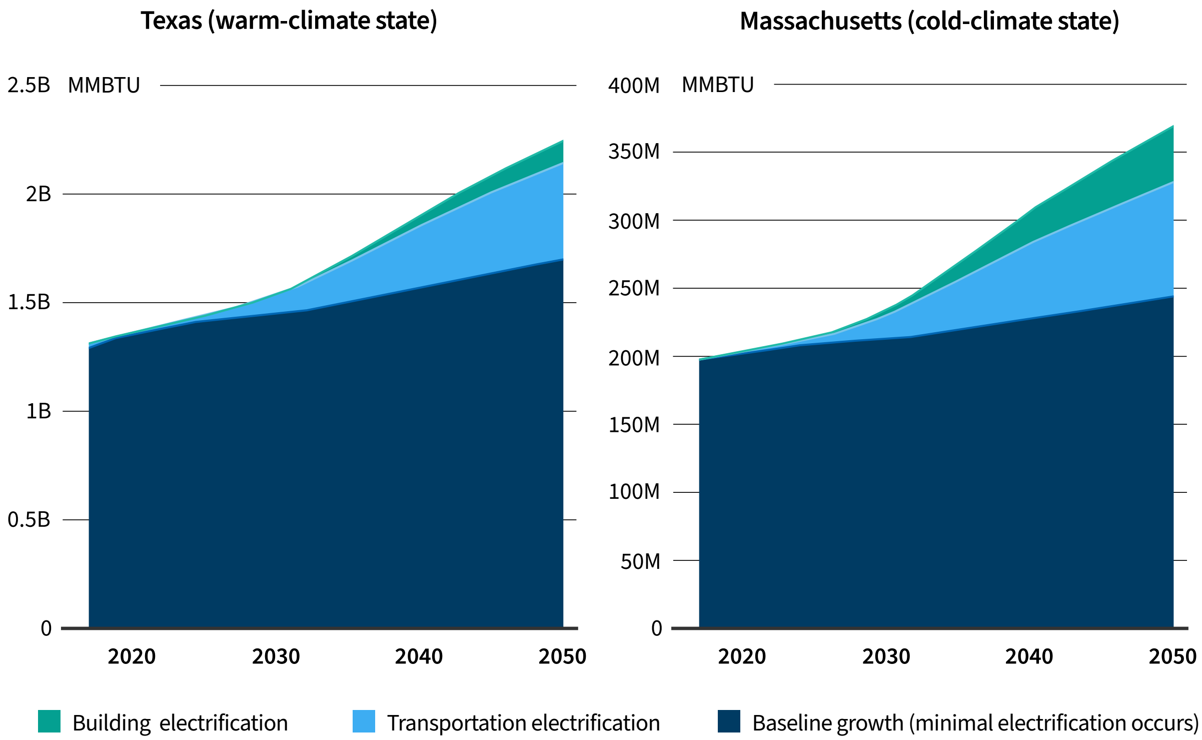
Anticipating changing energy demand in population centers

Increased electrification will impact cities and other population centers dramatically. Fortunately, that is where CS+ projects can be most innovatively and effectively deployed. Although total US electricity consumption has remained relatively flat over the past decade, widespread electrification—the shift to electricity-powered, end-use technologies such as EVs, electric stoves, and heat pumps—is expected to significantly increase future demand even when paired with additional energy efficiency and conservation measures. For example, as shown in Exhibit 6, additional electrification is expected to increase total electricity demand in Texas and Massachusetts by a respective 30% and 50% by 2050 compared with the baseline.[14]

iv In VCE's clean energy scenario, greenhouse gas emissions would decrease by 95% in 2050 from 1990 levels.

Exhibit 6 **Projected Electric Load Growths in Texas and Massachusetts by 2050**

Base Case and High Electrification Scenarios



Source: NREL, ***Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States***

Anticipating load growth will become more important as EVs create local grid stress patterns—again, likely in denser population centers. In a 2019 survey of grid and resource planners, 68% of respondents reported facing transmission and distribution constraints—many citing concerns over "clustering" of EV chargers.[15]

The most common mechanism to invest in urban-sited solar—primarily using net-metering rules—is greatly limited by existing demand and single-ownership models. All community solar programs address bias toward historical demand for DER siting and sizing challenges, such as net-metering programs, by aggregating multiple bills toward one installation, thereby allowing for demand and supply to be geographically flexible. However, most community solar projects are located peripherally to population centers and lack storage or EV integration. In these locations, projects provide negligible value to the consumer through charging or resilience and are usually less cost-effective than utility-scale solar. This is, in part, due to the initial cheaper cost of land, but also because community solar has generally not previously been designed with the intent of capturing system-wide value.

Unleashing DER innovation and business models

New business models offer an opportunity to integrate EV charging with CS+ financial and subscription models, especially in dense population centers where charging infrastructure will need to be deployed and shared. In fall 2020, the Town of Yorktown, New York, in partnership with the New York State Energy Research and Development Authority (NYSERDA), completed the first hybrid community solar, EV charging, and storage project for demand charge reduction.[16] This is an important innovation: a bank of six DC fast chargers can require the power equivalent of a high-rise office building.

A solar canopy powers an electric bikeshare charging station in Basalt, Colorado. This innovative application of a solar canopy was developed by WE-cycle in partnership with Skyhook Solar and PBSC Urban Solutions. **Source:** Craig Turpin, Rising Sun Photography

If vehicle-to-grid charging moves toward mainstream adoption, vehicles would be able to act as grid assets, potentially aggregated and administered through a community solar program. The innovation potential is not limited to EVs; it could also be applied to shared infrastructure for electrified food trucks, community greenhouses, multiuse or multifamily building electrification, transit stations, or other shared community assets that may have high electricity demand (i.e., flexibility potential or resilience importance).

As CS+ projects continue to innovate, we will see further opportunities to align customer and grid value, regardless of historical usage patterns or on-site demand. Community solar subscription models also can help scale flexible DERs to open new doors for greater localized energy generation.

