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ENERGY RESILIENCE FOR MEDICALLY VULNERABLE MULTIFAMILY AFFORDABLE HOUSING RESIDENTS:

A TECHNOECONOMIC ANALYSIS FOR CONNECTICUT

April 10, 2025

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Affordable, reliable, clean energy for all.

Climate Resilience and Community Health

Distributed Energy Access and Equity

Energy Storage and Flexible Demand

Fossil Fuel Replacement

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Health and Energy Security

Keeping life-saving services powered for medically vulnerable people.

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Florida Association of Community Health Centers

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Technical Assistance Fund

Providing technical support to build local resilience.

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USDN urban sustainability directors network

Solar installation in Puerto Rico. Credit: Solar Responders

www.cleanegroup.org/initiatives/technical-assistance-fund

Webinar Speakers

Energy Resilience for Medically Vulnerable Multifamily Affordable Housing Residents: A Technoeconomic Analysis for Connecticut

Marriele Mango
Senior Project Director, Clean Energy Group

Bryan Garcia
President and CEO, Connecticut Green Bank

Annie Harper
Assistant Professor, Yale School of Medicine Dept. of Psychiatry

Keyla Palala
People and Operations Manager, Operation Fuel

Nate Mills
Vice President of Operations, American Microgrid Solutions

Anna Adamsson
Project Manager, Clean Energy Group

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OPERATION FUEL
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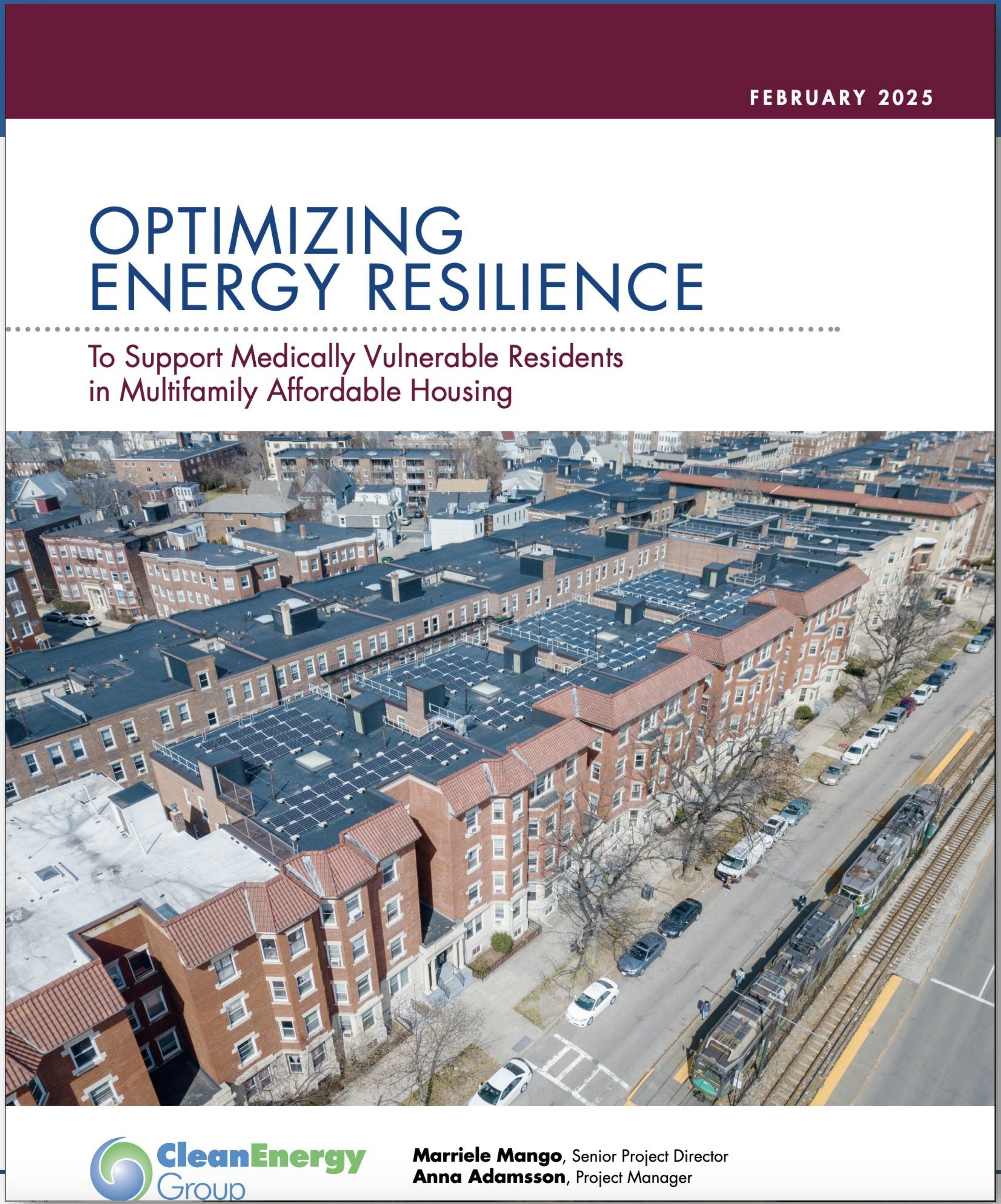
February 2025

