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OPTIMIZING ENERGY RESILIENCE

To Support Medically Vulnerable Residents in Multifamily Affordable Housing

Clean Energy Group

Marriele Mango, Senior Project Director
Anna Adamsson, Project Manager

ABOUT THIS REPORT

This report, prepared by Clean Energy Group with American Microgrid Solutions, documents the technical assistance results of the Climate Smart Technologies and Home Medical Devices for Affordable Housing initiative, an effort co-funded by the Robert Wood Johnson Foundation and Connecticut Green Bank, led in partnership with Connecticut Insurance Department, Operation Fuel, and the Yale Center on Climate Change and Health. This report overviews opportunities for resilient power—solar PV paired with battery storage (solar+storage)—to support electricity-dependent, medically vulnerable residents of multifamily affordable housing in the event of a power outage.

The focus of this report is an analysis of three case studies of multifamily affordable housing facilities in Connecticut. Each case study includes a technoeconomic assessment of three different resilient power scenarios, each tailored to support residents who are dependent on medical devices that require electricity in the event of an outage. The analysis highlights the economic impact of Connecticut's supportive clean energy policies on solar+storage development at multifamily affordable housing properties. The report concludes with key findings from the analysis and recommendations related to developing programs and policies that recognize solar+storage at affordable housing as necessary to public health in the event of an outage.

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Contents

Executive Summary

Over nine million people live in subsidized housing in the United States, almost 150,000 of whom are in Connecticut.[1,2] Beyond offering safe and secure housing, affordable housing providers can support residents with comprehensive services like assisted care and community-focused programming. Some provide their residents with basic preparedness information for emergencies, like evacuation plans. Planning for emergency situations can be vital, especially for residents reliant on electricity for home medical devices, including electric wheelchairs, oxygen concentrators, and refrigeration for temperature-regulated medication. In fact, as severe weather continues to result in catastrophic public health impacts, more states are requiring institutionalized residential health care facilities (such as nursing homes) to invest in reliable backup power to avoid a crisis in the event of a power outage.

Despite their essential role in supporting vulnerable populations, affordable housing providers have limited access to programs that advance the development and affordability of backup power resources. Even fewer programs exist that encourage adoption of renewable and resilient powers systems—solar paired with battery storage (solar+storage). For the millions of individuals who rely on electricity-dependent home medical devices, many of whom live in affordable housing, the lack of access to reliable backup power can be life threatening. To meet these challenges, affordable housing providers need tailored clean energy policies and programs that will enable them to explore and invest in solar and battery storage technologies.

This report, a product of the Climate Smart Technologies and Home Medical Devices for Affordable Housing initiative through the Robert Wood Johnson Foundation and Connecticut Green Bank, underlines an indisputable link between energy security and public health. Without access to reliable, local, and easily accessible back-up power, the most vulnerable residents—including low-income and medically vulnerable residents—will face disproportionately severe health impacts in the event of an outage. This report advocates for solar+storage as 1) an energy resilience resource for vulnerable affordable housing residents and 2) an energy resource to generate revenue for the housing provider and reduce the energy burden of residents.[3]

1 "How many people live in subsidized housing in the United States," *usafacts.org*, https://usafacts.org/answers/how-many-people-live-in-subsidized-housing/country/united-states (accessed January 27, 2025).

2 "How many people live in subsidized housing in Connecticut," *usafacts.org*, https://usafacts.org/answers/how-many-people-live-in-subsidized-housing/state/connecticut (accessed January 27, 2025).

3 Energy burden is the percent of median annual income that households pay for electricity and gas bills. To learn more about energy burdens, visit: https://www.nrdc.org/bio/maria-correa/resource-energy-burdened-communities.

Photo: iStockphoto.com/_human

The focus of this report is an analysis that examines the technological, economic, and resilience outcomes of three solar+storage scenarios at three differently sized affordable housing facilities in Connecticut: small (6 to 20 units), medium (21 to 75 units), and large (over 75 units). The analysis was designed to evaluate opportunities for solar+storage at multifamily affordable housing (MFAH) to support the unique needs of electricity-dependent, medically vulnerable residents in the event of an outage. The solar and battery storage incentives available in the State of Connecticut provide a distinctly supportive economic landscape for solar+storage adoption at MFAH facilities and are incorporated into the analysis.[4]

Findings of the analysis include the following.

1. Incentives that Value Resilience Could Support Improved Health Outcomes in the Event of an Outage

By incentivizing and improving the project economics of a larger battery storage system, Connecticut's battery storage incentive program (Energy Storage Solutions) supports multi-family affordable housing providers by enabling greater energy resilience for electricity-dependent, medically vulnerable residents in the event of a power outage. This analysis found that, in some instances, maximizing (or approaching) the incentive limit resulted in projects that could support a notably larger battery without considerably higher costs.

4 For the purpose of this report, MFAH is defined as facilities containing at least six units of housing.

2. Comprehensive Incentive Programs Include Technical Assistance

Tailored technical assistance provided valuable insights into developing solar and battery storage solutions for MFAH providers. Providers also gained internal capacity through the technical assistance process, including the in-house knowledge necessary to consider resilient power applications beyond this effort and throughout their housing portfolios.

3. Larger Facilities Benefit from Economies of Scale for Battery Storage; Smaller Facilities Encounter More Challenges

Larger facilities supported better solar+storage economics due, in large part, to a higher maximum incentive threshold and the ability to achieve economies of scale through building a larger battery system. Smaller facilities resulted in less favorable solar+storage economics, with project complexities and barriers to economic feasibility increasing as the facility size (measured in housing units) decreased.

4. In-Unit Resilience Can Be a Cost-Competitive Option for Multifamily Affordable Housing Providers, and the Preferred Energy Resilience Solution for Residents

Resident engagement efforts, led by Yale and Operation Fuel, found many MFAH residents reliant on electricity for home medical devices would prefer to have in-unit backup power available, for privacy, comfort, and safety reasons. However, the battery storage required to support in-unit resilience is considerable and costly. This analysis finds that, by incentivizing resilience through battery storage incentives like Energy Storage Solutions, providers can develop solar+storage systems that support in-unit resilience (in this case, an outlet in each unit), without sacrificing project economics.

Project Partners

Connecticut Insurance Department is a state agency committed to ensuring insurance companies follow the state's laws and treat customers fairly. Connecticut Insurance Department offers guidance, support, and education, and regulates the industry in a way that promotes fair competition and ensures insurance availability.[5] https://portal.ct.gov

The Connecticut Green Bank (Green Bank) was established in 2011 through Public Act 11-80 as a quasi-public corporation. As the nation's first state-level green bank, the Green Bank makes clean energy and environmental infrastructure more accessible and affordable for Connecticut citizens and businesses by creating a thriving marketplace to accelerate the growth of a green economy. The Green Bank facilitates clean energy and environmental infrastructure deployment by leveraging a public-private financing model that uses limited public dollars to attract private capital investments.[6] https://www.ctgreenbank.com

Clean Energy Group (CEG) is a national nonprofit organization that works at the forefront of clean energy innovation to enable a just energy transition to address the urgency of the climate crisis. Founded in 1998, CEG has been a thought leader on effective climate strategies for more than two decades. CEG provides innovative technical, economic and policy solutions to enable communities to participate equitably in the clean energy transition, including through its Resilient Power Project, Technical Assistance Fund, and Health and Energy Security initiatives.[7] https://www.cleanegroup.org

5 "Home," *CT Insurance Department*, https://portal.ct.gov/cid?language=en_US (accessed January 27, 2025).

6 "Comprehensive Plan: Fiscal Years 2023 through 2025," *Connecticut Green Bank*, January 2025 (revised), https://www.ctgreenbank.com/wp-content/uploads/2025/01/9_Comprehensive-Plan_FY-2025_Revisions_011725.pdf.

7 "Vision & Mission," *Clean Energy Group*, https://www.cleanegroup.org/vision-mission (accessed January 27, 2025).

AMERICAN MICROGRID SOLUTIONS

American Microgrid Solutions (AMS) is a nationwide developer for hybrid power systems that improve security, savings, and sustainability for a wide range of facilities including health clinics, multifamily affordable housing facilities, and other C&I properties. AMS is a leading developer of Resilience Hubs—community-serving facilities augmented to support residents and coordinate resource distribution and services before, during, or after a natural hazard event—and provides end-to-end solutions that empower communities with energy autonomy and resilience.
https://www.americanmicrogridsolutions.com

OPERATION FUEL power for good

Operation Fuel was founded to provide relief for residents who fell through the gaps of government assistance programs. Its mission includes ensuring Connecticut residents can access affordable heat, energy, and water and can feel heard when expressing their energy needs. Operation Fuel works to improve the health and economic wellbeing of all people in Connecticut by seeking to reduce their energy burden.[8] https://operationfuel.org

Yale Center on Climate Change and Health

The Yale Center on Climate Change and Health, within the Yale School of Public Health (Yale), utilizes research, education, and public health practice to help safeguard the health of human populations from adverse impacts of climate change and human activities that cause climate change. The Center works to advance innovative research to address public health concerns and challenges, including topics related to climate change, food insecurity, and air pollution.[9] https://ysph.yale.edu/yale-center-on-climate-change-and-health

8 "Our Mission," *Operation Fuel*, https://operationfuel.org/about/mission-history (accessed January 27, 2025).

9 "A Public Health Response to a Changing Climate," *Yale Public School of Health*, https://publichealth.yale.edu/climate (accessed January 27, 2025).

Introduction

Advances in health care have resulted in more people being able to receive home-based health care, as opposed to in an institutional setting, than ever before. Medical technology innovations like telehealth, online medical records, portable medical equipment, and self-administered medications have changed how health care is delivered and have allowed medically vulnerable individuals to reap the emotional and physical benefits of receiving their health care at home. At least three million Medicare beneficiaries rely on electricity-dependent home medical devices (HMD) as part of their home health care plan.[10] Of that total, over 22,000 live in Connecticut. For this population, a power outage can be an emergency and, in some cases, a life-threatening event.

Despite this risk, the rise in home health care availability and popularity has not resulted in insurance-supported or updated regulations related to backup power support for electricity-dependent patients living at home. In fact, whereas hospitals and select housing institutions, such as certain types of nursing homes, are required to have a reliable source of backup power, there are no similar mandates for electricity-dependent home health care patients.[11] Backup power requirements do not extend to affordable housing, which can include senior housing and assisted living facilities with significant populations dependent on electricity for HMDs. While certain HMDs may have integrated battery backup, many do not and will fail to operate without an active electrical outlet to plug into.

The dangers posed by power outages to medically vulnerable, electricity-dependent populations are increasingly well documented. In Florida, after Hurricane Irma in 2017, 14 nursing home residents died from heat exposure, with potentially hundreds more dying from power outage-related complications in the months following the hurricane.[12] While elderly populations are particularly vulnerable, all ages can face fatal consequences when the power goes out. After the 2021 Texas winter ice storm, extreme cold temperatures combined with a days-long power outage resulted in at least 250 deaths from hypothermia and related complications in the months following. Some studies suggest that 250 may be too low an estimate and that the storm resulted in closer to 700 or even 800 fatalities.[13]

10 "HHS emPOWER Map," *empowerprogram.hhs.gov*, https://empowerprogram.hhs.gov/empowermap (accessed January 27, 2025).

11 "Categorical Waiver—Health Care Microgrid Systems (HCMSs)," *Department of Health & Human Services, Centers for Medicare & Medicaid Services*, March 31, 2023, https://www.cms.gov/files/document/qso-23-11-lsc.pdf.

12 David M Dosa, Julianne Skarha, et al., "Association Between Exposure to Hurricane Irma and Mortality and Hospitalization in Florida Nursing Home Residents," *JAMA Network Open*, October 6, 2020, https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2771392.

13 Mose Buchele, "One year later, many question the 'official' number of deaths linked to the Texas blackout," *kut.org*, February 15, 2020, https://www.kut.org/energy-environment/2022-02-15/one-year-later-many-question-the-official-number-of-deaths-linked-to-the-texas-blackout.

While heating and cooling hasn't typically been viewed as "home medical equipment," it is increasingly necessary to ensure the safety of vulnerable individuals during periods of extreme heat and cold.

Resilient power technologies—solar paired with battery storage (solar+storage)—can help to reduce medical emergencies and loss of life in the event of a power outage by providing reliable and renewable backup power to electricity-dependent HMDs. Solar+storage can also support the equipment necessary to maintain a safe indoor temperature, including heating and cooling systems, fans, window air conditioning units, and space heaters.[14]

There remain hurdles for multifamily affordable housing (MFAH) providers in accessing solar+storage technologies, with economic barriers being a primary challenge. Federal, utility, and state incentive programs can improve the economic feasibility of solar+storage systems. For providers working to ensure resident safety in the event of an outage but operating on a shoe-string budget, these incentives can be paramount to achieving economic feasibility for a solar+storage project.