Creating a More Equitable Energy System

The first generation of solar projects laid the groundwork to increase access to clean energy by overcoming key barriers to rooftop solar (e.g., credit scores and home ownership) and associated disparities by race and income.[17] Community solar projects have used methods such as subscription carve-outs for LMI households to reduce existing disparities in clean energy access. Plus, more than 70% of community solar projects offer financing for people with low credit scores, immediate and direct bill savings, community education, and little or no up-front investment requirements.[18] These features are needed to engage LMI subscribers and are similar to those for other clean energy and community solar projects. However, CS+ projects take this further by extending the benefits of a clean, electrified, and resilient system right in the heart of lower-income and marginalized communities.

CS+ effectively creates community energy hubs that leverage existing local assets—such as libraries, community centers, medical centers, transit centers, and emergency service centers—and extend clean energy, electrification, EV infrastructure, and resilience into marginalized communities. Renters and LMI households, often communities of color, face similar challenges in accessing electrification and resilience investments as they do in accessing solar. Moreover, landlords and property management companies have no incentive to provide access to charging infrastructure or shared mobility services, or to invest in resilience measures to protect against grid outages and extreme weather.

Hospitals, fire stations, and police stations provide essential emergency services, especially during disaster response and recovery. For this reason, grids are usually set up to protect the circuits powering these facilities. This can have unintended consequences of leaving less affluent areas without power during a disaster because these areas get de-prioritized. Texas communities saw this firsthand during Winter Storm Uri in 2021, when grid operators deliberately avoided blacking out critical circuits with hospitals and public safety services—most of which were also in more affluent and predominantly White areas. As a result, non-White households and lower-income communities lost power for as long as three days, while others on a critical circuit never lost power.[19]

> **CS+ projects take this further by extending the benefits of a clean, electrified, and resilient system right in the heart of lower-income and marginalized communities.**

CS+ can offer local energy resilience independent of grid structures or class- and race-based inequities among neighborhoods. By deploying CS+ at community centers, transit stations, schools, and other community facilities, a new opportunity emerges for daily energy services and subscriptions that invest in low-income community resilience.[20] CS+ is far more than just electricity generation; rather, it is a community energy hub for related electricity, transportation, and resilience needs.

The final piece that CS+ brings to the puzzle is greater scale. While the first generation of community solar projects certainly achieved better installation costs than individual residential rooftop customers could, projects to date rarely come close to the economies of scale of utility-scale solar. CS+ can tap into additional value streams and thus greater scale. Accordingly, project developers can attain better economies of scale if state and utility programs do not unnecessarily cap project capacity. This reduces prices on a per-kilowatt-hour basis to further increase access to the clean energy, battery storage, and related EV services. Plus, financing resilience or electrification upgrades with pooled electricity subscriptions reduces the cost burden on individuals, increases community ownership of energy systems, and offers new opportunities to spread out fixed costs over time.

To ensure that CS+ projects are meeting the needs of the community, cities should prioritize procedural equity by including local stakeholders and forging local partnerships in the communities in which solar is planned, installed, and managed. Subin DeVar, director of the Community Renewable Energy Program at the Sustainable Economies Law Center, asserts that equitable community solar must not only be “intentionally focused on benefitting marginalized communities,” but also “prioritize local community governance and ownership.”[21] See *Recommendations for Planning, Procurement, and Policymaking* for policy and program guidance for decision makers and key stakeholders on advancing equitable community solar.

Parking Canopies: A Special Use Case for Additional Value

Parking facilities, both surface lots and garages, can be attractive locations for CS+ projects. Ideal parking facilities for canopies are those intended to support vehicle parking far into the future, including parking garages, transit hubs, park and rides, grocery stores and other retail centers, vehicle dealerships, major event centers, and more. It is worth noting that many urban areas may have higher and better uses planned for existing parking lots, so the priority for deploying solar parking canopies should be for those parking facilities that are here to stay.

Deploying solar parking canopies helps scale community solar in population centers by unlocking two additional peripheral value streams:

- Providing covered parking and weather protection
- Mitigating the urban heat island effect

Moreover, siting community solar projects at parking facilities can reinforce other CS+ value streams and further capture economies of scale.

Providing Covered Parking and Weather Protection

Owners and customers of solar canopy projects can capture the benefit of protection from the elements along with additional parking revenue and reduced insurance premiums. Paying for parking, especially covered parking, is commonplace in the United States. Parking canopies provide protection from direct sun, excess heat, rain, hail, sleet, snow, and other elements in cold and hot climates alike. Early examples of solar canopy projects indicate that consumers are willing to pay $10 to $15 per space per month as a premium for covered parking—revenue that can add significant value to a 25-year solar project.[v] The epitome of community solar parking canopies is the San Antonio Big Sun Community Solar Program (pictured on next page), which is described in more detail in *Case Studies*.

While parking canopies are not solely created for vehicle protection, anecdotal evidence suggests that this may be a valuable opportunity for project developers, vehicle dealerships, fleet managers, parking facility operators, and insurance providers. Reputable solar panels are built to withstand strong winds, hail, and debris, while vehicles are not nearly as resilient.[22]

v This range for a covered parking premium is based on the authors' sources and experiences with projects ranging from West Virginia to Texas. It is not an industry-wide assumption, rather an initial basis for planning and market considerations. Willingness and ability to pay for covered parking will vary by region and community.

Parking canopies installed in San Antonio as part of the Big Sun Community Solar Program protect vehicles from hail damage, direct sun, and excess heat. **Source:** Big Sun Solar, 2020

Some insurance companies offer discounts on premiums if vehicles are parked in a garage. Individual vehicle owners may be eligible for a 5% discount, while fleet operators could potentially see discounts of up to 20%.[23] Although canopies do not offer the same protections as garages, they do provide enough protections that some benefit could be negotiated. For instance, one truck dealership in San Antonio saved 10% from its insurance company (approximately $32,000 annually) by hosting solar canopies above more than 180 of its vehicles—both cars and semi-trucks.[24]

Mitigating the Urban Heat Island Effect

Another value solar canopies can provide is helping to reduce heat islands in urban areas. The urban heat island effect refers to the higher temperatures generated by greater concentration of heat-retaining materials and surfaces in the built environment. This temperature increase can be particularly dramatic on dry, dark surfaces, such as pavement. On a hot, sunny day, temperatures can be 50°F to 90°F hotter on dry, dark surfaces than the surrounding air—and, in turn, these surfaces radiate that additional heat and further warm the surrounding air.[25]

Even a few degrees can make the difference between a hot day and a heat emergency. A 2007 study showed that solar panel coverage of paved parking lot structures can reduce surface temperatures by up to 55°F compared to fully exposed asphalt.[26] This not only increases the comfort of drivers, passengers, and pedestrians, but also reduces the fuel needed to cool the interior of vehicles.

