Making It Happen: On-Site Renewable Energy and Storage Challenges and Solutions for Commercial Buildings

Preprint

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Making It Happen: On-Site Renewable Energy and Storage Challenges and Solutions for Commercial Buildings

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ABSTRACT

The U.S. Department of Energy's (DOE's) Better Climate Challenge invites organizations to partner with DOE to set ambitious, portfolio-wide greenhouse gas (GHG) emissions reduction goals. To better understand the barriers to these goals and to demonstrate successful emissions reduction pathways, organizations can access working groups as one form of technical assistance from leading experts.

One working group focus was the use of on-site renewable energy and storage—a key decarbonization strategy after energy efficiency. Members of the Better Climate Challenge on-site renewable energy and storage working group first identified barriers to implementing these technologies. Solutions were then brainstormed to support portfolio building owners to move from single systems to widespread implementation. Example insights include improving understandings of installation processes and location decisions, making the business case to relevant stakeholders, discussing unanticipated challenges throughout the process, and replicating these technologies across portfolios. This paper details valuable market feedback and highlights pathways to move toward widespread deployment of renewable energy and storage solutions.

Background

The U.S. Department of Energy's (DOE's) Better Buildings Initiative is a voluntary, private-public partnership program with the mission to catalyze leadership and accelerate adoption and investment in energy efficiency and emission reduction technologies and practices across the market economy. One of the program areas within the Better Buildings Initiative is the Better Climate Challenge. The Better Climate Challenge launched in 2022, specifically focusing on accelerating the reduction of GHG emissions. The challenge engages building owners and operators—referred to as partners. To date, more than 200 partners have committed to the ambitious goal of reducing scope 1 and 2 GHG emissions by at least 50% over ten years (DOE 2023, DOE 2024a). DOE works with partners to help them identify and understand the barriers as they work toward these goals. In addition, partners share their real-world successes and scalable solutions as they develop strategies to reduce energy and emissions.

To ensure progress toward carbon reduction goals, DOE deploys several strategies including producing webinars, publishing partners' case studies in the Solution Center on the DOE Better Buildings website, hosting peer-to-peer exchanges and an annual conference, and supporting working groups. In working groups, partners actively participate and learn from each other, gathering information about barriers and providing useful feedback on resource development (Torcellini 2022). A working group focuses on a specific problem that participants are facing, and, works to address that problem over the course of eight months. The on-site

renewables and energy storage working group formed in response to feedback from discussion with partners in the previous year.

The working group's first task was to identify barriers by answering the question, "what is stopping commercial building owners from using on-site renewable technologies and storage now?" The group's focus was on using renewable energy and energy storage technologies in the building and on the building site. The objectives of the working group were to:

- Identify and understand technical and nontechnical challenges to deploying renewable energy and energy storage in buildings and on building sites.
- Provide information and resources to overcome these challenges.
- Share successes and lessons learned.

The working group:

- Facilitates peer-to-peer information exchange by sharing insights as partners planned and executed on-site renewable and energy storage projects.
- Highlights the importance and impact of improving building energy efficiency measures on maximizing generation.
- Identifies internal and external stakeholders needed to implement on-site renewables and energy storage.
- Identifies strategies and successes by highlighting success stories.
- Develops technical resources to guide on-site renewable and energy storage implementation. This outcome could take the form of webinars, case studies, technical and information briefs, documentation of barriers, or an implementation guide.

This working group was made up of large portfolio owners that own and operate with multiple buildings. The working group hosted 40 unique partners across 10 different sectors, including:

- Higher education
- Commercial real estate
- Multifamily housing
- K-12 schools
- Local governments
- Healthcare
- Data centers
- Retail, food service, and grocery
- State government
- Hospitality.

The topics of discussion included an in-depth review of solar photovoltaic (PV) technologies, partner presentations on their experiences with solar PV technologies, a detailed review of other renewable energy technologies, an in-depth review of battery and thermal energy storage technologies, and discussion of working group deliverables (Table 1).