This report outlines the efforts of and analysis resulting from the solar+storage technical assistance and development process conducted through the Climate Smart Technology and Home Medical Devices for Affordable Housing project (Climate Smart Technologies), a Robert Wood Johnson Foundation and Connecticut Green Bank supported effort to evaluate the investment needed in climate smart technologies, including solar+storage, to support medically vulnerable, electricity-dependent MFAH residents. Climate Smart Technologies was a multi-year collaborative effort involving the Connecticut Green Bank, Clean Energy Group, American Microgrid Solutions, Operation Fuel, the Connecticut Insurance Department, and the Yale Center on Climate Change and Health. This report focuses on the results of the solar+storage technical assistance and analysis portion of Climate Smart Technologies.

14 Marriele Mango and Annie Shapiro, "Home Health Care In The Dark," June 2019, https://www.cleanegroup.org/wp-content/uploads/Home-Health-Care-in-the-Dark.pdf.

Supporting Resident Health Through Energy Resilience

Climate Smart Technologies and Home Medical Devices

The goal of Climate Smart Technologies was to better understand and address, through solar+storage solutions, the specific concerns and needs of electricity-dependent HMD users in the event of an outage. This report uses the definition of HMD as electricity-reliant medical equipment that empower independent living or are necessary for living with a medical condition.[15] This includes but is not limited to life-support equipment (such as dialysis machines and ventilators) and technologies for independent living (such as electric wheelchairs, refrigeration for medicine, and stable indoor temperatures).

For the purposes of Climate Smart Technologies, the definition of HMD is intentionally broad in scope and includes any electricity-dependent equipment that supports the home health care needs of individuals. A wide range of medical technologies can be included within this definition, from oxygen concentrators to refrigeration for temperature-regulated medication to building heating and cooling systems. The broad scope of Climate Smart Technologies recognizes that the United States is increasingly moving to a home-based health care model where individuals rely on electricity for multiple HMDs as well as for services necessary to coordinate day-to-day care and health management, like the internet. For example, an individual may depend on an oxygen concentrator, a refrigerator for insulin medications, and the internet to update their doctor as to their oxygen and blood sugar levels. Without backup power to all three devices, their health needs would not be fully supported in the event of an outage.[16]

While energy resilience for medically vulnerable populations was a central focus of Climate Smart Technologies, the effort also recognized that solar+storage provides value, not just during a power outage but also during regular grid operations. Solar+storage can reduce energy burdens by offsetting utility costs (resulting in electric bill savings) and generating revenue through grid services. The cost savings can be significant: Connecticut has the fourth highest electricity bills in the United States, with the average monthly

15 This report utilizes the definition of 'home medical device' as defined by the Yale School of Public Health in their report, "Emerging Public Health Needs for Climate Smart Technology in Connecticut Affordable Housing." This report presents the findings of the resident engagement piece of the Climate Smart Technologies effort, and can be found here: https://www.cleanegroup.org/publication/emerging-public-health-needs-for-climate-smart-technology-in-connecticut-affordable-housing.

16 While solar+storage solutions can support a wide variety and combination of critical loads, including those that support HMDs, it (like any technology) has limits. Patients of in-home hospital units, for instance, may require a load too high to be supported for a significant enough time by battery storage and would therefore be better equipped being served at a hospital in the event of an outage.

electric bill costing over $190 a month.[17] Electricity rates show no signs of decreasing, with one Connecticut investor-owned utility having announced a rate hike in 2024 that would result in a $30 increase to the average customer's monthly electric bill.[18] Furthermore, behind-the-meter solar+storage doesn't only benefit the facility in which it's installed. Battery storage, by providing grid services, can also contribute to improved grid reliability and reduced utility costs for all ratepayers by offsetting energy during times of peak demand.[19]

In recognition of the wide-ranging benefits of renewable and resilient energy technologies, the State of Connecticut developed solar and battery storage incentive programs to encourage more widespread adoption. MFAH providers benefit from increased tariff rates and additional incentive adders, as well as tailored finance options.[20] The economic benefits, combined with the incentives and financing, help make solar+storage a viable option for many MFAH providers in Connecticut.

In order to assess the potential for solar+storage to support MFAH residents with HMDs, Climate Smart Technologies supported solar+storage feasibility assessments for 15 MFAH properties at no-cost, totaling over 1,000 units of affordable housing.[21] Of the properties assessed, approximately two-thirds were located in a Justice40 community, a low-income community, and/or an energy community—and almost half were located in all three.[22,23] Throughout the assessment process, Clean Energy Group provided one-on-one support to MFAH providers and acted as a liaison between the provider, the Green Bank, and an energy engineer.

The Analysis Results section of this report (p. 29) is based on data compiled from solar+storage feasibility assessments conducted by Clean Energy Group at participating MFAH facilities.[24]

17 Adam McCann, "Energy Costs by State (2025)," *WalletHub*, July 1, 2024, https://wallethub.com/edu/energy-costs-by-state/4833.

18 Patrick Skahill, "CT electric rates set to jump as regulators signal approval for bill adjustments," *Connecticut Public Radio*, April 17, 2024, https://www.ctpublic.org/news/2024-04-17/eversource-ui-rate-increase-ct.

19 To learn more about opportunities for behind-the-meter battery storage to improve grid reliability and reduce utility costs for all ratepayers, see the 2021 Clean Energy Report, *Energy Storage Policy Best Practices from New England: Ten Lessons from Six States*: https://www.cleanegroup.org/publication/energy-storage-policy-best-practices-from-new-england.

20 CT Green Bank offers solar and solar+storage finance options for MFAH (to learn more about specific incentive and finance programs, see Connecticut Energy Programs on p. 17.

21 Eight MFAH providers participated in Climate Smart Technologies. As of the publication of this report, two facilities have solar+storage assessments underway but not yet completed, with an extension approved for early in 2025. To learn more about barriers that can delay solar+storage development at affordable housing, visit Appendix C (p. 47).

22 Affordable housing providers that received solar+storage assessments were recruited through outreach by Clean Energy Group, in partnership with CT Green Bank and other CT agencies.

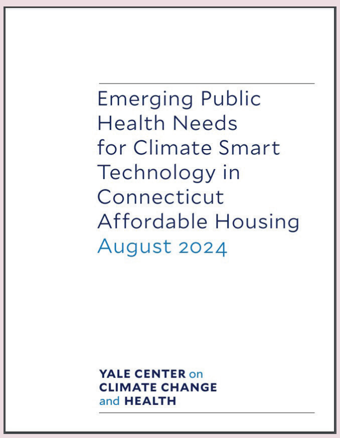
23 To learn more about what qualifies a project as a low-income or energy community, see Appendix B (p. 45).

24 This report maintains anonymity of the providers that own the properties featured in this report.

Resident Input: Focus Groups and Interviews of Home Medical Device Users

As part of Climate Smart Technologies, Operation Fuel and Yale led a comprehensive study to better understand the concerns of MFAH residents reliant on electricity-dependent HMDs when experiencing a power outage. The results of that effort were published in a 2024 report, *Emerging Public Health Needs for Climate Smart Technology in Connecticut Affordable Housing.*[25]

Evaluating the Needs of Electricity-Dependent Multifamily Affordable Housing Residents


Emerging Public Health Needs for Climate Smart Technology in Connecticut Affordable Housing
August 2024
YALE CENTER on CLIMATE CHANGE and HEALTH

Emerging Public Health Needs for Climate Smart Technology in Connecticut Affordable Housing

The report, Emerging Public Health Needs for Climate Smart Technology in Connecticut Affordable Housing, presents the results of multifamily affordable housing resident engagement led by Operation Fuel and the Yale Schools of Medicine and Public Health. Residents reliant on home medical devices provided insight as to the concerns when a power outage occurs, as well as preferences for accessing backup power.

This report was prepared by the Yale Schools of Medicine and Public Health and Operation Fuel in collaboration with the Connecticut Insurance Department, the Connecticut Green Bank, and Clean Energy Group, with funding from the Robert Wood Johnson Foundation, the Energy Storage Solutions program, and the U.S. Department of Energy's Building Technologies Office.

Through one-on-one interviews and focus groups, 94 MFAH residents reliant on HMDs were interviewed on their electricity-dependent needs, the impacts of power outages on their safety and quality of life, and their preparedness to withstand a power outage event. The following findings are based on these interviews:

- Many residents depend on multiple HMDs, including oxygen concentrators, dialysis machines, and CPAP machines.
- Most of the HMDs used by residents require an active electrical outlet to function.

25 The report, Emerging Public Health Needs for Climate Smart Technology in Connecticut Affordable Housing, can be found here: https://www.cleanegroup.org/publication/emerging-public-health-needs-for-climate-smart-technology-in-connecticut-affordable-housing.

- Residents shared feelings of fear and anxiety associated with the mental, physical, and emotional toll of preparing for and surviving a power outage. One person spoke to the anxiety caused by evacuations, in which residents' lives are "turned upside down." Another referenced how power outages can exacerbate existing mental health conditions.
- Many residents reported a lack of adequate preparedness plans for power outages, such as having a reliable source of backup power or evacuation plan. Residents reported having no knowledge of an evacuation or emergency plan through their housing provider.

While study participants agreed that power outages are potentially life threatening, mixed views were expressed on potential solutions. Key findings that impacted the analysis presented in this report include the following:

- Residents were generally open-minded to solar and battery storage technologies but expressed concerns about the cost and the lack of resident control over installation decisions.
- While most residents were receptive to the idea of having a fully functioning common space that could provide backup power services in the event of an outage, concerns were raised about privacy, comfort, and the potential for illness to spread in such close quarters.
- Some residents preferred to remain in their apartment or go to a friend or family member's house during a power outage.

These findings highlight the need for a multifaceted approach to address power outages for individuals reliant on HMDs. Clean Energy Group incorporated resident concerns into the Climate Smart Technologies technical assistance and provider education process by requiring that 1) a health rubric be completed by each housing provider, documenting the general health needs of their facility's residents, and 2) the feasibility assessment include multiple resilient power scenarios, including one that focuses on communal area backup power applications of battery storage, and one that incorporates in-unit backup power support for each apartment.[26] The health rubric and solar+storage assessment components and processes are outlined in the Solar+Storage Feasibility Assessmet section of this report (p. 24).

26 The health rubric was an aggregation of resident needs. Resident anonymity was prioritized throughout Climate Smart Technologies by all partners.

Connecticut Energy Programs

Market development for battery storage in historically marginalized communities requires incentives and finance solutions that recognize, and work to overcome, the barriers to equitable distribution of renewable and resilient energy technologies. Through the Connecticut Green Bank and partner utilities, Connecticut investor-owned utility customers, including MFAH providers, have access to solar and battery storage incentive options and, in some instances, financing.

The following incentive and finance programs are integral to the economic feasibility of solar+storage at MFAH. Each program was incorporated into all solar+storage economic scenarios evaluated through this effort.

Energy Storage Solutions

The Energy Storage Solutions Program (ESS) combines equipment rebates with performance payments to encourage new behind-the-meter battery storage installations, with significant incentive adders for installations in historically underserved communities.[27] Residential customers, including MFAH, participating in the program can qualify for up to $16,000 in upfront incentives. Customers can also receive additional semi-annual performance payments in exchange for allowing the utility to dispatch their battery during periods of high demand on the electric power grid.

To encourage adoption in historically marginalized communities, ESS offers an upfront incentive for low-income communities at $600 per kilowatt-hour of installed storage capacity, higher than the standard ESS incentive.[28] MFAH is also eligible for the $600 per kilowatt-hour rate. Underserved communities (that do not qualify for the low-income incentive) can receive a $450 per kilowatt-hour incentive.[29] Grid-edge communities, which are communities

27 Energy Storage Solutions does not require that battery storage be paired with solar, but it is a preference of the program.

28 The standard incentive rate is $250 per kilowatt-hour for the first 10 megawatts of energy storage enrolled in ESS. In the later stages of the ESS program when more than 10 megawatts of cumulative energy storage have been installed, the standard incentive rate drops to $212.50 per kilowatt-hour and $162.50 per kilowatt-hour. ESS has enrolled less than 10 megawatts to date, and thus the current rate is $250 per kilowatt hour. The upfront incentive rate for underserved and low-income residents remains constant regardless of how many megawatts of energy storage participate in ESS.