Parking Canopies Can Reinforce Core Community Solar+ Value Streams and Further Capture Economies of Scale

Reinforcing core CS+ value streams

In addition to the above-mentioned additional value streams, siting community solar projects at parking facilities can reinforce core CS+ value streams.

Accelerating investment in EV charging infrastructure: Of all the community solar siting opportunities, parking canopies are best positioned to further accelerate the integration of EV charging. For canopy projects, the elimination of soft-cost redundancies with EV charging installations (see *Enhancing the Value of Community Solar Projects*) are complemented by reductions in hard-cost redundancies. These include coordinated trenching, groundwork, electrical engineering, and labor for the solar and lighting. If canopies are planned with EV charging as a near-term add-on, everything but the charger itself can be set up and wired at a marginal cost difference for the added wiring and conduits. There are operational efficiencies as well; by installing all the equipment at once, facility managers limit the number of times they need to halt or adjust their parking operations to install new technology. Another opportunity may exist for fleet operators and site hosts looking to offset costs, either through selling capacity into the community solar market, or for reducing the cost of electricity on peak-demand days when the electricity price spikes. Projects pairing community solar with fleet charging should consider the cost reduction opportunity for the project itself, or the price of electricity on peak-demand days.

Creating a more equitable energy system: CS+ canopies advance equity by helping cool communities that, historically, have had disproportionately more heat-absorbing surfaces with fewer investments in greenery and parks. In fact, as a 2020 *New York Times* article explains, urban heat islands have stark roots in decades-old racist housing and land-use policies:

> **Neighborhoods with White homeowners had more clout to lobby city governments for tree-lined sidewalks and parks. In Black neighborhoods, homeownership declined and landlords rarely invested in green space. City planners also targeted redlined areas as cheap land for new industries, highways, warehouses and public housing, built with lots of heat-absorbing asphalt and little cooling vegetation.**[27]

While parking canopies are no panacea, they can be part of a strategy to shelter people and vehicles from adverse weather, mitigate urban heat islands, accelerate vehicle electrification, and create a more equitable energy system. The Minnesota Department of Transportation (MnDOT) developed a parking canopy project that achieved workforce targets for underrepresented populations and provided subscription options for low-income households, all while providing covered parking and shade on MnDOT property in downtown Minneapolis.[28]

Plus, the opportunity to monetize covered parking, thereby adding a new revenue stream to offset overall project costs, could further fund a more comprehensive, equitable, and innovative project. For instance, this additional revenue could subsidize community solar subscriptions, reduce EV charging costs, and increase the financial viability of siting innovative, renewable, resilient projects in lower-income communities.

Capturing further economies of scale

CS+ canopies can be scaled larger than rooftop projects, allowing these projects to realize better economies of scale in densely populated areas. Since parking facilities may not be able to utilize all of the solar energy they are capable of producing, community solar (or virtual net-metering) structures can allow these facilities to maximize their output potential, making canopy projects as cost-effective or more so compared with other siting options.

Parking canopies are assumed to cost more on a per-Watt basis than a rooftop array due to the additional materials and infrastructure required. However, recent examples from Vermont to California indicate that solar parking canopies' greater size (~1 MW and greater) can allow them to compete with rooftop projects.[29]

For example, the City of San Diego's on-site solar project portfolio demonstrates that the larger the system, the more cost competitive it is. Of the 14 distinct rooftop and parking canopy municipal solar projects in San Diego, the 983 kW Balboa Park parking canopy was not only the largest, but also the cheapest project on a per-kWh basis. In fact, even averages of San Diego's portfolio show that the cost reduction from the larger scale of the parking projects outweighs the added expense of their lofted solar canopy structures (see Exhibit 7).

Though not community solar, the City of San Diego's 983 kW parking canopy in Balboa Park is the largest and cheapest project on a per-kWh basis of the 14 distinct rooftop and parking canopy solar projects installed by the city. **Source:** City of San Diego, 2020

Exhibit 7 San Diego Phase 1 Solar Portfolio Summary

	Rooftop arrays	Parking canopies
Average PPA rate	$0.175/kWh	$0.145/kWh
Average project size	143 kW	252 kW
Number of projects	4	10

Note: All projects were energized between November 2017 and January 2019.

Source: City of San Diego

This does not mean all canopies are cheaper than rooftop arrays, but how projects are sited and designed matters. This bodes well for larger-scale solar parking canopy deployment at facilities such as stadiums, arenas, markets, schools, and airports. Larger parking canopy projects may be far more cost-competitive on a dollar-per-kWh basis compared with a smaller rooftop project. See the San Antonio and Washington Metropolitan Area Transit Authority examples in *Case Studies* for large-scale community solar canopy projects.

The takeaway here is that communities should look beyond the apples-to-apples comparison of similarly sized systems, especially when the constraint is often the on-site building load or size of rooftop. Instead, compare the relative pricing of the feasible scales based on the site. Whether large rooftops are available or not, canopies offer an increasingly attractive option for large local community solar projects even before accounting for the added value streams available through a CS+ strategy.