Table 1. Working group timeline and covered topics

Meeting Number	Meeting topic
1	Overview of working group (WG) objectives and barrier identification
2	Deep dive into solar PV
3	Partner presentations with lessons learned from PV projects
4	Deep dive into other renewable energy technologies
5	Deep dive into storage and discussion on WG deliverables
6	Deep dive into thermal energy storage & feedback session on WG deliverables
7	WG summary and next steps

Information Collection

On-Site Renewables – Solar Photovoltaics

Participants in this working group were self-selecting from the Better Climate Challenge partners. There were nearly 40 partners that opted in to participate in the working group. All sessions were virtual. In the first session, researchers asked participants questions about their experiences and challenges with on-site renewables.

Most participants indicated some experience with on-site renewables and the desire to expand their current on-site renewables. Very few participants had no on-site renewable energy systems experience, and a few participants did not yet have on-site renewables but installing them was part of their organization's decarbonization plan.

When asked about significant barriers, participants cited several barriers to on-site renewables:

- Cost, budget, financing, making a business case
- Utility interconnection processes
- Timing of installation
- Request for proposal (RFP) and contracting processes; liability concerns
- Equipment lead times, supply chain, reliable vendors
- Existing site conditions and locations for on-site renewables
- Long-term maintenance.

Partners described experience using various solar PV location strategies. These include solar PV panels on building rooftops; on top of shade structures, canopies, or carports; and ground-mounted PV panels on nearby land.

Organizations have various goals that inform on-site solar PV strategies. Some examples of these goals include deploying PV panels on-site where possible, and adding panels to 100% of the rooftop space, and/or 100% of parking lot coverage. Partners shared additional goals, including using power purchase agreements (PPAs) to finance on-site renewables. In this strategy, the partner agrees to pay a third party for the power generated from the on-site renewables, often at a rate lower than conventional grid power.

Several barriers to achieving partner goals related to PV include:

- Cost of panels and infrastructure, poor payback time of PV panels, varying budget priorities
- Increased cost of financing with higher interest rates impacting PPA rates as well as traditional financing
- Inexperience in procuring and using PV panels
- In-house project management
- Utility relationships
- Practicality of on-site PV, including available space
- Finding project champions within organizations
- Complex procurement structures.

Partners discussed the types of information needed to address these barriers, including available financing options and guidance on how to evaluate different system and panel options. Partners also expressed interest in exploring best practices for PV panels site selection and ideal arrangements of panels on-site. Technical information to determine PV array size, which includes factors such as solar incident radiation, feeder maps, electric load studies, and building load information, is crucial to support partners in this PV sizing decision process. Finally, partners need sound financial information to address financial challenges and make the PV project a reality. This information includes the unit cost of panels and arrays, information on how to leverage government incentives and funding (e.g., Inflation Reduction Act [IRA] funding), example PPA rates by region, and example PPA forms that could be used to start negotiations.

Partners who successfully installed PV panels on-site shared information and best practices on making the business case. These best practices include using IRA and other tax incentives, sharing the pre- and post-tax internal rate of return, demonstrating the payback period of the PV panels and array within ten years, and also working with a known and trusted PPA partner.

Partners also discussed concerns with on-site PV renewable generation. Some of those concerns include operating and maintaining PV arrays to maximize their use and end of life considerations for panels. Relatedly, partners shared concerns about consistent panel value over time. As prices increase and supply issues arise, PV strategies can become more challenging to deploy. Considerations related to the duration of PV array installations and replacement costs when damage occurs have also impacted partners' PV experiences. Finally, partners shared concerns about weather damage (e.g., hail) to panels, and the eventual change of technologies that might require an overhaul of the system should certain technologies become obsolete, resulting in increased costs and longer payback periods.

Beyond concerns, partners shared an interest in additional topics related to on-site PV technologies. Some of those areas include guidance in handling utility connections; life cycle cost analysis; case studies on large-scale off-site PV; PPAs for smaller buyers; the role of energy storage in conjunction with PV; integrated PV with building management systems; the business case for large energy users; issues with existing PV contracting, installation, or operations; and PV recycling options. Due to the intensive process to conceive and successfully deploy solar technologies, partners also shared an interest in guidance to make buildings PV-ready to facilitate more seamless on-site PV additions.