29 Underserved communities include those that are either considered a distressed municipality or are in a census block where 30 percent of the population is living below 200 percent of the federal poverty level. Learn more: "What Is an Environmental Justice Community," *Connecticut Department of Energy & Environmental Protection*, https://portal.ct.gov/deep/environmental-justice/05-learn-more-about-environmental-justice-communities (accessed January 27, 2025).

located in areas with particularly vulnerable grid infrastructure, receive a 50 percent adder in addition to the standard, low-income, or underserved community incentive rate for which the project qualifies. MFAH is eligible for this incentive, which would result in a $900/kilwatt-hour ESS incentive.

When the battery is used for grid services (to reduce electricity demand), ESS participants can receive performance incentives of up to $200 per kilowatt in the summer, and $25 per kilowatt in the winter, for the first five years, and then receive reduced incentive rates (by half) from year six through year 10. The structure of ESS is designed to value the economic and resilience benefits of battery storage, while the grid services provided through an aggregated network of behind-the-meter battery storage systems lowers costs and increases grid reliability for all ratepayers.[30]

Most notably for this effort, ESS applies the low-income residential incentive rate to MFAH facilities *per unit* of affordable housing. For example, 30 units of income-restricted housing could be eligible for up to $480,000 ($16,000 multiplied by 30) in upfront incentive support for the battery storage portion of a system. The calculation of the ESS incentive for MFAH providers is based on the minimum of the following three formulas:

- $600 per kilowatt-hour of energy storage capacity
- 50 percent of the total installed cost
- the equivalent of $16,000 per unit of affordable housing

The Energy Storage Solutions program does not specifically carve out funds for medically vulnerable customers; however, the incentive structure enables affordable housing providers to benefit from economies of scale. Economies of scale refers to the reduction in the relative incremental cost of adding an additional kilowatt-hour of battery storage capacity. After accounting for the infrastructure costs for a battery storage project, the incremental cost of adding additional capacity (kilowatt-hours) to the system is relatively small.

30 The aggregation of many hundreds, or even thousands, of smaller behind-the-meter distributed energy resources for the purposes of providing grid services is a "virtual power plant" model. To learn more about the benefits of virtual power plants for all ratepayers see: "An Introduction to Virtual Power Plants," *Clean Energy Group*, September 28, 2020, https://www.cleanegroup.org/webinar/an-introduction-to-virtual-power-plants.

What does it mean to "achieve economies of scale"?

Open battery storage cabinet with cells visible.
Photo: Clean Energy Group

Economies of scale refers to the cost savings that can be achieved when developing larger projects. When projecting the economics of a construction project, the percentage of fixed costs is smaller as it spreads across more product (for example, the cost savings associated with bulk purchasing). In this analysis, once a battery storage system reached a certain size threshold, any additional increase became more cost effective.[31] This is because battery storage infrastructure costs are fixed, and soft costs (like labor) become much less significant as battery storage size increases.[32]

For instance, many battery cabinets that house the battery cells are fixed at one size, regardless of the number of battery cells added in the project (see photo). The same is true of the battery management software—it's a fixed price regardless of the battery system size. As battery capacity is added, the investment primarily becomes adding more cells (which is a relatively small added cost to the project), not adding additional infrastructure to support those cells.

Residential Renewable Energy Solutions

The Residential Renewable Energy Solutions (RRES) program, launched in 2022, is a renewable energy tariff incentive that compensates residential solar owners for the power their systems produce and provide to the local electric grid.[33]

31 There is no one battery size that can indicate when an economies of scale threshold has been reached. It differs based on the facility and battery. A specific battery (in terms of kilowatts and kilowatt-hours) at two different facilities will have different economic performance at each location because of the energy usage of those facilities and their rate schedules. Finding the optimal combination of savings, incentives, and cost must be evaluated individually, based on each site's unique characteristics.

32 This is true to an extent. Once a battery system's needed capacity reaches a certain amount, it may require a second battery. That would result in a bigger step up in cost than simply adding another battery cabinet because there are more costs associated with the new infrastructure (more electrical conduits, labor, wires, and battery enclosure components, to name a few).

33 "Solar MAP for affordable multifamily housing," *Connecticut Green Bank*, https://www.ctgreenbank.com/building-solutions/multifamily-financing/solar-map-for-affordable-multifamily-housing (accessed January 27, 2025).

The RRES tariff rates have steadily increased; in 2025, these tariff rates increased to $0.3195 per kilowatt-hour.[34] This is more than an 8 percent increase in the incentive rate compared to 2022, the first year RRES rates were available.[35] Low-income participants, classified as those with incomes 60 percent or below the State Median Income, are automatically enrolled to receive a $0.055 per kilowatt-hour adder to the base incentive rate. The baseline and adder combined result in a 2025 incentive rate of $0.3745 per kilowatt-hour for low-income participants.[36]

The RRES program requires that MFAH providers share a portion of the solar savings with residents as a "tenant benefit." The allocation of the tenant benefit funds to the residents differs depending on if the building is master-metered or individually metered.[37]

- For individually metered buildings, a minimum of 20 percent of the tariff must be set aside to benefit tenants of the property. The solar savings benefit must be evenly divided among tenants and is provided in the form of an on-bill credit on the tenant's electric utility bill, allowing the tenant to see a direct bill reduction from the solar array.
- For master-metered buildings, in which utility charges are included in the rent and tenants do not have an electric bill, the net present value of 25 percent of the tariff must be re-invested into a tenant benefiting building upgrade,including broadband internet, onsite mental health services, energy efficiency measures, and green spaces.[38] Battery storage is an eligible building upgrade. Allowing providers to reinvest the RRES tenant benefit in battery storage can significantly improve the economics for a solar+storage project. Acting much like an upfront incentive, the tenant benefit funds can reduce upfront costs, thereby improving capital costs, cash flow, and payback of the system. The economic implications of applying the RRES tenant benefit to battery storage are further explored in Case Study 3 in the Analysis Results section of the report (p. 36). In the future, there is potential for the tenant benefit to become a part of the decision-making process for master-metered facilities, allowing the tenants to help identify the types of investments in property improvements that they prioritize.

34 "Annual Residential Renewable Energy Solutions Program Review – Year 3," *State of Connecticut, Public Utilities Regulatory Authority*, November 1, 2023, https://www.dpuc.state.ct.us/dockcurr.nsf/8e6fc37a54110e3e852576190052b64d/6bf949e674ea002d85258a5a00536ec7/$FILE/230802-110123.pdf.

35 2022 RRES rate was $0.2943 per kilowatt-hour."Annual Residential Renewable Energy Solutions Program Review and Tariff Rate Setting," *State of Connecticut, Public Utilities Regulatory Authority*, October 6, 2021, https://www.dpuc.state.ct.us/dockcurr.nsf/8e6fc37a54110e3e852576190052b64d/988aeb38bbad4d678525876600662497/$FILE/210802-100621.pdf.

36 In 2023, low-income participants received a $0.025 adder, $0.030 less than the 2024 rate.

37 The important distinction is in who is paying the utility costs (the provider or the resident). For a master-metered building, there is a single meter associated with the entire building (including all units), meaning the provider pays for all utility costs (this type of project follows the master-metered program rules in RRES). In an individually metered building, each unit has its own meter and therefore its own utility bill. Typically, this means that the resident pays their electric utility bill (this type of project follows the individually metered program rules in RRES). In some cases, a building could be individually metered, and the provider still pays for the resident's electric utility bill (this type of project follows the master metered-program rules in RRES). For this analysis and report it's assumed that residents of individually metered building pay for their unit's electric utility bills, and would therefore fall under the individually metered program rules in RRES.

38 For a master-metered building, the compliance period to allocate funds to the tenant benefit is six months post operation of the system. However, the tenant benefit funds can be stretched over an extended period of time until the total dollar value required to hit the 25 percent net present value (NPV) calculation is completely expended. If it takes greater than the initial six-month period, there are additional compliance reporting requirements.

Projects can enroll in RRES through 2028, and once enrolled, they will receive benefits over 20 years. RRES and ESS incentives can be applied to the same project and, in fact, complement one another. Economic benefits for solar are generated through the RRES program, while the ESS program incentivizes the battery storage installation. Connecticut MFAH providers pursuing solar+storage are encouraged to participate in both RRES and ESS programs to optimize savings and potential revenue generation.

Solar Marketplace Assistance Program

The Connecticut Green Bank's Solar Marketplace Assistance Program (Solar MAP) works with municipalities, state agencies, and MFAH properties in Connecticut to develop solar and solar+storage projects.[39] The program provides multiple pathways of support, including no-cost technical assistance and a lease financing option for solar and solar+ storage systems sized at or above 50 kilowatts.[40] For projects that decide to participate in the Solar MAP program, the Green Bank oversees the project development, works with the competitively selected installer, and manages the development, design, permitting, procurement, and installation processes.

The Solar MAP lease is structured as a revenue-share mechanism, with the Green Bank fronting the capital to complete the installation so the MFAH provider does not pay any upfront capital costs. Over the 20-year term of the lease, the Green Bank owns and maintains the solar or solar+storage system. The MFAH provider also financially benefits by receiving a portion of the revenue of the sale of electricity from the solar system as an on-bill credit. Under the lease agreement, the Green Bank (the system owner) is able to monetize any federal tax credits and other incentive benefits, which in turn helps to reduce the percentage of the RRES tariff needed to recoup the investment in solar+storage. While this benefits the property owner as more incentives pulled into the project mean better lease economics and terms, the property owner can't take direct (and full) benefit of the incentives because they don't own the solar+storage system.

Through this effort, upon the completion of the solar+storage assessment, eligible projects received a Solar MAP lease estimate for both solar-only and solar+storage scenarios.

Commercial Property Assessed Clean Energy

The Connecticut Commercial Property Assessed Clean Energy (C-PACE) retrofit financing program enables MFAH providers to install solar, battery storage, EV charging infra-structure, or other measures that reduce energy usage at no upfront cost. In this program, Connecticut Green Bank or a qualified capital provider finances the project at low-interest rates for terms of up to 25 years. The affordable housing provider can choose to take a loan out for up to 100 percent of the project's installation costs and opt for the loan to cover the installation of solar, storage, or solar+storage. To qualify for C-PACE, sites need to apply with the Green Bank and provide evidence of a completed solar+storage

39 To learn more about solar MAP, visit "Solar Marketplace Assistance Program," *Connecticut Green Bank* https://www.ctgreenbank.com/community-solutions/solar-solutions-for-communities/solar-map.

40 "Solar MAP for affordable multifamily housing," *Connecticut Green Bank*, https://www.ctgreenbank.com/building-solutions/multifamily-financing/solar-map-for-affordable-multifamily-housing (accessed January 27, 2025).

feasibility study. Projects that are requesting funds for other energy efficiency upgrades need to have undergone an energy audit before applying.[41]

While CPACE may be a potential solar+storage finance opportunity for some MFAH providers, the requirement that a benefit assessment that is senior to any mortgages must be placed on the building is unfavorable for most providers and limits participation.[42] The benefit assessment ensures that any C-PACE payments that are in arrears are repaid first in the event the facility is foreclosed or is sold. This priority allows C-PACE subscribers to have below-market interest rates because it is a prioritized loan, but it can be problematic for affordable housing providers with complicated financial stacks that include multiple investors, many of whom would be uncomfortable or unwilling to prioritize a loan other than their own return on investment.

None of the MFAH properties assessed through Climate Smart Technologies explored C-PACE as a finance option.

41 "C-PACE Retrofit Financing," *Connecticut Green Bank*, https://www.ctgreenbank.com/building-solutions/c-pace/retrofit-financing (accessed January 2025).

42 Walter Johnsen, "Addressing Energy Insecurity in Philadelphia's Affordable Multi-Family Housing with C-PACE Financing," *Kleinman Center for Energy Policy*, March 29, 2023, https://kleinmanenergy.upenn.edu/research/publications/addrEnergy Storage Solutionsing-energy-insecurity-in-philadelphias-affordable-multi-family-housing-with-c-pace-financing.

Federal Incentives: Investment Tax Credit

In addition to Connecticut incentive programs, the Federal Investment Tax Credit (ITC) is a significant incentive that can be combined with Connecticut's RRES and ESS programs. Under the ITC, at least 30 percent of all eligible solar and battery storage installation costs can be reimbursed as a tax rebate. Nonprofit affordable housing providers or facilities that are municipally owned are eligible to receive the ITC through Direct Pay reimbursement. System owners can also apply for several bonus credits, including a 10 percent bonus credit for projects located in an energy community, a 10 percent bonus credit for domestically manufactured materials, and either a 10 percent bonus credit for projects located in low-income communities or a 20 percent bonus credit for low-income residential projects that equitably allocate the financial benefits of the project.