This highlights a far more efficient opportunity to scale local solar through parking canopies, and, as noted previously, CS+ is an effective and valuable project structure to make scaling a reality. Given the car-centric history of urban development in the United States, many cities can learn from this, too. This opportunity is already possible with existing parking facilities and does not suggest that new parking spaces should be built to host solar parking canopies. Rather, this is merely one way to better utilize existing parking spaces.[30]

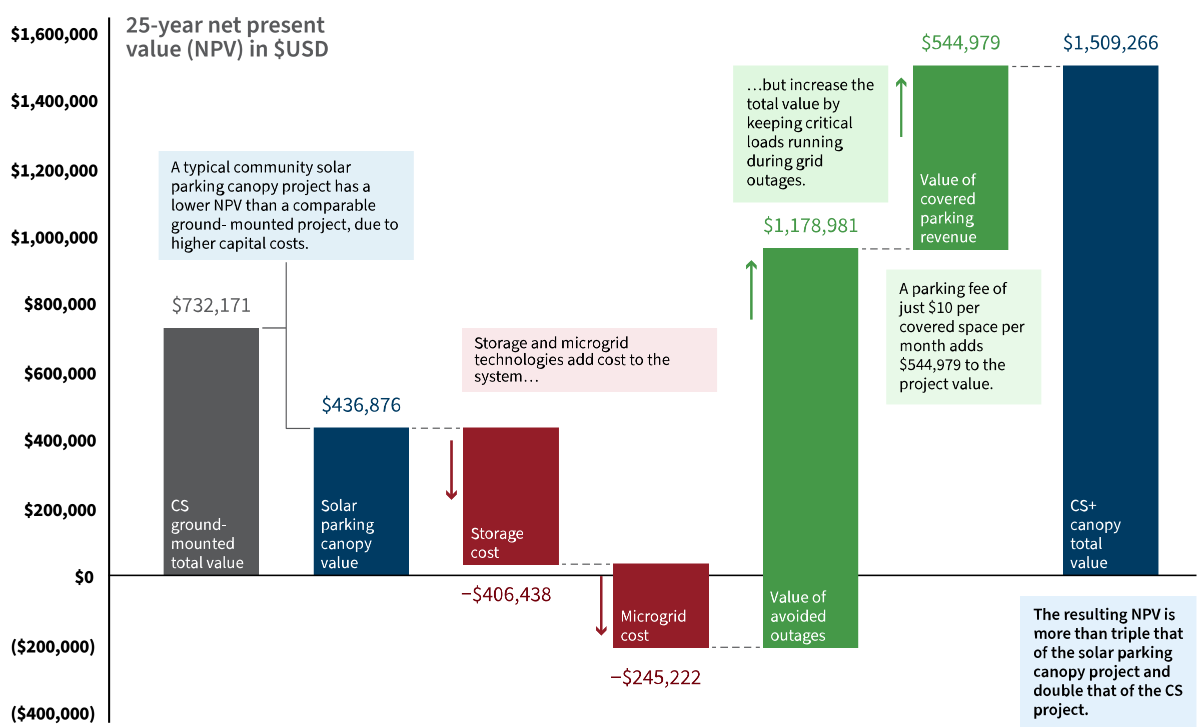
Evaluating the Stacked Value Proposition of Community Solar+

While adjusting project and program designs to capture the value streams highlighted in this report may increase the upfront cost of CS+ projects, the resulting value streams fundamentally change the cost-benefit analysis of a project. Some benefits may be difficult to explicitly monetize, but others can provide additional concrete revenue or add quantifiable values that improve the economic attractiveness of a CS+ project. In all cases, the local context and community priorities should dictate which of the value propositions take precedent.

To illustrate relevant financial implications, consider the following hypothetical example of a solar project seeking to capture two value streams: resilience and covered parking, respectively monetized as avoided outage costs and added parking revenue.

Exhibit 8 Comparing Economics of Community Solar and Community Solar+

Capturing CS+ value streams more than triples the lifetime value of the 1 MW canopy project.



From left to right: (1) 25-year NPV of a hypothetical 1 MW ground-mount CS project in Vermont, (2) the NPV of an equivalent CS parking canopy project, (3) the cost to incorporate battery storage and (4) microgrid technologies to provide at least eight hours of resilience to critical loads in an adjacent hospital, (5) the value of that resilience assuming a value of lost load of $100/kWh, (6) the value of revenue from covered parking assuming $10/space/month, (7) the new total NPV of the CS+ parking canopy project.

A Vermont municipality intends to develop and manage a 1 MW community solar project on either an open field (ground mount) outside the city or a large parking lot (canopy) adjacent to a local hospital. Both sites are municipally owned, so site acquisition costs are assumed to be $0. On the parking lot site, the city has the option to integrate storage and microgrid technology to power select critical loads in the adjacent hospital through a major outage and will be able to levy an additional fee to monetize the covered parking spaces. The option involving the parking lot represents the CS+ project path and added value streams. The costs and benefits of incorporating resilience and covered parking into the community solar program design are highlighted in Exhibit 8.

The CS ground-mount and CS+ parking canopy net present values (NPVs) incorporate up-front and ongoing costs associated with development and operations of a community solar project along with the revenue from subscriptions. The CS+ canopy NPV also includes the costs and benefits of resilience and parking revenue from covered parking and weather protection. As shown, the original parking canopy project has an NPV nearly $300,000 less than that of the CS ground-mount project. However, when the value, including added costs, of resilience and covered parking are integrated into the CS+ parking canopy financial model, the total value of the project becomes $1.1 million *greater than* that of the solar parking canopy project and $777,000 *greater than* that of the CS ground-mount project.

The financial models underlying the findings shown in Exhibit 8 were developed using the **Community Solar Business Case Tool** and should be considered representative of potential projects.[31] The underlying assumptions for both the ground-mount and parking canopy projects differed only in installed cost, which is assumed to be a respective $2.08/W and $2.81/W, based on costs reported in the *Vermont Solar Cost Study*.[32] For both systems, the panel subscription rate is set to $4.80 per panel per month, which allows subscribers to have positive cashflows in year one of their investment and onward. The Vermont data also grounded this analysis in real-world costs, though it should be noted that other states and regions may have a range of different market and policy considerations impacting project cost and value.

To incorporate the value of resilience into the 1 MW parking canopy model, battery storage was optimally sized, using the National Renewable Energy Laboratory's (NREL) **REopt** tool, to be able to power 15% of the hospital's load through an eight-hour outage occurring when the hospital is at its annual peak load.[33] We assume the solar-plus-storage system is used to complement existing diesel backup generation and will power critical loads currently not covered by diesel generators. The resulting average resiliency (i.e., the average survival time for an eight-hour outage occurring at any hour of the year) is seven hours. The cost of the optimally sized, 1,282 kWh, 150 kW battery system was included in the model, along with the cost to make the system islandable from the grid, which was assumed to be 12% of the total system capital cost. As in Anderson, et al., the value of lost load during an outage was assumed to be $100/kWh.[34] The annual value of resilience was then calculated as the product of value of lost load, the mean critical load during an outage, and the average resiliency duration of seven hours. This quantity captures the value of being able to power critical equipment or common spaces in the hospital during a major outage event. Revenue from covered parking was conservatively assumed to be $10 per space per month. The full set of financial assumptions can be found in the appendix.