Although most partners had experience with PV technologies at a single site, a lot of partners sought advice on scaling the technology to more facilities.

Additional On-Site Renewables

Within working group sessions, partners also indicated interest in additional renewable energy technologies beyond PV, such as urban wind turbines, natural gas entrainment, renewable hydrogen, and recovered landfill gas. Although participants shared high-level information on these topics from industry experts, fewer partners had direct experiences with these technologies. In some rare cases, partners could use on-site wind generation, but it is limited by geographic locations and equipment size. Some partners expressed interest in procuring renewable natural gas through recovered landfill gas, but this is considered off-site and outside the boundaries of this working group.

On-Site Energy Storage

On-site storage can store electricity, fuel, or thermal energy for later use. On-site storage such as battery or thermal storage pairs well with PV and can store clean energy during peak production for later use. It can also reduce peak energy consumption and provide resilience during power outages. Working group participants cited a range of experiences and challenges with on-site energy storage deployment.

Few partners currently use on-site storage, which led to robust discussion about why partners did not use energy storage. Some mentioned barriers to on-site storage, including the knowledge gap of technical requirements for successful on-site storage connection, limited available options, and unclear utility requirements. Partners also cited the challenge of obtaining buy-in from the appropriate internal stakeholder and the lack of demand from building operators. These discussions indicated that more information on the benefits of energy storage as well as examples of successful projects would help boost market adoption. Additional challenges included cost determination, payback time awareness, viability and safety, space requirements, maintenance, lack of financial incentives, insurance underwriters' concerns, and slow utility feedback.

However, some partners do have some experience with energy storage or demand response strategies. These experiences consist of fuel availability for on-site generators, thermal energy storage (for example, tanks for domestic hot water supply systems), some battery storage systems, manually controlled demand response, and some demand response agreements with the local utility to adjust set points (for example, turning off unused elevators during peak hours).

Many partners have not formally established energy storage-specific goals. Organizations tend to prioritize other decarbonization or electrification goals that include on-site PV and the return on investment for those technologies. Some partners are considering energy storage for resilience purposes and benefits.

As partners look to set future goals, organizations need information to guide the process. For example, information on diesel fuel alternatives for generators (including costs, longevity, and maintenance issues), simple estimation tools for determining costs and space requirements for energy storage, and strategies to address structural concerns (weight) for including batteries on-site. Partners did not share specifics on making the business case for storage and did not have case studies using storage or demand response. Many are not aware of strategies that use storage to reduce carbon footprints, such as aligning energy storage with grid carbon intensities. Some were aware of using storage to better align with demand charges based on rate structures.

Partners also discussed several concerns with on-site energy storage. These included decommissioning energy storage systems and end of life best practices for batteries and other

energy storage devices. Partners also had concerns about the physical space constraints for batteries if they are meant to shift a significant portion of the building load. Permitting, replacement cost, maintenance, and reliability were unknown factors for partners. Comparing the cost of batteries in relation to their capacity and to that of fossil fuel generators would help partners present a compelling business case to relevant stakeholders. Finally, partners identified the software support that may be required for on-site energy storage and the possibility of vendors going out of business as concerns.

Solutions

After identifying barriers preventing partners from installing and using on-site renewable energy and energy storage, solutions were proposed jointly by working group participants and national lab experts. Interestingly, even though solar PV installation costs are decreasing (Feldman et al. 2021) and energy storage offers coupled resilience benefits, renewable energy and storage systems are not yet widespread at building sites. This is especially notable as numerous state and federal government agencies offer multiple incentives to encourage adoption. Therefore, it is crucial to analyze the barriers cited to market adoption to address gaps in knowledge and resource development. Table 2 summarizes the key challenges and proposed solutions for helping partners address these challenges by specific technology group.