To qualify for the 20 percent bonus credit, affordable housing providers need to equitably pass on at least 50 percent of the financial value of net energy savings to building occupants. Connecticut affordable housing providers are well positioned to apply for this tax credit because facilities are required through the RRES program to reserve *at least* 20 percent of the financial benefits of the solar savings for the residents.[43] Perhaps most importantly, the incentive infrastructure to support the solar benefit share is in place; tenants receive a credit on their monthly utility bill.[44]

To learn more about the ITC, the six available bonus credits, and Direct Pay option, see Appendix B (p. 45).

43 20 percent is the minimum. Providers can allocate a greater share of the RRES tariff to residents.

44 For individually metered MFAH properties.

Solar+Storage Feasability Assessment: Design And Process

Solar+storage feasibility assessments were conducted at 15 affordable housing properties, owned by eight different MFAH providers.[45] American Microgrid Solutions was the primary engineering partner and conducted 13 of these assessment.[46] Two assessments, conducted by different engineering partners, are still underway (to learn more about the pending assessments and reasons for delay, see Appendix C on p. 47).

The feasibility assessment timeline was approximately three to six months, depending on the complexity of the facility and the time needed to obtain required documentation (such as utility bills and electrical drawings). The resulting reports provided a 20-year, detailed financial forecast that includes capital costs, operational expenses, and financial benefits for solar+storage at a specific facility.

Once drafted, the engineer presented the solar+storage feasibility assessment results to the affordable housing providers, at which point the provider could ask questions and provide additional feedback. The assessment and corresponding report were considered complete when the provider indicated there were no remaining questions or concerns. Upon completion of the assessment, all MFAH providers were introduced to the Connecticut Green Bank to overview finance opportunities, specifically Solar MAP. There was no obligation for the provider to move forward with solar and/or battery storage installation, to do so with the engineer's support and/or partnership, or to use Green Bank financing.

While the final analysis provides a comprehensive overview of solar+storage potential at a facility, it is not intended to be a "shovel ready" design document. Each site will require additional steps to develop a project, including engineering, permitting, procurement, installation, and commissioning. The feasibility analysis makes this development process more informed, effective, and streamlined, and further equips MFAH providers with the information necessary to make an informed decision and/or to seek financing.

Each solar+storage feasibility assessment included the following components.

Technoeconomic Analysis

A technoeconomic analysis was conducted for multiple solar+storage scenarios. This analysis included the system design, cost to build and maintain the system, economic

45 AMS conducted the solar+storage assessments for all the properties, except two that had an existing partnership with other engineers. The comparative analysis featured in this report was conducted by AMS.

46 AMS was also responsible for preparing the analysis for this report. To learn more about AMS, see the Project Partners descriptions (p. 10).

opportunities (such as incentives and utility bill savings), and resilience benefits (backup power duration). Connecticut MFAH providers are eligible to participate in ESS and RRES program and to receive federal Investment Tax Credits (see the Connecticut Energy Programs section of this report, p. 17). All three were incorporated in the solar+storage assessment analysis and final report.

The technoeconomic analysis projects the solar+storage economics over 20 years.[47] RRES is a 20-year program and utility bill saving are also projected over 20 years. However, ESS incentives are only guaranteed for 10 years. The solar+storage feasibility assessment reports therefore only include ESS incentive income in years 1–10. Furthermore, batteries and inverters do not have a useful life of 20 years, which requires the engineer to make informed assumptions as to when the inverter and battery storage inverter/cells would likely need to be replaced, and the costs associated with those replacements (typically after year 10 and before year 15 of system operation). For this analysis, the payback of the system had to be under 20 years to be considered economically viable.[48]

Multiple Resilience Scenarios for Multifamily Affordable Housing

One of the primary goals of Climate Smart Technologies was to incorporate a health focus into the solar+storage design and development process. In doing so, the provider would build an understanding of solar+storage technologies, as well as its applications to support health outcomes for medically vulnerable affordable housing residents in the event of an outage. To meet that goal, the solar+storage feasibility assessment reports outlined options to develop solar+storage systems that supported communal and/or in-unit resilience.

The analysis conducted for this report examines three different solar+storage scenarios: Resilient Power 1 (RP1), Resilient Power 2 (RP2), and Resilient Power 3 (RP3).[49]

RP1 evaluated solar+storage to support a "resilience hub." The resilience hub model ensures residents can access a communal space, with backup power, in or near their apartment building in the event of an outage. A resilience hub typically offers a safe, well-lit space with heating and cooling, refrigeration for food and temperature-regulated medication, internet, and outlets to charge medical equipment and cellphones.[50] Some resilience hubs also include a food prep or even cafeteria space. The RP1 resilience hub scenario also includes facility common loads, such as emergency lighting.

47 See Appendix C to learn more about why the economic projections were restricted to 20 years (p. 47).

48 A payback was not calculated once a project exceeded 20 years. When this report references payback it is the "simple payback" of the system. To learn more about calculating simple payback see Appendix C.

49 There were two additional scenarios allowed as part of the solar+storage feasibility assessment with providers but not included in this analysis. Some facilities had existing fossil-fuel generators or were interested in installing fossil-fuel generators to further improve upon the redundancy of the backup power system. In this case, the assessment considered a hybrid scenario in which a fossil-fuel generator was included. A solar-only scenario was also included. The analysis in this report only presents the solar+storage results.

50 Critical loads are select electrical equipment and devices that are the most important to keep powered during a grid outage. Critical loads will vary depending on the type of facility and customer needs. Examples of common critical loads include emergency lighting, outlets for charging electric devices, and refrigeration.

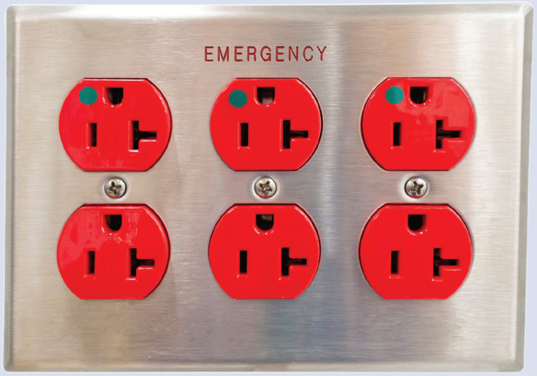


Photo: Shuttersock/Badon Hill Studio

Red Plug Outlet

This image is of a red plug outlet in a hospital. The red color indicates that the outlet will receive power from a backup power system and remain live in the event of an outage. The same concept would apply to affordable housing through the red plug analysis—each unit would have a single red plug they could use in the event of an outage.

RP2 evaluated solar+storage to support a "red plug model." This model is based on the red plug concept used by hospitals, in which red plugs indicate which outlets will receive backup power and remain active and operational in the event of an outage (see box above).[51] The red plug application in affordable housing, as outlined in this analysis, ensures that one 200-watt outlet in each unit is available to power devices in the event of an outage, including devices critical to health such as a medical device, window air conditioner, space heater, and refrigerator.[52] For this analysis, the red plug is only operational during an outage. The determination to make the outlet inactive during regular grid operations was primarily economic. It is the assumption of this analysis, and informed by the input from the resident engagement, that the benefits of having access to an in-unit outlet in the event of an outage outweighs the inconvenience of having an unusable outlet during regular grid operations.[53]

RP3 evaluated solar+storage to support the same loads as RP1 and RP2 combined, resulting in solar+storage sized to support a communal resilience hub and in-unit red plugs.

Health Considerations Rubric

American Microgrid Solutions and Clean Energy Group developed a health rubric to inform solar+storage system design with the specific health considerations of the tenants at that facility (see Table 1, p.27). The rubric was completed in partnership with the housing provider prior to conducting a feasibility assessment. The rubric assisted in tailoring solar+storage solutions that support improved health outcomes at that facility in the event of an outage. For instance, if the provider indicated that there are tenants reliant on

51 "Why Are There Red Electrical Outlets In Hospitals? *Medi-Products*, April 29, 2024, https://www.mediproducts.net/blog/healthcare-design/why-are-there-red-electrical-outlets-in-hospitals.

52 The red plug model requires coordinated resident education and cooperation among building residents about the best ways to utilize the outlets in the case of a power outage. In the event of an outage, providers cannot track or enforce how much power is being drawn from the battery and delivered to each unit. If residents try to draw more than the 200-watt outlet allows, the battery could be drained faster than anticipated or result in system malfunction, such as tripping the breaker.

53 Appendix C (p. 47) further overviews the economic justifications of analyzing a red plug that is only active during a grid outage.

TABLE 1

Example Health Rubric

This table is an example of a health rubric completed in partnership with a MFAH provider prior to a feasibility assessment. A health rubric was included in every Climate Smart Technologies solar+storage feasibility assessment.

Occupant Needs	
Mobility-impaired residents on upper floors?	Yes
Temperature-sensitive medical conditions?	Yes
Temperature-sensitive medications?	Yes
Medically dependent on electricity?	Yes
Alternative arrangements (hours)?	24-72 hours
Building Attributes	
Common area gathering space?	Yes
Common area refrigeration?	Yes
Common corridor space?	Yes
Outlets in corridors?	Yes
Common HVAC supply?	Partial
Master metered?	Yes

temperature-regulated medication, the resulting solar+storage system would be designed to be able to support a refrigerator (or multiple), in-unit and/or in a communal space.

Energy Efficiency

An Energy Star Score was provided for each facility to build housing provider awareness as to the energy efficiency of the facility. An Energy Star Score is a 1-100 assessment of a building's energy efficiency as compared with similar buildings nationwide, adjusting for climate and business activity.[54]

In addition to the Energy Star Score, every property was eligible for an ASHRAE Level 2 Energy Audit.[55] The ASHRAE Energy Audit is a comprehensive energy efficiency assessment that includes a review of building envelope; lighting; heating, ventilation, and air conditioning (HVAC); domestic hot water; and plug loads. The intent of the audit is to identify both near-term no-cost/low-cost energy savings opportunities, as well as more capital intensive modifications and retrofits that would yield longer-term cost reductions through energy savings.[56] For all projects within an existing building, the results from the ASHRAE Level 2 Energy Audit were published separately and summarized in the solar+storage assessment report, including how energy efficiency upgrades could impact the design and economics of a solar+storage system.

Resilience Score

American Microgrid Solutions provided each facility with their Federal Emergency Management Agency (FEMA) Resilience Score, which is used to evaluate the baseline risk of natural disasters or hazards in any one community. The FEMA Resilience Score is calculated through a communities Risk Index, Expected Annual Loss, Social Vulnerability, and Community Resilience Score, all of which evaluate natural hazard and community risk factors for any particular county and Census tract.[57] Table 2 is an example of a FEMA Resilience Score for Norwalk, Connecticut.

54 To learn more about Energy Star Score, visit: "How the 1–100 ENERGY STAR Score is Calculated," *EnergyStar.gov*, https://www.energystar.gov/buildings/benchmark/understand-metrics/how-score-calculated (accessed January 28, 2025).

55 Two properties opted out of the ASHRAE Level 2 Energy Audit as their property was new construction and already had plans for energy efficiency, making the Audit unnecessary.

56 To learn more about ASHRAE Energy Audits, visit: "What are ASHRAE Energy Audits," *CleanBC Better Buildings*, 2019, https://www.betterbuildingsbc.ca/faqs/what-are-ashrae-energy-audits.

57 To learn more about the FEMA Resilience Score and related indices, visit: "National Risk Index," *Federal Emergency Management Agency*, https://hazards.fema.gov/nri/map (accessed January 28, 2025).

TABLE 2

FEMA Resilience Score Example

Hazard Types		
Avalanche	N/A	N/A
Coastal Flooding	Relatively High	96.0
Cold Wave	Relatively Low	57.1
Drought	Relatively Low	53.9
Earthquake	Relatively Low	88.0
Hail	Very Low	17.6
Heat Wave	Relatively Moderate	84.8
Hurricane	Relatively High	97.0
Ice Storm	Very High	97.6
Landslide	Relatively Moderate	90.2
Lightning	Relatively High	96.3
Riverine Flooding	Relatively Moderate	77.2
Strong Wind	Very High	99.1
Tornado	Relatively Moderate	76.1
Tsunami	N/A	N/A
Volcanic Activity	N/A	N/A
Wildfire	Very Low	44.7
Winter Weather	Relatively High	87.1

Risk Index: 95.45

- The Risk Index rating is **Relatively High** for Fairfield County, CT when compared to the rest of the U.S.
- Risk Index scores are calculated using an equation that combines scores for Expected Annual Loss due to natural hazards, Social Vulnerability, and Community Resilience

Expected Annual Loss: 95.91

- In Fairfield County, CT, expected loss each year due to natural hazards is **Relatively High** when compared to the rest of the U.S.
- Expected Annual Loss scores are calculated using an equation that combines values for exposure, annualized frequency, and historic loss ratios for 18 hazard types

Social Vulnerability: 61.84

- Social groups in Fairfield County, CT have a **Relatively High** susceptibility to the adverse impacts of natural hazards when compared to the rest of the U.S.
- Social Vulnerability is measured using the Social Vulnerability Index (SVI) published by the Centers for Disease Control (CDC).