This comparison demonstrates that designing projects to meet multiple goals can add value to the community while also improving the financial attractiveness of a community solar program to the project developer.

Case Studies

The four case studies that follow represent how community solar is already being used in new and innovative ways to provide additional value to communities. They provide a glimpse into how we can use CS+ to chart our path to a more holistic, equitable, and clean energy future.

Renewable Denver Initiative

A rendering shows a planned ~500 kW rooftop solar installation at the National Western Center in Denver. **Source:** City and County of Denver

Project Overview

The City and County of Denver is **pursuing 4.6 MW of community solar** through Xcel Energy's Solar*Rewards program and intends to expand its efforts to additional municipal buildings in the future. Denver chose to finance and own the solar projects and is partnering with building design and construction firm McKinstry to design, build, and maintain them. Parking canopy sites, several of which are in low-income areas, will be designed to include EV charging infrastructure. The initiative specifically focuses on increasing equitable access to clean energy in Denver, with at least 20% of the energy generated by the solar gardens to be allocated to income-qualified housing and low-income residents to help alleviate their energy burden.

To pursue this project, the city issued a competitive RFP for a master service agreement that defined how project developers should construct the community solar projects, manage customer enrollment, coordinate with the city's equity and workforce goals, assist in site selection among several city-owned buildings and properties, and engage with communities to improve equity and empowerment.

Community-Wide Value Enhancements

Creating a more equitable energy system: The project enables disadvantaged and vulnerable communities to have access to bill savings. As part of the master service agreement with the developer, communities will also have direct workforce training and educational programs coordinated with schools where projects are sited.

Accelerating investment in EV charging infrastructure: The solar carport sites will include publicly accessible, free EV charging. By considering and planning for future charging infrastructure at the same time as the community solar project, the city is providing an affordable and streamlined mechanism to deploy shared electric charging infrastructure.

Covered parking and weather protection: Many of the project sites will feature solar canopies to host panels. This has the dual benefit of increasing the site's solar generation potential as well as protecting vehicles from hail, rain, snow, and sunlight.

Increased resilience for critical assets serving vulnerable communities: The city is using this opportunity to evaluate sites and plan for future energy storage on these community buildings.

Aligning evolving grid and customer needs for an electrified future: A comprehensive look at the city's asset portfolio provided an opportunity to interface with the utility and understand where the grid had significant capacity for local generation and to use that information to site investments in locations that benefit overall grid health.

> **This initiative is an opportunity to improve our air, mitigate the effects of climate change, and invest in our community … and by leading on climate issues, it's also a way to help residents lower their electric bills. The arrays also provide ideal locations to co-locate with publicly accessible electric vehicle charging stations.**
>
> – Denver Mayor Michael Hancock

Big Sun Community Solar in San Antonio

A solar canopy at Farinon Business Park in San Antonio is one of 12 parking canopies in the city built as part of a community program.
Source: Big Sun Solar, 2020

Project Overview

The Big Sun Community Solar Program is a public-private partnership consisting of a total of almost 5 MW of community solar at 12 sites across San Antonio. The program directly capitalized on the additional value provided by the parking canopies by leveraging the covered parking revenue. Private parking facility operators pay local developer Big Sun Solar for the canopies, which enable the operators to increase parking fees for customers. This created a new revenue stream for Big Sun Solar, which in turn reduced the program's costs for residential customers. Big Sun Solar built the project after being selected by San Antonio's municipal utility, CPS Energy. Through the program, 500 to 600 CPS Energy residential customers buy panels from Big Sun Solar and receive a fixed-rate production credit on their electricity bill, resulting in an estimated 12-year payback. The 12 canopies became operational in 2020.

Community-Wide Value Enhancements

Accelerating investment in EV charging infrastructure: The canopies were designed to be electric vehicle supply equipment (EVSE)-ready, thereby reducing the costs of future EVSE deployment.

Creating a more equitable energy system: The program reserved at least 20% of enrollment for limited-income residents. To further enable uptake from lower-income groups, Big Sun Solar partnered with local foundations and a bank to create a solar assistance program.[35]

Providing covered parking and weather protection: Because all participating parking facilities can now offer covered parking, Big Sun Solar created a new revenue stream to offset the cost of the project. One truck dealership in San Antonio that had suffered costly hail damage on multiple occasions took this a step further. By pointing out the protection afforded to its fleet of 188 vehicles by the solar canopies without a costly garage, the dealership was able to reduce its monthly insurance premiums by 10%, providing total annual savings of approximately $32,000.

Mitigating the urban heat island effect: The canopies are located throughout urban San Antonio and are thus able to reduce the urban heat island effect across the community. The shade and reduced heat are particularly valuable in San Antonio, which experienced more days above 100°F between 2010 and 2017 than any decade since recordkeeping began in the 1890s.[36]

Pepco Resiliency Center in Washington, D.C.

Rooftop solar panels cover the Pepco Resiliency Center at Maycroft Apartments, an affordable housing complex in Washington, D.C. **Source:** Timothy B. Wheeler, Bay Journal Media

Project Overview

The Pepco Resiliency Center at Maycroft Apartments, an affordable housing complex developed by Jubilee Housing, demonstrates the ability of community solar paired with storage and microgrid technologies to provide cost savings and affordable clean energy as well as critical resilience for vulnerable communities. The 62.4 kW community solar photovoltaic (PV) system is paired with a 46 kW/56 kWh battery storage system and 50 kW diesel generator to provide up to three days of backup power for critical loads.[37] The solar array, completed in 2019, is part of the New Partners Community Solar portfolio, a group of installations that provide bill savings for 100 low-income residents at no cost. This first-of-its-kind community solar installation involved collaboration with a diverse array of partners for technical assistance, program design, and funding, and it was developed through the D.C. Department of Energy and Environment Solar for All initiative.

Community-Wide Value Enhancements

Increased resilience for critical assets and vulnerable communities: As stated by Jim Knight, president and CEO of Jubilee Housing: "Resiliency is especially important for vulnerable communities that already experience great uncertainty in the course of their lives."[38] The Pepco Resiliency Center at Maycroft addresses this need by providing up to three days of backup power to critical loads, including lights in stairs and hallways, a refrigerator for food and medicine, several outlets for medical equipment and cell phone charging, a water pump, and floor fans.