Table 2. Key challenges and proposed solutions by technology type

Technology	Challenges	Potential Solutions
Photovoltaics	Unclear Policies	Updated resources on federal and state-level policies
	Unclear Economics	Resources showing an effective utility rate after installation and life cycle cost using incentive and tax programs
	Utility Barriers	Resources on how to navigate utility requirements
	Issues with Monitoring Multiple Sites	Case studies focused on solar PV monitoring including building automation systems or other systems
Other Renewables	Reliability	Case studies of other renewables as part of a resilience strategy
	Unclear Economics	Resources showing an effective utility rate after installation and life cycle cost using incentive and tax programs
	Unclear Costs Compared to Solar	Cost comparisons between other renewables and PV
	Procurement Challenges	Resources on how to procure and use other renewables outside of solar (i.e., wind, geothermal, hydrogen, etc.)
Battery Storage	Cost Challenges	Resources showing economic breakdowns of installing battery storage with PV and other renewables
	Regulatory Challenges	Resources on regulations related to installing battery storage
	Lack of Tools for Scoping Projects	Screening and estimating resources for understanding size requirements and cost
	Lack of Understanding to Engage with Contractors	Resources on how to engage with third parties to investigate and install battery storage
	Lack of Real-World Examples	Case studies on successful battery installations

In order to address some of these challenges, researchers are developing a series of resources to address the multiple stages that can lead to successful renewables and storage deployment. One particular resource guide was developed to support partners on one of the first, prevalent challenges shared by building owners—the ability to assemble an effective team to streamline the implementation of these renewable energy and storage systems (DOE 2024b). The content in this guide is discussed below.

The guide focuses on three topics. The first outlines common roles in renewable energy and storage projects. Specific skill sets are required for different phases of the project:

- Design phase: In this phase, skills such as visioning; leadership; project management; building expertise; contract management; knowledge of regulations including local permitting jurisdiction; understanding of local utilities; knowledge of incentives and finances; and technical knowledge of renewable generation, storage systems, and site evaluation systems are necessary to procure informed designs.
- Installation phase: Procurement and construction management skill sets are required, along with knowledge of how to install and commission systems.
- Operational phase: Experience in maintaining and operating systems is essential.

The second topic assists in identifying individuals with the required skill sets to fill these roles, both internally and externally.

The final topic highlights other project considerations. These projects require clear communication. For instance, although the visioning and planning group determines the project scope, flexibility is crucial to accommodate inputs from the regulations and financial incentives team members and facilitate smooth deployment.

It is important to remember that operation and maintenance will require skilled staff on-site, which may necessitate training new and existing staff or hiring a qualified contractor. Projects involving storage may pose additional operational and maintenance complications due to additional equipment and controls.

Utilities may exert varying levels of ownership over on-site renewable energy and storage projects, and depending on the utility or project size, there may be more restrictive requirements for contractors involved, such as certification, installation requirements, or system size. The financing structure will also impact how the renewable energy project is managed.

Direct ownership models are most useful for smaller systems or organizations with multiple resources that can better manage the financial risk of owning assets. Indirect ownership models, such as power purchase agreements, equipment leases, building roof leases, and hosting community solar projects, are suitable for organizations with limited resources, but they can complicate project contract management due to ownership clauses of the solar installed on-site that can restrict other work near or around the equipment.

Conclusion

The use of on-site renewable energy and storage is a key part of decarbonizing our built environment. DOE, through the Better Buildings Initiative and the Better Climate Challenge, has prioritized the understanding of barriers to enable this key decarbonization strategy. The hope is that the working group will demonstrate successful examples and provide strategies to overcome barriers. This paper summarizes the findings from the on-site renewable energy and storage working group, consisting of leading organizations that have committed to ambitious decarbonization goals. We report that the most common on-site renewable energy technology deployed to date by partners in the working group is solar PV panels. Despite its prevalence, there are still many challenges to procuring and installing more panels. We also report that there

are barriers to employing other on-site renewable energy technologies and energy storage. To address some of these barriers, we provide guidance on one of the crucial parts of deploying these technologies—assembling the right team of stakeholders and players to facilitate more on-site renewable energy and storage technologies.

Additionally, this work demonstrates the value of the working group model, allowing participants to interact with one another in order to gain market momentum. The working group model allows for peer exchange of challenges and successes, information gathering related to barriers to success, case study development, and feedback on guidance documents that aim to address the barriers.

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