Community Resilience: 66.68

- Communities in Fairfield County, CT have a **Relatively High** ability to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions when compared to the rest of the U.S.
- Community Resilience is measured using the Baseline Resilience Indicators for Communities (HVRI BRIC) published by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI).

Analysis Results

The analysis featured in this report overviews solar+storage system size and cost considerations when developing resilient power solutions tailored to support electricity-dependent, medically vulnerable MFAH residents in the event of an outage. The economics are specific to MFAH properties located in Connecticut. The analysis is organized into three affordable housing case studies, based on facility size. Each case study is based on data compiled through actual solar+storage feasibility assessments conducted by American Microgrid Solutions through Climate Smart Technologies. The names and details of each facility have been removed for privacy.

The case studies are followed by a compilation of key takeaways resulting from this effort, including the impact of Connecticut's ESS program on the economic feasibility of solar+storage for MFAH facilities and considerations for program replicability in other states.

Overview: Resilient Power Scenarios

Three resilient power scenarios are applied to each case study:

- Resilient Power 1 (RP1) examined solar+storage to power a resilience hub
- Resilient Power 2 (RP2) examined solar+storage to power in-unit red plugs
- Resilient Power 3 (RP3) examined solar+storage to power both red plugs and a resilience hub.[58]

For each case study, the rooftop solar array reached maximum capacity, meaning solar was sized to offset 100% of the annual electricity consumption for the supported load, unless that was not possible due to roof space limitations. For this reason, the size of the solar system is the same across all scenarios for each case study and only the size of the battery storage system differs, depending on power needs of the critical loads supported.[59]

Each resilient power scenario includes the "minimum resilience" (in hours) expected to be provided by solar+storage. Minimum resilience is the most conservative estimate, representing a worst-case scenario that assumes a high demand for the loads supported by the solar+storage system and no solar availability to charge the battery system before

58 To learn more about each Resilient Power scenario see Solar+Storage Feasibility Assessment: Design and Process on p. 24.

59 While solar can be installed as ground mounted or atop carport structures, rooftop solar was either the most economical or physically feasible, and/or the preferred option of the provider. For other properties, both carport and ground-mounted solar could be an option for those interested in maximizing solar beyond what the rooftop of the building can provide.

the stored energy is depleted in the battery.[60] Minimum resilience is held constant for all three resilient power scenarios in each case study. This is because each resilient power scenario sizes the battery storage system to meet specific critical loads for a minimum duration, not to necessarily extend the duration of backup power provided to those loads.[61]

Notably, projections for "typical resilience," the likely (or average) duration of solar+ storage backup power a facility can expect, varies significantly depending on the case study and resilient power scenario. Typical resilience is an important metric as it is the more likely scenario given that at least some sun will be available for the solar panels to generate energy, which will help to charge a battery and power critical loads during an outage, thus extending the backup power duration provided by the system. Typical resilience duration (in hours) is included in each case studies resilience overview.

Economic Considerations

Each case study includes a graphic depicting solar+storage system size, minimum resilience, and three economic projections that correspond to each of the resilient power scenarios—**capital cost, ITC amount**, and **cash flow**.[62] The **capital cost** is the upfront cost to install the solar+storage system. There are two ITC opportunities that are considered for each scenario: the baseline **30 percent** and the **50 percent** (the baseline plus 20 percent in bonus adders). To learn more about federal tax credits, see Appendix B (p. 45). The **cash flow** reflects whether solar+storage generates net savings over a 20-year operating period or if it fails to recoup the investment (depicted as negative cash flow in the graphic). The cash flow takes into consideration all incentives (Connecticut and federal), utility bills savings, estimated costs for operations and maintenance, performance degradation of key components, and replacement costs for solar inverters and battery storage system inverter and modules.[63] Each case study also includes a table overviewing the breakdown of the Connecticut incentives applied, Solar MAP financing lease figures (if applicable), and utility bills savings.

For each facility, multiple utility rate structures were considered when determining the best, most economically beneficial match to the facility's size, energy usage, and resilient power goals. The project economics across case studies are therefore not always directly comparable as the facilities do not all share the same utility electric rate.[64] These differences are noted in each case study.

60 Minimal resilience typically applies when a facility has sustained, high electricity demand and has little-to-no solar production to recharge the battery.

61 Minimum backup power duration (in hours) varied slightly across resilient power scenarios in some case studies. The difference was minor. For consistency and ease of reviewing the results, the minimum backup power duration utilized in this analysis is the least amount of time provided by backup power for any given resilience power scenario for each case study.

62 The analysis assumes a cash purchase of the system.

63 These components require replacement between year 10 and year 15 of the installed system.

64 For example, the medium and large facility received utility savings from time-of-use arbitrage and demand charge management, respectively, but the most financially advantageous rate schedule for the small facility does not include time of use rates or demand charges.

The following are economic considerations when reviewing the analysis results:

- "Utility savings" result from one of the following: 1) time-of-use arbitrage by using the battery system to shift when the property uses grid energy to reduce grid consumption when electricity rates are higher, or 2) demand charge management, where the battery is used to reduce the amount of electricity needed from the grid when demand-related electricity rates are highest.
- RRES is the only solar tariff option for MFAH in Connecticut. Affordable housing projects that participate in RRES and have more than five units must participate in the buy all sell all (BASA) incentive rate structure, which requires that all the electricity generated by the solar system be exported to the grid before offsetting any usage on site. All three case studies in this analysis utilize the BASA incentive rate structure.
- RRES requires a "tenant benefit" in which a portion of the solar generated savings are shared with the residents. The tenant benefit is applied differently depending on if the site is master-metered (Case Study 3) or individually metered (Case Study 1 and 2). See Connecticut Energy Programs to review the difference in tenant benefit distribution (p. 17).
- ESS incentives are based on the size (kilowatt/kilowatt-hour) of the battery. In the resilient power scenarios for each case study, the ESS rate fluctuates relative to the battery's size.
- Each resilient power scenario includes a comparison of two ITC amounts, 30 percent (baseline) and 50 percent (30 percent baseline plus 20 percent in bonus credits).[65] One way to reach the 50 percent ITC is to apply for the 20 percent low-income residential project bonus credit. To receive the bonus credit, MFAH providers must share half of the financial value of the system's savings with residents, which is not factored into this analysis.

Available Finance: Solar MAP Program

Upon completion of the assessment, each facility was reviewed for eligibility to participate in the Solar MAP program (to learn more about Solar MAP, see Connecticut Energy Programs, p. 17). The small and medium facilities were not eligible for Solar MAP. The small facility did not meet the minimum solar size requirement for Solar MAP (50 kilowatts) and the project economics for the medium facility did not meet MAP lease requirements. Connecticut Green Bank determined that it would not be able to recoup its investment, provide the necessary tenant solar benefit share (required through RRES), and provide a lease payment to the provider.

Solar+storage at the large facility was eligible for Solar MAP. An example of a lease for the large facility is outlined in the Large Facility Case Study.

65 There are multiple ITC adders that could result in a facility being eligible for tax credits worth up to 70% of a solar+storage system's installed cost. To learn more about the ITC and other bonus credits see Appendix B (p. 45).

CASE STUDY 1

SMALL Multifamily Affordable Housing Facility

Description: The small MFAH case study represents properties that have 6–20 units. The small facility is individually metered, and residents are responsible for their electric utility bill. However, heating, cooling, and hot water for the entire building are on the house meter, meaning the provider pays for these utilities. In all three scenarios, the provider incorporated the costs to convert from a natural gas to an all-electric heating, cooling, and hot water system into the payback considerations of the solar+storage system.[66] The provider featured in this case study found that the value of all-electric heating as an opportunity to increase facility sustainability and resilience outweighed the higher costs.

Due to the limited footprint of the property, this facility did not have a large enough common area space to designate as a resilience hub.[67] In **RP1**, solar+storage would instead provide backup power to all common area loads in the building (for example, hallway lighting) as well as heating, cooling, and hot water. **RP2** explores solar+storage to support only in-unit resilience through red plugs. **RP3** sizes solar+storage to support RP1 and RP2, which would provide residents with in-unit red plug and heating, cooling, and hot water in the event of an outage. **Figure 1** overviews analysis results for three resilient power scenarios for a small MFAH facility.

FIGURE 1

Analysis Results: Small Affordable Housing Facility

Each scenario was based upon the same solar capacity, minimum backup power duration, and range of units served. Battery size varies depending on the loads to be powered during an outage.

Solar Capacity	Backup Power Duration	Number of Housing Units
14 kW	23 hr. minimum	6–20

1 RP1 Resilience Hub Equivalent

Solar+storage would support full-building electric heating.

Battery Storage	Capital Cost	ITC	Cash Flow
30 kW/67 kWh	$269,800	30% ITC $80,900	Cash Flow –$212,962
		50% ITC $134,900	Cash Flow –$159,005

2 RP2 Red Plugs

Solar+storage would support a single in-unit electrical outlet.

Battery Storage	Capital Cost	ITC	Cash Flow
16 kW/41 kWh	$128,300	30% ITC $36,900	Cash Flow –$127,920
		50% ITC $61,500	Cash Flow –$103,339

3 RP3 Resilience Hub and Red Plugs

Solar+storage would support full-building electric heating and a single in-unit electrical outlet.

Battery Storage	Capital Cost	ITC	Cash Flow
30 kW/101 kWh	$296,400	30% ITC $87,300	Cash Flow –$212,706
		50% ITC $145,500	Cash Flow –$154,511

None of the three scenarios are projected to result in a positive cash flow.

Source: Clean Energy Group/Mentimeter

66 The investment in the new heating system was estimated at approximately $85,000. The ASHRAE report for this property had found switching to an electric heat source would not be cost effective.

67 It is not uncommon for there not to be community space in affordable housing under six units due to the space restrictions of the property.

Resilience: The minimum resilience provided by solar+storage for all resilient power scenarios is 23 hours.[68] The typical backup power duration is significantly higher: over three days (72 hours) for RP1 and RP2 and over two days (52 hours) for RP3.

Connecticut Incentives: The RRES program is anticipated to generate over $98,000 in revenue over 20 years. Twenty percent of the savings, or approximately $18,000, would be shared with tenants to reduce monthly electric bills over the same period. Through the ESS program, the facility would receive an upfront incentive in the first year and grid services incentives for 10 years. ESS for RP3 (the largest battery proposed) would provide $60,480 in upfront incentives and generate annual performance payments ranging from $2,000 to $4,000 (see Table 3).

Utility Bill Savings: Solar+storage at the small facility would not result in any utility savings. There are multiple reasons for the lack of savings. First, after considering multiple rate schedules, the most financially beneficial tariff option for this site does not include demand charges nor time-of-use arbitrage. Furthermore, this provider explored, as part of their solar+storage feasibility analysis, converting to all-electric heat (from natural gas), which would allow the solar+storage system to support heating, cooling, and hot water in the event of an outage. An all-electric heating system significantly increases electricity costs, which is reflected in the negative cash flow costs. Natural gas utility savings were reflected in the total savings.

Bottom Line: All three resilient power scenarios for the small facility are projected to have the same negative cash flow over the life of the system, regardless of the ITC applied. With a negative cash flow and no project utility savings, this facility is unlikely to secure financing. Alternatively, the provider could maintain a natural gas heating system and explore a solar-only scenario (RRES projections are $98,466), which would be a positive investment, but would result in no resilience benefits. It's worth noting that, even if the facility had not converted to all electric/replaced the heating system, the cash flow for all solar+storage scenarios would remain negative.

The challenges faced by small MFAH providers in accessing economically feasible solar+storage is detailed further in Key Takeaways on p. 39.

TABLE 3

Small Facility Projected State Incentive and Utility Savings

The following table outlines savings for each scenario of the small facility over a 20-year period for RRES and utility savings and a 10-year period for ESS.

	RP1	RP2	RP3
RRES		$98,466	
ESS (Upfront and Performance)	$62,020	$37,378	$89,543
Utility Savings	-$83,600	-$83,600	-$83,600

68 RP2 resulted in a minimum of 27 hours of backup power duration. Due to the minimal difference between RP2 and the 23 hours attributed to RP1 and RP3, the figure included in the "backup power duration" figure was reduced to 23 for consistency and ease of review.