Creating a more equitable energy system: The solar projects in the New Partners Community Solar portfolio are estimated to reduce energy expenditures by $40 to $50 per month for 100 of Jubilee's most rent-burdened residents. Importantly, Jubilee and New Partners ensured that solar savings were not offset by increases in rent (which would eliminate the benefit to residents), and that bill savings were not considered additional income (which could preclude eligibility for income-based assistance). These types of considerations are critical to keep in mind when designing projects to generate solar bill savings for residents of subsidized housing.

Washington Metropolitan Area Transit Authority's Community Solar Partnership

A rendering shows canopies in a proposed community solar project at WMATA's Cheverly transit station in Cheverly, Maryland.
Source: SunPower Corporation, September 2021

Project Overview

In July 2020, the Washington Metropolitan Area Transit Authority (WMATA) announced that it would partner with SunPower Corporation and Goldman Sachs Renewable Power LLC (GSRP) to install 12.8 MW of solar canopies on its facilities.[39] It's the **largest community solar project in the nation's capital**—and one of the largest in the country—and is expected to generate an estimated 15,000 MWh annually, or roughly enough to power 1,500 homes.[40] WMATA will host the solar canopies on three of its parking lots and one parking garage at Metrorail transit stations in both Washington, D.C., and Maryland, providing covered parking across 17 acres of D.C. Metro property. GSRP will own the solar canopies and renewable energy credits, and it will lease WMATA facilities through 2047, resulting in approximately $50 million in new revenue to support WMATA's transit operations.[41] Meanwhile, the electricity produced will be sold to Pepco customers in Washington, D.C., and Maryland through a community solar program.

WMATA initiated the multijurisdictional project to advance two core project goals: supporting Washington, D.C.'s goal to transition to 100% renewable energy by 2032 and providing a steady revenue stream to aid WMATA's operations while boosting clean energy growth.

Community-Wide Value Enhancements

Creating a more equitable energy system: This is a unique example of a transit agency hosting solar energy on its facilities to extend indirect economic resilience benefits to marginalized communities and lower-income commuters who rely on affordable rail and bus systems to commute and to get around. These projects will be a small but meaningful step in mitigating massive ridership declines due to the COVID-19 pandemic and may alleviate the need for future fare increases.[42] Decreased revenue for public transit results in decreases of service that disproportionately impact lower-income communities.[43] In 2020, WMATA saw declines in its daily rail ridership of 71% to 93% compared with the same period in 2019—a challenge that will continue until the end of the pandemic.

Providing covered parking and weather protection: WMATA leveraged existing parking assets to raise new revenue from solar leases while increasing covered parking for customers at WMATA transit stations. During the summer, the canopies provide shade from intense heat for vehicle owners and passengers, reducing the energy needed to cool vehicles, especially valuable as summers in the mid-Atlantic states are getting hotter and more humid. In fact, the Washington, D.C., area not only set a record with 42 days straight of low temperatures above 70°F in 2020, but also has experienced 5 of the 10 longest low-temperature record streaks in the past decade—the warmest decade on record.[44]

> **This project benefits residents of our region, even people who don't ride Metro, by leveraging the potential of our stations to generate revenue and increase the community's access to a clean, renewable source of energy.**
>
> – Metro General Manager/CEO Paul J. Wiedefeld

Recommendations for Planning, Procurement, and Policymaking

Organizations such as the Institute for Local Self-Reliance and NREL have developed recommendations to guide community solar planning, policies, and development. The sections below build upon existing guidance by providing CS+ specific recommendations for several key stakeholders: local governments, state governments, utilities, and community choice aggregation entities. Some recommendations may be applicable to solar developers, non-profit groups, community-based organizations, and other institutional partners.

Recommendations for Local Governments	
Plan effectively to set your community up for success.	**Identify available sites during planning:** Embrace master planning and climate action to layer or "zone" for potential sites that would be ideal to host CS+ projects beyond solar readiness. Example considerations could include future load growth, increased EV demand, necessity for resiliency hubs, suitability of parking facilities, and locations of existing heat islands. **Simplify the development process:** Ensure zoning ordinances, permitting, and other approvals for solar and EV infrastructure development, including those for parking canopies, are clear and easy to navigate. When possible, streamline permitting with standardized, automated online processes. **Publicize market opportunities to spur innovations:** Issue requests for information (RFIs) or RFPs for CS+ type projects to developers with clear goals, sites, scale, and demand to proactively spur innovative project proposals. **Cross-coordination is key to project success:** Work across municipal departments and authorities—including transit, port, and housing—to gain buy-in, leverage key assets, and capture the most value. **Assess the potential for covered parking:** Quantify the demand for covered parking at both public and private facilities along with the benefits related to the urban heat island effect, weather protection, coordination with shared mobility options, damage risks, and insurance premiums. Work with relevant insurance companies to identify and monetize potential resilience and covered parking benefits for municipal fleets.
Use partnerships and other tools to extend participation from underserved communities.	**Partnerships can expand access to underserved communities:** Work with community nonprofits, local banks, community development financial institutions, or green banks to reduce borrowing rates for those purchasing shares up front, remove credit score minimums that can hinder participation, provide guarantees for bill payments to the project developer, or increase engagement with underserved communities. **Equitable outreach is key:** Organize educational sessions to increase buy-in, offer multiple sign-up methods, and plan intentional outreach to underserved communities.
Structure projects to enable flexibility in design.	**Leverage your buying power:** Consider acting as an anchor off-taker or guarantor of subscriptions for community solar projects to help increase the scale and reduce risks for a project developer. **Seek CS+ value streams:** Consider ways to leverage supplemental revenue streams or reduce subscription rates to lower costs for LMI subscribers.

Recommendations for State Governments	
Set market conditions that will accelerate community solar and innovation.	**Expand virtual net metering:** Enact or expand access to virtual net metering via new legislation. Consider exempting community solar projects on underutilized land—such as parking facilities, brownfields, and landfills—from virtual net-metering capacity limits or program caps. **Align incentives with core value streams:** Create programs that explicitly incentivize CS+ value streams and ensure limited-income residents can participate and access the benefits.[45] This could be achieved via a grant, rebate, customer credit, or adder—as is done in Massachusetts' SMART Program.[46]
Provide public, clear channels to enable program success.	**Target outreach appropriately:** Implementing agencies should communicate in ways that reach the intended communities. For example, Oregon created a **website** that hosts a subscriber matching program with clear eligibility requirements, including specifics for low-income subscribers, and partnered with a local non-profit, Community Energy Project, to help low-income households participate in its program. **Share data to enable synergy:** Public utility commissions and other state regulators can open the door to coordinated mobility, electrification, and resilience planning by requiring local grid operators or utilities to provide transparent "hosting capacity" data that includes information on how many megawatts of solar can be added to which distribution feeder lines and where those lines are located.[47]

Recommendations for Utilities and Community Choice Aggregation Programs	
Plan effectively to set your project up for success.	**Incorporate CS+ into business model:** Develop scalable local community solar programs if none exist statewide to retain your customer base, prioritize project siting to reduce grid investments, and align projects with strategic EV demand and critical facilities. **Publicize market opportunities to manage load growth:** Release RFIs or RFPs for CS+ type projects to developers where load growth is forecasted or where underserved communities lack access to clean energy systems. **Seek local partners:** Collaborate with local institutions, businesses, and community organizations to leverage large, local assets and build trust with customers while identifying the values streams that are the optimal fit.
Use partnerships and other tools to extend participation from underserved communities.	**Equitable outreach is key:** Organize educational sessions to increase buy-in, offer multiple sign-up methods, and plan intentional outreach to underserved communities. **Simplify eligibility and payment:** Implement consolidated billing or on-bill financing and use payment history over credit checks to improve access. **Design to accommodate subscription changes:** Ensure programs can easily accommodate a change in subscriber address within the service territory. This will help increase renter participation and reduce turnover and gaps in program participation.[48]

This solar canopy at a San Antonio open-air market is one of 12 parking canopies in the Big Sun Community Solar program. **Source:** Big Sun Solar, 2020

To help local governments incorporate community solar projects in general, the **American Cities Climate Challenge Renewables Accelerator** has assembled a variety of guidance, tools, and resources:

- **Community Solar Procurement Guidance:** This provides a framework and guidance, along with links to other useful tools, to help local governments understand how they can directly support community solar projects in their jurisdictions.
- **Community Solar RFP Tool:** This is designed to help local governments develop a community solar-specific RFP by providing a sortable catalogue of example clauses extracted from previously released RFPs.
- **Municipal Solar Site Selection Tool (MSSST):** To help communities consider and evaluate a range of available sites, the MSSST guides users step-by-step through the evaluation process for potential rooftop, parking canopy, ground-mounted, brownfield, and landfill sites.[49]

Conclusion

Given the challenges of realizing a just energy transition within the confines of a climate crisis, CS+ offers a mutually reinforcing set of strategies that can help achieve community goals, leverage underutilized assets, and unlock new value streams while increasing access to clean energy. Moreover, CS+ offers increasingly attractive and creative ways to scale solar in urban and suburban areas—and prepare for a more electrified, resilient, and equitable future. This can directly complement the efforts of cities small and large that are already reinventing public spaces with creative revitalization, placemaking, and resilience strategies.

CS+ further encourages planners, stakeholders, developers, and decision makers to think creatively and systemically about how they can repurpose public and private spaces in communities to capture—and even monetize—multiple value streams in community solar project design. It is not enough to think about project cost alone—and more opportunities are available if we expand considerations to include additional, often complementary, value streams.[50] This results in projects that are both community and grid assets, in which clean electricity is merely one of the values provided, and projects are more likely to be truly distributed and local.

The next generation of community solar is here. It's time to embrace Community Solar+.

Appendix

Valuation of Resilience and Covered Parking

This section provides details on the assumptions and methodologies used within the section *Evaluating the Stacked Value Proposition of Community Solar+*.

The appendix is divided into three sections:

1. **Baseline Comparison** details the approach used to determine the 25-year NPV of a 1 MW parking canopy and a 1 MW ground-mount community solar project, without taking any additional value streams into account.
2. **Resilience (Parking Canopy Only)** describes the methods and assumptions used to calculate the additional costs and benefits of resilience for a 1 MW parking canopy project.
3. **Covered Parking (Parking Canopy Only)** describes the methods and assumptions used to calculate the additional costs and benefits of covered parking for a 1 MW parking canopy project.

Baseline Comparison

Financial models for both the parking canopy and ground-mount systems were developed using Elevate Energy's **Community Solar Business Case Tool**.[51]

The total installed costs and performance assumptions are based on the ground-mount and canopy systems modeled in the Clean Energy States Alliance Vermont Solar Cost Study.[52] The Vermont study provides cost estimates for 100 kW, 500 kW, and 2 MW ground-mount systems and a 100 kW canopy system. As shown in Exhibit A1, to determine the cost of the 1 MW ground-mount system, the $/W costs of the 500 kW and 2 MW ground-mount systems were averaged (note that the resulting value of $2.08/W is similar to the average $2/W reported in the **LBNL Tracking the Sun report, Figure 31, Large Non-Residential, Ground-Mounted & Fixed-Tilt**).[53] We assume that the economies of scale for the canopy system mirror those of the ground-mount system to determine a 1 MW solar canopy cost of $2.81/W. This approximation aligns with anecdotal evidence that indicates solar canopies increase costs by about 33% over a typical ground-mount system.[54]

Exhibit A1 **Installed Costs of Ground-Mount and Canopy PV Systems by System Size**

Size (MW)	Ground-mount VT price ($/W)	Canopy VT price ($/W)
0.1	2.28*	3.01*
0.5	2.17*	2.9**
1	2.08***	2.81***
2	1.91*	2.64**

**Costs from Vermont Solar Cost Study, **Calculated to have the same economies of scale as the ground-mount system in VT, ***1 MW cost calculated assuming linear economies of scale between 0.5 and 2 MW*

Source: **CleanEnergy States Alliance, *Vermont Solar Cost Study***

Exhibits A2, A3, and A4 show additional assumptions used in the two financial models. All assumptions except installation cost were identical across the ground-mount and canopy financial models (note that the "Installation Type" was changed to "Ground Mount" for the ground-mount system).