MEDIUM Multifamily Affordable Housing Facility

Description: The medium MFAH case study is representative of properties with between 21–75 units. The medium facility is individually metered, meaning there is a meter in each apartment and residents are responsible for their own utility bills.

Figure 2 overviews analysis results for three resilient power scenarios for a medium MFAH facility.[69]

Resilience: The minimum resilience provided by solar+storage for all resilient power scenarios is 25 hours. The typical backup power expected is significantly higher: over three days for RP1 and RP2 and 61 hours for RP3.

Connecticut Incentives: The RRES program is anticipated to generate approximately $319,000 in revenue over 20 years. Twenty percent of the savings, or approximately $64,000, would be shared with the tenants to reduce monthly electric bills over the same period. ESS for RP3 (the largest battery proposed) would provide over $223,200 in upfront incentives and generate annual performance payments ranging from $12,000 to $24,000 (see Table 4, p. 35).

Utility Savings: The medium facility is eligible for a time-of-use rate. Through energy arbitrage the battery system could reduce electric utility expenses by $64,459 over 20 years. The estimated utility savings are

FIGURE 2

Analysis Results: Medium Affordable Housing Facility

Each scenario was based upon the same solar capacity, minimum backup power duration, and range of units served. Battery size varies depending on the loads to be powered during an outage.

Solar Capacity	Backup Power Duration	Number of Housing Units
47 kW	25 hr. minimum	21–75

1 RP1 Resilience Hub

Solar+storage would power common area loads.

Battery Storage	Capital Cost	30% ITC	Cash Flow	50% ITC	Cash Flow
30 kW/100 kWh	$388,300	$116,500	$60,734	$194,100	$138,391

2 RP2 Red Plugs

Solar+storage would support a single in-unit electrical outlet.

Battery Storage	Capital Cost	30% ITC	Cash Flow	50% ITC	Cash Flow
60 kW/190 kWh	$455,900	$128,700	$53,384	$214,500	$139,194

3 RP3 Resilience Hub and Red Plugs

Solar+storage would support the comon area and a single in-unit electrical outlet.

Battery Storage	Capital Cost	30% ITC	Cash Flow	50% ITC	Cash Flow
150 kW/372 kWh	$699,700	$209,900	–$15,922	$349,800	$124,012

All three scenarios can expect net savings over the system's lifetime, if the provider pays for the system in cash and receives the 50 percent ITC. When the ITC is reduced to 30 percent, RP1 and RP2 still result in net savings.

Source: Clean Energy Group/Mentimeter

69 The minimum backup duration for RP2 was evaluated at 27 hours, rather than 24. For consistency and ease of reviewing the results, the duration was rounded down to 24 hours.

constant across all three scenarios because even the smallest battery system modeled (RP1) was able to maximize the bill savings from offsetting facility demand charges (see Table 4).

Bottom Line: The medium facility has multiple pathways to developing an economically feasible solar+storage project. Assuming a 30 percent ITC, RP1 and RP2 result in net savings, with a system payback of approximately 15 years. When the ITC is assumed at 50 percent, all three scenarios generate a positive cash flow over the lifetime of the system with a payback of 7.6 years for RP1, 6 years for RP2, and 4.4 years for RP3. In the 50 percent ITC scenario, all three scenarios are expected to have similar cash flow, even though the RP3 battery is almost double the size of battery in the RP1 and RP2 scenarios and would support significantly more loads.

Despite the positive cash flow, the medium facility still did not qualify for a solar+storage lease through Solar MAP as the project economics did not support the requirements of the lease (which included a lease payment to the provider from Connecticut Green Bank and a benefit share to the residents).

TABLE 4

Medium Facility Projected State Incentive and Utility Savings

The following table outlines savings for each scenario of the medium facility over a 20-year period for RRES and utility savings and a 10-year period for ESS.

	RP1	RP2	RP3
RRES	$319,108		
ESS (Upfront and Performance)	$89,063	$172,128	$343,330
Utility Savings	$64,459	$64,459	$64,459

LARGE Multifamily Affordable Housing Facility

Description: The large MFAH case study represents properties that have more than 75 units in one building. The large facility is master-metered, meaning that the housing provider pays the utility bill for the electricity usage of the entire building and the utility costs are included in the cost of rent.[70]

Figure 3 overviews analysis results for three resilient power scenarios for a large MFAH facility.

Resilience: The minimum resilience provided by solar+storage for all resilient power scenarios is 4 hours. The typical backup power expected is at least double the minimum: 12 hours for RP1, 9 hours for RP2, and 10 hours for RP3.

Connecticut Incentives: The RRES program is anticipated to generate approximately $1,131,470 in revenue over 20 years. The tenant benefit portion is approximately $171,000.[71] ESS for RP3 (the largest battery proposed) would provide over $318,000 in upfront incentives and generate annual performance payments ranging from $12,000 to $24,000 (see Table 5, p. 37).

Utility Savings: The large facility is on a

70 Master-metered affordable housing providers commonly choose to include utilities in the rent or have tenants pay a flat rate (or ratio, based on the unit's size, occupancy, or other factors) for their electricity regardless of their usage habits

71 Since this is a master-metered facility, the tenant benefit is calculated as the net present value of 25 percent of the RRES tariff. The tenant benefit portion must be invested in eligible community-benefit programs or building upgrades (which includes battery storage).

FIGURE 3

Analysis Results: Large Affordable Housing Facility

Each scenario was based upon the same solar capacity, minimum backup power duration, and range of units served. Battery size varies depending on the loads to be powered during an outage.

Solar Capacity	Backup Power Duration	Number of Housing Units
130 kW	4 hr. minimum	75+

1 RP1 Resilience Hub

Solar+storage would power common area loads.

Battery Storage	Capital Cost	30% ITC	Cash Flow
125 kW/330 kWh	$953,163	$285,949	$610,164
		50% ITC	**Cash Flow**
		$476,581	$800,797

2 RP2 Red Plugs

Solar+storage would support a single in-unit electrical outlet.

Battery Storage	Capital Cost	30% ITC	Cash Flow
90 kW/185 kWh	$818,020	$212,612	$514,601
		50% ITC	**Cash Flow**
		$354,354	$656,343

3 RP3 Resilience Hub and Red Plugs

Solar+storage would support the common area and a single in-unit electrical outlet.

Battery Storage	Capital Cost	30% ITC	Cash Flow
200 kW/558 kWh	$1,128,239	$305,678	$640,518
		50% ITC	**Cash Flow**
		$509,463	$844,303

All three scenarios are projected to have payback periods within 10 years. The largest battery, RP3, could net $640,000 in savings (or positive cash flow) over 20 years.

Source: Clean Energy Group/Mentimeter

utility rate tariff that has demand charges. By lowering the facility's demand for grid electricity during periods of peak demand, the battery system can deliver significant savings over time, with larger batteries resulting in greater cost reductions. The largest battery is expected to generate $345,774 in savings over 20 years (see Table 5).

Solar MAP Lease Estimate: RP1 and RP3 scenarios for the large facility were eligible for Solar MAP.[72]

TABLE 5

Large Facility Projected State Incentive and Utility Savings

The following table outlines savings for each scenario of the large facility over a 20-year period for RRES and utility savings and a 10-year period for ESS.

	RP1	RP2	RP3
RRES	$1,131,470		
ESS (Upfront and Performance)	$304,567	$170,280	$498,643
Utility Savings	$265,736	$189,382	$345,774

While RP3 is a much larger and more expensive battery than RP1, the lease economics are similar. This is primarily because the ESS incentive and the tenant portion of the solar incentive both offset a significant portion of the increased battery cost. An example of the lease structure is represented in Table 6 for review. To learn more about considerations in calculating the Solar MAP lease; see Appendix D, p. 49.

Since the large facility for this analysis is master-metered, the $171,189 tenant benefit must be reinvested to tenant serving programs or building updates. In this instance, the large facility must reinvest the full amount into battery storage (an eligible upgrade) to be able to utilize the Solar MAP program. Without the re-investment, project economics would not be favorable enough to justify the lease. To learn more about the Solar MAP lease

TABLE 6

Large Facility Solar MAP Lease Figures, RP1

This table outlines the lease figures for the resilience-hub-only scenario (RP1) at the large facility. The lease assumes a 30% ITC.

	Resilience Hub (RP1)
Solar System Size	130 kilowatts
Storage System Size	125 kilowatts/330 kilowatt-hours
System Cost	$953,163
Financial Benefit for the Provider	$90,853
Share Allocated to Tenant-Benefitting Initiatives	$171,189

72 The RP2 scenario was specific to this analysis and not included in the original solar+storage assessment. For this reason, there was no lease scenario generated for RP2. Additionally, the battery modelled by Conneticut Green Bank for the RP3 Solar MAP lease scenerio was actually larger and more expensive than the battery in the RP3 scenerio featured in the analysis. Regardless, the lease had a positive cash flow for the provider.

option for the large facility analysis, see Appendix D, p. 49.

Bottom Line: The large facility had the best economic projections for all resilient power scenarios. All three scenarios are projected to have a positive cash flow. RP3, the largest battery modeled, is expected to break even in under eight years and net at least $640,000 over the life of system.[73] When applying the 50 percent ITC to RP3, the project breaks even in five years and nets nearly $850,000 over the life of the system. The two Solar MAP lease scenarios modeled resulted in a positive cash flow in year 1.

The savings and revenue generated by battery storage at the large facility increase with the size of the battery. In this case study, the affordable housing provider can achieve the greatest economic and resilience benefits with the largest battery modeled (RP3). The favorable economics are the result of a combination of state and federal incentives, a utility rate that includes demand charges, and achieving economies of scale.

73 Assumes 30 percent ITC and a cash purchase of the system.

Key Takeaways

The results from the analysis indicate that supportive policies and programs, including incentives and technical assistance, can both result in improved project economics for solar+storage and also encourage more robust systems and energy resilience solutions for medically vulnerable populations. However, even with favorable incentives and finance programs, economic feasibility is not guaranteed, and other barriers persist in impeding solar+storage development. The following are key takeaways resulting from Climate Smart Technologies and the resulting analysis featured in this report.

1. Incentives that Value Resilience Could Support Improved Health Outcomes in the Event of an Outage

By incentivizing and improving the project economics of a larger battery storage system, ESS supports affordable housing providers in ensuring greater energy resilience for electricity-dependent, medically vulnerable residents in the event of a power outage. This analysis found that, in some instances, maximizing (or approaching) the ESS incentive maximum resulted in projects that could support a notably larger battery without considerably higher costs. This was especially true of larger facilities, in which a significantly larger battery storage system had similar or better project economics than a smaller system supporting fewer loads.

MFAH benefits from the ESS structure, which encourages providers to size a battery based on resilience needs rather than on incentive limitations. Providers can consider incorporating red plugs, which have historically been economically infeasible, in addition to a resilience hub. In-unit and communal space backup power availability during an outage can ensure that residents reliant on electricity for HMDs, and who may otherwise need to evacuate during a power outage, can potentially avoid a life-threatening emergency by either sheltering-in-place through an outage or safely awaiting for emergency support to arrive.

2. Comprehensive Incentive Programs Include Technical Assistance

Technical assistance provides valuable insights into developing solar+storage for a specific facility, including overviewing the available incentives that contribute to positive project economics. It also builds the capacity of the recipient organization by educating staff about the benefits of resilient power technologies. By the end of the technical assistance process, an MFAH provider is not only better prepared to take the next steps in building a solar+storage project, but also empowered to explore resilient power solutions throughout its portfolio.

Climate Smart Technologies was holistic in its process. Targeted outreach was conducted to ensure that the MFAH providers that were engaged in this study served medically vulnerable residents. Information sharing included tailored guidance as to solar and battery storage technologies, system design as it relates to energy resilience for residents in the event of an outage (with a focus on the needs of electricity-dependent residents), and the applicable incentive programs available for MFAH providers. From there, interested providers received no-cost solar+storage assessments from an engineer and were guided through the feasibility assessment process by Clean Energy Group. Connecticut Green Bank reviewed all assessment proposals to ensure maximum benefits were included (tariff, utility rate, and incentive level). Finally, all eligible projects received a lease figure through Solar MAP. This full circle process ensured the MFAH provider was supported throughout and understood their options each step of the way.

All the MFAH providers that were engaged through Climate Smart Technologies had a base level knowledge of solar but little or no familiarity with battery storage. This isn't a particularly noteworthy finding; many MFAH operate on tight budgets and must prioritize capacity to day-to-day management and any necessary building upgrades/upkeep. Some MFAH providers had a one-person building operations department. By the end of the technical assistance process, all providers reported a better understanding of solar and battery storage technologies, their applications, and the next steps necessary in developing a project.