Exhibit A2 **Baseline Information for Financial Model Assumptions**

System owner financials	
Business model	Panel leasing
Monthly panel lease price	$4.80
Project information	
City	Montpelier
State	Vermont
System size—DC (gross kW)	1,000
Panel size (W)	300
Installation type	Ground mount
Ownership entity	Non-tax-exempt entity
Panels per subscriber	8
Years to full subscription	1

Exhibit A3 Financial Model Assumptions

Community solar program assumptions	
System life (years)	25
% of system subscribed by anchor	40%
Annual subscriber retirement	1.5%
Panel price/lease escalator	0%
Solar project financial metrics	
Annual energy & demand cost increase	2.9%
Subscriber NPV discount rate	10%
Developer NPV discount rate	8%
Solar project financing options	
Percent of costs financed	0%
Interest rate	8%
Financing term (years)	5
Photovoltaic system technical assumptions	
Capacity factor	0.131
System losses	14%
Inverter efficiency	96%
Annual power production (kWh per kW)	1,150 kWh
Annual derate (%)	0.5%
Number of panels	3,333

Exhibit A4 **Incentive and Cost Assumptions**

Incentive assumptions		
Federal investment tax credit (ITC)	% of qualified costs	22%
State/local generation incentives (if applicable)	$/kWh	$0.00
State/local capacity subsidy (if applicable)	$/Watt	$0.00
State/local lump sum incentive (if applicable)	$	$0.00
Subscriber subsidy	$/panel/month	$0.00
Solar renewable energy credit (SREC) value	$/SREC (MWh)	$0.00
SREC lifetime	Years	15
SREC payout schedule	Years	5
Tax rate for MACRs depreciation	%	26%
Salvage value	% of system cost	0%
Administrative & transactional cost assumptions		
Subscriber acquisition difficulty	N/A	Moderate
Labor rate for acquisition activities	$	$50
Labor rate escalator	%	3%
Up-front billing software costs	5	0
Ongoing billing software licensing costs	$/year	0

Resilience (Parking Canopy Only)

Exhibit A5 lists assumptions used to determine the cost-optimal battery size and associated costs to provide resilience for the example hospital. The battery sizing optimization was completed using NREL's **REopt**, with the solar PV system size fixed at 1 MW. All financial assumptions utilized in the Community Solar Business Case Tool (in the exhibits above) were also used when in the REopt analysis.

Exhibit A5 **Assumptions Used to Determine Battery and Microgrid Technology Sizing and Costs**

Assumptions	Data input	Notes
Annual electrical load (kWh)	8,425,063	DOE commercial reference building model default for a hospital in VT's climate zone.[55]
Critical load factor (%)	15%	The percentage of typical load that must be met during a grid outage. Assuming central lighting, outlets, refrigeration, and fans will be powered.
Duration of design outage (hrs)	8	A mid-length outage that could have significant impacts on hospital operations.
Outage start date and time	July 13, 5:00 p.m.	Auto-populated by REopt with the date and time of the max load of the critical load profile.
Type of outage event	Typical (annual)	
Battery energy capacity cost ($/kWh)	$372	Source: 2018 Li-Ion Battery. DOE, Storage-Cost and Performance Characterization.[56]
Battery power capacity cost ($/kW)	$388	Source: 2018 Li-Ion Battery. DOE, Storage-Cost and Performance Characterization.[57]
Energy capacity replacement year	Never during PV lifetime	Assuming the battery and inverters do not need to be replaced, because they will only be used during grid outages.
Power capacity replacement year	Never during PV lifetime	Assuming the battery and inverters do not need to be replaced, because they will only be used during grid outages.

Exhibit A6 lists the results of the REopt battery sizing optimization, along with the associated battery and microgrid technology costs.

Exhibit A6 REopt Results and Associated Costs to Ensure Resiliency

Assumptions	Data input	Notes
Battery capacity (kWh)	1,282	REopt optimal given defined outage.
Battery power (kW)	150	REopt optimal given defined outage.
Average resiliency (hours)	7	The average amount of time that the system can sustain the critical load across all possible outages throughout a year.
Net CapEx (with battery, after tax & incentives)	$2,043,513	REopt result. Initial cost (after incentives); PV + battery system capital cost, without islanding technology.
Net CapEx + replacement + O&M (with battery, after tax & incentives)	$2,194,377	REopt result. The installed system cost, including the capital cost of the system (after tax and incentives) and the present value of future O&M costs for the system.
Net CapEx + replacement + O&M (without battery, after tax & incentives)	$1,788,029	REopt result for only 1 MW PV system.
Total lifetime battery costs (after tax & incentives)	$406,348	Battery net CapEx + replacement + O&M (net CapEx with battery minus net CapEx without battery).
Microgrid upgrade cost (% of capital cost)	12%	Additional equipment such as an automatic transfer switch, critical load panel, and a smart inverter may need to be installed to ensure the system can safely operate during a grid outage. Anecdotal evidence shows that this cost can range from 10% to 50% of the non-islandable PV and storage cost. The analysis of 21 scenarios determined an average maximum allowable cost to island (the cost that balances avoided outage costs and added microgrid costs) to be 12% of the non-islandable costs.
Microgrid upgrade cost ($)	$245,221.56	12% non-islandable system capital cost (already discounted).

Covered Parking (Parking Canopy Only)

Exhibit A7 shows the assumptions made to determine the additional annual revenue that can be obtained by charging for covered parking under the solar parking canopy.

Exhibit A7 **Assumptions Used to Determine Annual Revenue from Covered Parking**

Assumptions	Data input	Notes
Parking revenue ($/space/month)	$10.00	Estimate based on authors' experience. Does not escalate over time.
Size of canopy (sf)	67,610	Average* of three 1 MW commercial solar carport systems.
Size of standard parking space (sf)	171	9 ft x 19 ft.
Number of covered spaces	389	Assuming 1,000 sf of buffer (subtracted 100 sf size of canopy).
Annual revenue from covered parking ($)	$46,680	Annual revenue.

**Average based on information from Solar Electric Supply, Inc. (https://www.solarelectricsupply.com/commercial-solar-systems/solar-carport)*

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