At the time of this report's publication, MFAH providers with completed assessments are either working with Connecticut Green Bank to finance a solar or solar+storage project, actively applying for grants, assessing solar+storage at a different facility, or reworking their original solar+storage feasibility assessment to include a larger battery.

3. Larger Facilities Benefit from Economies of Scale for Battery Storage, Smaller Facilities Encounter More Challenges

Larger MFAH facilities benefit from a higher ESS maximum incentive and the economies of scale that can be achieved by building a larger battery.[74] In this analysis, once a battery

TABLE 7

Large Facility Resilient Power Scenarios

This table overviews the difference in system size, cost, and payback of the resilient power scenarios analyzed for the large facility. The figures assume a 30 percent ITC.

	RP1	RP2	RP3
Solar Size	130 killowatts		
Battery Size	125 killowatts/ 330 killowatt-hours	90 killowatts/ 185 killowatt-hours	200 killowatts/ 558 killowatt-hours
Capital Cost	$953,163	$818,020	$1,128,239
Simple Payback	8.5 years	9.9 years	7.8 years
Cash Flow	**$610,164**	**$514,601**	**$640,518**

74 To review the formula for calculating the upfront ESS incentive and an overview of economies of scale as it pertains to solar+storage, see Connecticut Energy Programs, p. 17.

storage system reached a certain size threshold, any additional increase became more cost effective, with the largest battery (RP3) having the best cash flow and payback (see Table 7, p. 40).[75] The ESS incentive (both upfront and performance payment), in turn, becomes that much more valuable with each kilowatt-hour of capacity added to the battery.

Smaller MFAH facilities face a more challenging road to economic feasibility; the only case study to not achieve positive solar+storage economics in at least one resilient power scenario was the small facility. This is due to several factors. The leading barriers to economic feasibility for this project were the utility rate and the need for additional building upgrades to support optimal energy resilience for residents. These barriers are not uncommon to MFAH facilities that have fewer than 20 units.

First, the utility rate available for this facility did not allow for energy arbitrage and demand charge management, resulting in the battery only generating economic benefits through ESS grid performance payments. Second, designing solar+storage to provide worthwhile resilience benefits to residents requires making other facility upgrades. The provider did not have the community space available to develop a resilience hub and opted instead to explore an equivalent resilience option, which required investing in an all-electric heating system to provide heating, cooling, and hot water to all units in the event of an outage. This investment would be worthwhile from a resilience standpoint—with over 24 hours in minimum backup power duration for residents—but did not result in an economic benefit.

If a small MFAH facility had a rate schedule available that allowed the battery to generate savings, then the project economics would likely be improved. All small facility resilient power scenarios would likely have resulted in positive cash flows if the facility were eligible for a different rate schedule and had an existing all-electric HVAC system. In reality, this ideal scenario is rare. Few affordable housing facilities are all electric (none assessed as part of this effort were all electric).

4. In-Unit Resilience Can Be a Cost-Competitive Option for Multifamily Affordable Housing Providers, and the Preferred Energy Resilience Solution for Residents

Focus groups and interviews conducted by Yale and Operation Fuel found many MFAH residents reliant on electricity for HMDs would prefer to have in-unit backup power available for privacy, comfort, and safety reasons. However, the battery storage required to support backup power in-unit is considerable and costly.

This analysis finds that by incentivizing resilience through battery storage incentives like ESS, affordable housing providers can provide reliable backup power to a single in-unit outlet in each apartment (referred to as the "red plug model" in this report), without sacrificing project economics (see Table 8, p. 42).

75 There is no one battery size that can indicate when an economies of scale threshold has been reached. It differs based on the facility and battery. A specific battery (in kilowatts and kilowatt-hours) at two different facilities will have different economic performance at each location because of the energy usage of those facilities and their rate schedules.

TABLE 8

Comparison of Red Plug (RP2) Scenarios for Medium and Large Facility

This table overviews the difference in system size, cost, and payback of solar+storage to power in-unit red plugs for medium and large facility types. The figures assume a 30 percent ITC.

	Medium Facility	Large Facility
Solar Size	47 kilowatts	130 kilowatts
Battery Size	60 kilowatts/190 kilowatt-hours	90 kilowatts/185 kilowatt-hours
Capital Cost	$455,900	$818,020
Simple Payback	15.5 years	9.9 years
20-Year Cash Flow	**$53,384**	**$514,601**

This analysis found that red plugs can be economic for MFAH providers. This was the case for the medium and large facilities, both of which could 1) take advantage of rate schedules that result in the battery generating utility bill savings, 2) access a more substantial ESS incentive, and 3) achieve economies of scale. These three economic advantages resulted in a positive cash flow for the red plug only scenario (RP2) for both the medium and large facilities (see Table 8). The investment for RP2 further improved in a 50 percent ITC scenario, resulting in a 6-year payback and $139,194 cash flow for the medium facility, and a 7.7-year payback and $656,343 cash flow for the large facility.

APPENDIX A

Background

ABOUT CLEAN ENERGY GROUPS TECHNICAL ASSISTANCE FUND

Clean Energy Group's Technical Assistance Fund (TAF) supports community-serving institutions interested in learning about how solar+storage can provide resilient backup power. Local partners work with a TAF-referred engineer that produces a technoeconomic feasibility assessment for solar+storage at a specific site. The assessment report outlines how much a system would cost to install and maintain over its lifetime as well as a detailed analysis about its backup power, sustainability, and economic benefits. Only facilities planning to provide services to marginalized communities during power outages are eligible to participate in the program. Such facilities may include community centers, emergency shelters, cooling centers, affordable housing, food pantries, fire departments, and health clinics.

As of 2025, the TAF has supported over 300 community-serving facilities across 33 states, territories, and Native Nations in developing solar+storage. Over 100 TAF-supported facilities across the country have installed solar or solar+storage. Every $10,000 in predevelopment support provided through the TAF leverages an average of over $1 million in outside capital to install solar+storage.

CLEAN ENERGY GROUP AND CONNECTICUT GREEN BANK TECHNICAL ASSISTANCE PARTNERSHIP

In order to promote ESS and ensure MFAH participation in the program, Connecticut Green Bank partnered with Clean Energy Group in 2022 to offer a tailored version of CEG's Technical Assistance Fund for MFAH providers in Connecticut. The partnership was designed to build awareness of resilient power and provide predevelopment support to MFAH providers that could participate in the ESS program. Through this partnership, Clean Energy Group and Connecticut Green Bank identified an opportunity to make the feasibility assessments more holistic by providing an energy audit and valuing the impact of reliable backup for residents.

Clean Energy Group has been a technical assistance partner, specifically for affordable housing, for Connecticut Green Bank prior to Climate Smart Technologies. It has worked with the Green Bank to provide technical assistance for five affordable housing providers (representing 297 units of MFAH), first-time homebuyer residences, and single-family affordable housing. Additionally, Clean Energy Group has supported two affordable housing providers in assessing solar+storage for five of their community-serving properties. Properties were located across the state, including Bantam, Enfield, Litchfield, Hartford, New Haven, Norfolk, and Willington. The largest property assessed had 99 units of housing, all of which was reserved for low-income seniors and medically vulnerable individuals. Clean Energy Group connected with these sites through outreach and online webinars, as well as through direct referrals from the Connecticut Department of Housing and the Connecticut Green Bank. To date, one provider is moving forward to further develop solar+storage, with an additional two providers moving forward with solar-only projects, as the economics were more favorable than solar+storage.

APPENDIX B

Federal and State Incentives

INVESTMENT TAX CREDITS AND DIRECT PAY

The Inflation Reduction Act of 2022 (IRA) updated and expanded the Investment Tax Credit (ITC) for solar+storage in three important ways: 1) nonprofits with no tax liability can now apply for Direct Pay reimbursement equal to the value of the tax credit, 2) storage-only projects are now eligible for the ITC, and 3) several "bonus credits" are now included that can significantly increase savings for projects serving low-income and underserved communities.[76]

Direct pay enables tax-exempt entities to receive payment equal to the full value of the ITC and its bonus credits after a clean energy project has been placed in service. This new provision allows nonprofit organizations, states, local governments, and Tribal Nations to more fully participate in the benefits of clean energy.[77] To participate in Direct Pay, tax exempt entities must alert the IRS in that year's tax return and through the IRS pre-filing registration form.[78]

Of the available bonus credits, MFAH providers should focus on their eligibility for the following four criteria:[79]

- **Energy community**—Any project that is located in an IRS-defined energy community is eligible to receive a 10 percent bonus credit that can be stacked on top of the other bonus credits. Projects can reference a mapping tool by the US Department of Energy to assess if it qualifies as an energy community.[80,81]
- **Low-income community**—Projects that are in low-income areas can apply for a 10 percent bonus credit but are not guaranteed to receive it. Projects that qualify under certain additional ownership or geographic criteria are more likely to receive

76 Anna Adamsson, "What Nonprofits Need to Know about the Investment Tax Credit," *Clean Energy Group*, February 22, 2024, https://www.cleanegroup.org/what-nonprofits-need-to-know-about-the-investment-tax-credit.

77 Anna Adamsson, Investment Tax Credit (ITC) Direct Pay Fact Sheet for Nonprofits," *Clean Energy Group*, February 13, 2024, https://www.cleanegroup.org/publication/Direct-Pay-Fact-Sheet.

78 Anna Adamsson, "What Nonprofits Need to Know When Applying for Direct Pay," *Clean Energy Group*, February 13, 2024, https://www.cleanegroup.org/publication/ITC-Direct-Pay-Guide-for-Nonprofits.

79 Anna Adamsson, "Investment Tax Credit Fact Sheets: Bonus Credit Program, *Clean Energy Group*, February 27, 2023, https://www.cleanegroup.org/publication/investment-tax-credit-fact-sheets-bonus-credit-program.

80 "Energy Community Tax Credit Bonus," *Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization*, https://energycommunities.gov/energy-community-tax-credit-bonus (accessed January 28, 2025).

81 IRA Energy Community Tax Credit Bonus, US Department of Energy, https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d.

a bonus credit.[82,83] This credit can be stacked with the energy community bonus credit but is not eligible to be stacked with the affordable housing bonus credit.

- **Affordable housing**—Solar or solar+storage systems that are installed on affordable housing properties can apply for a 20 percent bonus credit.[84] To qualify, the "financial benefits" from the project must be "allocated equitably." Financial benefits are demonstrated through "net energy savings," such that "at least 50 percent of the financial value of net energy savings would be required to be equitably passed on to building occupants," either as equal shares among the low-income units in the program, or as proportional shares based on each dwelling unit's electricity usage. Net energy savings are defined differently based on whether the building owner owns the solar (and storage) project or whether it is third-party owned.[85] Like the low-income bonus credit, allocation of this bonus credit is not guaranteed.[86] It can be stacked on top of the energy community bonus credit, but not the low-income community bonus credit.
- **Domestic manufacturing**—Projects that meet certain domestic manufacturing requirements can receive an additional 10 percent bonus credit on eligible project costs.

The IRS provides more guidance for the Low-Income Communities Bonus Credit program, which includes both the bonus credit for projects located in low-income communities and the bonus credit for affordable housing projects.[87]

82 "Clean Electricity Low-Income Communities Bonus Credit Program," *U.S. Department of Energy*, updated December 2024, https://experience.arcgis.com/experience/12227d891a4d471497ac13f60fffd822.

83 Anna Adamsson, "How to Make the Most of the Investment Tax Credit: Applying for Bonus Credits," *Clean Energy Group*, October 27, 2023, https://www.cleanegroup.org/how-to-make-the-most-of-the-investment-tax-credit-applying-for-bonus-credits.

84 Eligible affordable housing properties must participate in a covered Federal housing program.

85 "Low-Income Communities Bonus Credit Program," *Clean Energy Group*, updated July 7, 2023, https://www.cleanegroup.org/wp-content/uploads/20-low-income-residential-project-bonus-credit.pdf.

86 Anna Adamsson, "How to Make the Most of the Investment Tax Credit: Applying for Bonus Credits," *Clean Energy Group*, October 27, 2023, https://www.cleanegroup.org/how-to-make-the-most-of-the-investment-tax-credit-applying-for-bonus-credits.

87 Clean Electricity Low-Income Communities Bonus Credit Amount Program, IRS, https://www.irs.gov/credits-deductions/clean-electricity-low-income-communities-bonus-credit-amount-program.

APPENDIX C

Solar+Storage Feasability Assessment

Design and Process

ASSESSMENTS INCOMPLETE AS OF REPORT PUBLICATION

As of this reports publication, two affordable housing providers (representing one property each) were unable to complete the solar+storage feasibility assessment in the anticipated timeline (both assessments are ongoing and have exceeded the six-month timeline).

One property has experienced delays related to coordination with the engineer and resulting inconsistencies and inaccuracies in the draft solar+storage feasibility assessment report. As of the release of this publication, the next iteration of the assessment report is underway.

One property, a medium-size new construction building that will provide long-term affordable housing for seniors and people with disabilities, experienced delays related to new construction; the predevelopment and design process required significantly more time than anticipated. For instance, the solar+storage feasibility assessment could not begin until a site plan and building design were finalized. Over the past 15 months, the site has navigated unexpected legal, zoning, appraisals, environmental reports, and various feasibility challenges, and is now on track to begin its solar+storage assessment in early Spring 2025.

DETERMINING CASE STUDY SIZES BY UNITS

Climate Smart Technologies supported 15 solar+storage feasibility assessments at affordable housing facilities that ranged from 6 to 328 units, with the average individual building consisting of 68 units. The assessment results indicated challenges and opportunities for designing and installing solar+storage systems, depending on the facility size. For this reason, the report overviews the cost and system design considerations for solar+storage at three different sizes of affordable housing facilities: small (6-20 units), medium (21-75), and large (over 75 units).

The case studies featured in this report are informed by actual solar+storage feasibility assessment results for an affordable housing facility in Connecticut with units in the range for each size group. Ranges for facility size were determined in partnership with American Microgrid Solutions—the lead engineer on this effort and responsible for generating this analysis—as reasonably representative, based on the findings of this effort.

20 YEAR CASH FLOW

AMS based the 20-year cash flow projection utilized in this report on several factors. Primarily, forecasting for future cash flows beyond 20 years into the future is where reliability in the numbers starts to fade. Forecasting up to 20 years provides much more certainty regarding estimated savings, versus projecting 25 or 30 years into the future.[88]

It is worth noting that the true useful life of solar is likely much longer than 20 years. Currently, many warranties for solar panels are 25+ years. Inverters for solar will need to be replaced before then, but the solar installation will likely continue to operate for many years beyond the 20-year cash flow used in this analysis.

SIMPLE PAYBACK

Simple payback is a metric that indicates how valuable the project is to the buyer in terms of the value of dollars today. It takes all the future cash flows and devalues the cash flows that are further out into the future and adds them up for a single dollar figure. Simple paybacks for this analysis required 20 years or less to be economically viable. A simple payback over 20 years was not calculated.

OPERATIONS AND MAINTENANCE COST

The lifetime cost of the solar+storage system considered annual operations and maintenance expenses, as well as what it would cost to replace the system's inverters and battery modules in year 16 (for solar) and year 12 (for battery storage). The costs, which were included in the analysis for each facility, are detailed below.

Small Facility: Operations and maintenance throughout the 20-year lifetime of the system are expected to be $77,000, excluding replacement costs. The cost to replace the system's inverters and battery modules is projected to be between $14,000 and $30,000 depending on the size of the battery storage system.

Medium Facility: Operations and maintenance throughout the 20-year lifetime of the system are expected to be between $106,000 and $132,000, excluding replacement costs. The cost to replace the system's inverters and battery modules is projected to be between $34,000 and $120,000 depending on the size of the battery storage system.

Large Facility: Operations and maintenance throughout the 20-year lifetime of the system are expected to be between $130,000 and $170,000, excluding replacement costs. The cost to replace the system's inverters and battery modules is projected to be between $76,000 for RP1 or as much as $182,000 if the large affordable housing provider chose RP3, which had the largest of the batteries modeled.

TABLE 9

Operation and Maintenance Costs for Small, Medium, and Large Facility

The following table overviews the operation and maintenance costs, on average, for each cast study.

	Small Facility	Medium Facility	Large Facility
Operations & Maintenance (20 years, excl. replacements)	About $77,000	$106,000–$132,000	$130,000–$170,000
Replacement Capital Cost	$14,000–$30,000	$34,000–$120,000	$76,000–$182,000

88 Eligible affordable housing properties must participate in a covered Federal housing program.

APPENDIX D

Solar Map Lease Results and Overview

The following provides more context related to Solar MAP and how lease figures were generated. The Solar MAP lease figures are reflective of the following financial considerations:

- 10-year usable life for the battery and 20-year usable life of solar.
- A 0.64 percent annual degradation rate estimate versus the industry standard of a 0.5 percent annual rate.
- Operations and maintenance estimates were calculated from realized costs in the Connecticut Green Bank's existing portfolio.
- The financial considerations of Solar MAP vary slightly from those assumed by American Microgrid Solutions when compiling the analysis. The lease figures provided are generated through Solar MAP.
- For sites that were master metered the tenant benefit funds were applied (as an eligible use of funds) to reduce the cost of capital for battery storage.
- The tenant benefit figure, calculated by Connecticut Green Bank, is slightly different than tenant benefit estimated by AMS for this analysis. This is because the Green Bank adheres to different assumptions than AMS when calculating the Solar MAP lease, including different discount rates and operation and maintenance costs, which impact the tenant benefit calculation.

TABLE 6—TERMS OVERVIEW

- **Financial Benefit for the Provider over 10 years:** The provider's portion of the revenue generation from the solar+storage system over the life of the system (10 years for the battery storage system and 20 years for the solar system).
- **Share Allocated to Resident-Benefitting Initiatives:** The provider's portion of the revenue generation from the solar+storage system in the first year of the lease.
- **Share Allocated to Resident-Benefitting Initiatives—Cumulative:** The amount of the tariff benefit-share requirement for the provider to invest into community benefitting programs or building upgrades (for master-metered properties). Solar MAP modeling for master-metered facilities applied the tenant benefit funds as an up-front payment to reduce the cost of capital for the storage system. For individually metered properties, the benefit-share is applied as an equivalent credit on the tenant's monthly electric utility bill.

APPENDIX E

Red Plug Model Overview

This report defines a red plug as a single outlet that is available only during a power outage. During normal grid operations, the red plug is not active (it is unusable). This decision on availability is primarily related to cost. Installing an automatic transfer switch for each unit of MFAH facility, which would be necessary to island an active outlet from the grid in the event of an outage, would be significantly more expensive. The solar+storage system proposed in the RP2 and RP3 scenarios only requires one automatic transfer switch for the entire red plug panel (where all red plug outlets are aggregated in the system's electric wiring).

Each red plug will be served by a 15A single-pole breaker dedicated to a single apartment. Installation of red plugs will be handled within the skin of the building. For this analysis, the red plug usage profile is adapted from an end-use load profile of a Climate Zone 5A apartment building's interior loads. Installation of red plugs is assumed to be a flat cost per unit. This may be subject to some economies of scale for large apartment buildings, but the cost impact is expected to be small because the majority of the cost is installation labor.

IMPLEMENTATION BARRIERS

Red plugs require building awareness and cooperation among building residents about the best ways to use the outlets in the case of a power outage. A MFAH facility cannot track or enforce how much power is being drawn from the battery and delivered to each unit. A household could plug a power strip into the red plug to power multiple devices at once, which may drain the battery faster. Another issue arises in the case where multiple apartments are connected to a single circuit, meaning residents sharing the circuit would have to coordinate usage. In this scenario, residents would have a harder time gauging whether to add or remove loads to avoid tripping a breaker. Breaker trips would not be easily addressed because the centralized panel supplying power to the red plugs would not be accessible to the residents. In this case, the residents may not have any way to reset the breaker to restore power and would likely require action by the building owner.

Uncertainty in the peak power requirement is the key risk to system feasibility. For example, during a power outage, a battery may run out of power if the solar system is not producing power, at night for example. When the solar recharges the battery the next day, the power would be restored and the electrical loads that were connected to the battery before the outage would attempt to start at once, creating a coincident starting surge. In most cases, a battery system big enough to support these surges would be cost prohibitive. To alleviate the issue, affordable housing providers should consider other measures, such as manual or smart load-shedding, discussed below.

INSTALLATION BARRIERS

A retrofit installation of red plugs can be difficult. If all apartments have exterior walls, it is possible to route an electrical conduit and wiring on the outside of the building, but this may have a negative impact on aesthetics. Apartments with no exterior walls would require routing of new wire inside finished walls, which is labor-intensive. Hallways with drop ceilings or convenient electrical chases in the building make the process easier.

Battery size is always a concern; many urban locations in particular have little space to spare on their sites, which makes it challenging to install batteries outdoors. This is most notable when the battery architecture transitions from an indoor wall-mounted battery to one that must be installed outdoors on a concrete pad.[89] Upsizing the battery to allow for red plugs (e.g., choosing RP3 scenario over RP1) is usually a nominal change in footprint but can cause issues if it results in the loss of an additional parking space or encroaches on authorities having jurisdiction-required offsets.

Any given building may have restrictions on the amount of power that can be aligned to the electrical system, as imposed by the building or utility equipment. Each building will have to be evaluated specifically for the maximum battery power allowed, and system limitations may preclude installing a battery of sufficient power to support both a Resilience Hub and red plugs. It's possible to limit (or "derate") battery inverters to satisfy code or interconnection requirements, but that limits both the ability of the battery to accomplish its resilience goals and its participation in incentive programs or use to manage utility costs.

ALTERNATIVE DESIGNS

Smart Load-Shedding. Within smart load-shedding, the system administrator would establish certain set points [i.e., a specific battery state of charge (SOC)] that would trigger the system to automatically shed loads to reduce the total load the system supports at that time. For example, this could mean that the solar+storage system supports full building loads when the power goes out. When the battery reaches its first set point at 75 percent SOC, the system automatically sheds loads so that it is only supporting red plugs and a resilience hub. Then, once the battery reaches its next set point at 50 percent SOC, the system automatically sheds the red plug loads and only supports the resilience hub. The system continues to support the resilience hub until the battery is drained.

At any point when the solar can charge the battery up to a level above a set point, the system would automatically add on the loads aligned with that set point. So, in the above example, if the battery dropped to 40 percent SOC but then was recharged by solar when the battery reached 50 percent SOC, it would pick up the red plug loads it had previously dropped. The addition of smart load-shedding, which was not considered in any of the analysis for this report, is estimated to cost an additional $20,000 for components, hardware, and programming for most systems.

89 Batteries that are sited indoors are typically not more than 40 kilowatt-hours in size. Outdoor batteries are usually at least 60 kilowatt-hours in size and cost more to get installed, including what it costs to add trenching, enclosures, and concrete pads, for example. Battery sizes that fall between the range of indoor and outdoor are often disproportionately expensive.

Red Plugs In Common Spaces. Instead of an in-unit red plug, it may be more cost effective for the affordable housing provider to add red plugs in common spaces, like the hallways leading to every unit. In this design, access to back-up power is not as convenient, especially for those that need it for their electricity dependent medical equipment. In this scenario, the affordable housing provider could supply each unit (or those that have electricity dependent medical needs) with a portable battery that they could charge from the common space red plugs and then use in the privacy of their own apartment. This design could also limit peak demand by limiting the number of electrical outlets that would be available and encouraging residents to conserve power by having these outlets in public spaces.

Smart Panels. For master-metered buildings, it may be possible to avoid the new wire installation completely by using "smart panels" that can automatically turn on and off selected loads. If the affordable housing provider replaces the unit's existing panel, they can allow only a single circuit to be activated, which in some cases can be done using a smartphone app. That could provide additional flexibility for the residents by allowing them to, for example, switch from powering the unit's lighting to its outlets as needed. However, this comes with its own installation cost, relies on some means of connectivity during the outage (for residents and the system), and is a less mature technological solution than direct wiring.

About Clean Energy Group

Clean Energy Group (CEG) is a national nonprofit that works to accelerate an equitable and inclusive transition to a resilient, sustainable, clean energy future. CEG fills a critical resource gap by advancing new energy initiatives and serving as a trusted source of technical expertise and independent analysis in support of communities, nonprofit advocates, and government leaders working on the frontlines of climate change and the clean energy transition. CEG collaborates with partners across the private, public, and nonprofit sectors to accelerate the equitable deployment of clean energy technologies and the development of inclusive clean energy programs, policies, and finance tools. CEG created and manages the Resilient Power Project to accelerate access to the benefits solar PV and battery storage technologies in historically marginalized and underserved communities. Learn more at *www.cleanegroup.org and www.resilient-power.org.*

CleanEnergyGroup

50 State Street, Suite 1, Montpelier, VT 05602

802.223.2554 | info@cleanegroup.org | www.cleanegroup.org