Optimizing Energy Resilience To Support Medically Vulnerable Residents in Multifamily Affordable Housing

Marriele Mango and Anna Adamsson


FEBRUARY 2025

OPTIMIZING ENERGY RESILIENCE

To Support Medically Vulnerable Residents in Multifamily Affordable Housing

CleanEnergy Group

Marriele Mango, Senior Project Director
Anna Adamsson, Project Manager

Read the report here:
https://www.cleanegroup.org/wp-content/uploads/CT-Optimizing-Energy-Resilience-Report.pdf

BACKGROUND:
Climate Smart Technologies and the Connecticut Battery Storage Solutions Program

Photo: Clean Energy Group

Project Overview
CST and HMD for Affordable Housing

Title – Climate Smart Technology (CST) and Home Medical Devices (HMD) for Affordable Housing

Goal – Seeks to understand the investment needed in CST, including back-up power (e.g., solar, battery storage) and stable indoor temperature (e.g., efficient heating and cooling, weatherization), to enable deployment of technologies to increase resilience of tenants reliant on HMDs for their health.

Partners

Project Activates
CST and HMD for Affordable Housing

1. **Community Engagement** – Operation Fuel working with Yale, reach at least **75 affordable housing residents requiring HMDs** for **focus groups to understand how resilience can be improved** in varying adverse conditions caused by climate change.

2. **Technical Assistance –** through engineering studies by the Clean Energy Group, no less than **15 affordable housing properties** will be assessed in participating vulnerable communities in terms of **technical and economic potential for the deployment of CST**.

3. **(Finance Assistance) Technology Deployment** – where appropriate, investment by the Green Bank in the **deployment of CST through innovative, replicable, and scalable financing mechanisms.**

Energy Storage Solutions

energy storage SOLUTIONS

Why Energy Storage in CT?

Smooth out peak demand on the grid

Provide on-site backup power when needed

Regulatory Background

- PA. 21-53 established statewide goal of 1000 MW of battery storage by 2030
- Docket 17-12-03RE03 created a 9-year incentive program – Goal of 580 MW behind-the-meter storage for residential and non-residential end-use customers
- Program goal of 40% of benefits reaching Underserved customers – primarily through residential low-income or distressed municipality
- Low-Income residential will be met primarily through multifamily affordable housing

Updated Customer Class	Tranche 1	Tranche 2	Tranche 3	Tranche 4	TOTAL
Residential	**50 MW**	50 MW	50 MW	0 MW	150 MW
Commercial and Industrial	50 MW	113.9 MW	126.1 MW	140 MW	430 MW
Total	**100 MW**	**163.9 MW**	**176.1 MW**	**100 MW**	**580 MW**

Multifamily Battery Incentives

Market Rate Multifamily

- Considered "Commercial"
- **$91 to $182 per kWh**
- **Capped at 50% of total project cost**
- +25% Grid-Edge, Small Business, or Replacing Generator adder
- Additional Performance Incentives paid seasonally for 10 years

Affordable Multifamily

- Considered "Low-Income Residential" for qualified properties
- **$600 per kWh ($900 for Grid-Edge)**
- **Capped at $16,000 per unit or 50% of total project cost**
- Additional Performance Incentives paid seasonally for 10 years

More Information

More information: Energy Storage Solutions (energystoragect.com)

Contractor Application: Contractor Application (energystoragect.com)

Program Resources: Contractor Resources (energystoragect.com)

Meet with our team: Contractor Trainings & Office Hours – Energy Storage Solutions

energystorage@ctgreenbank.com

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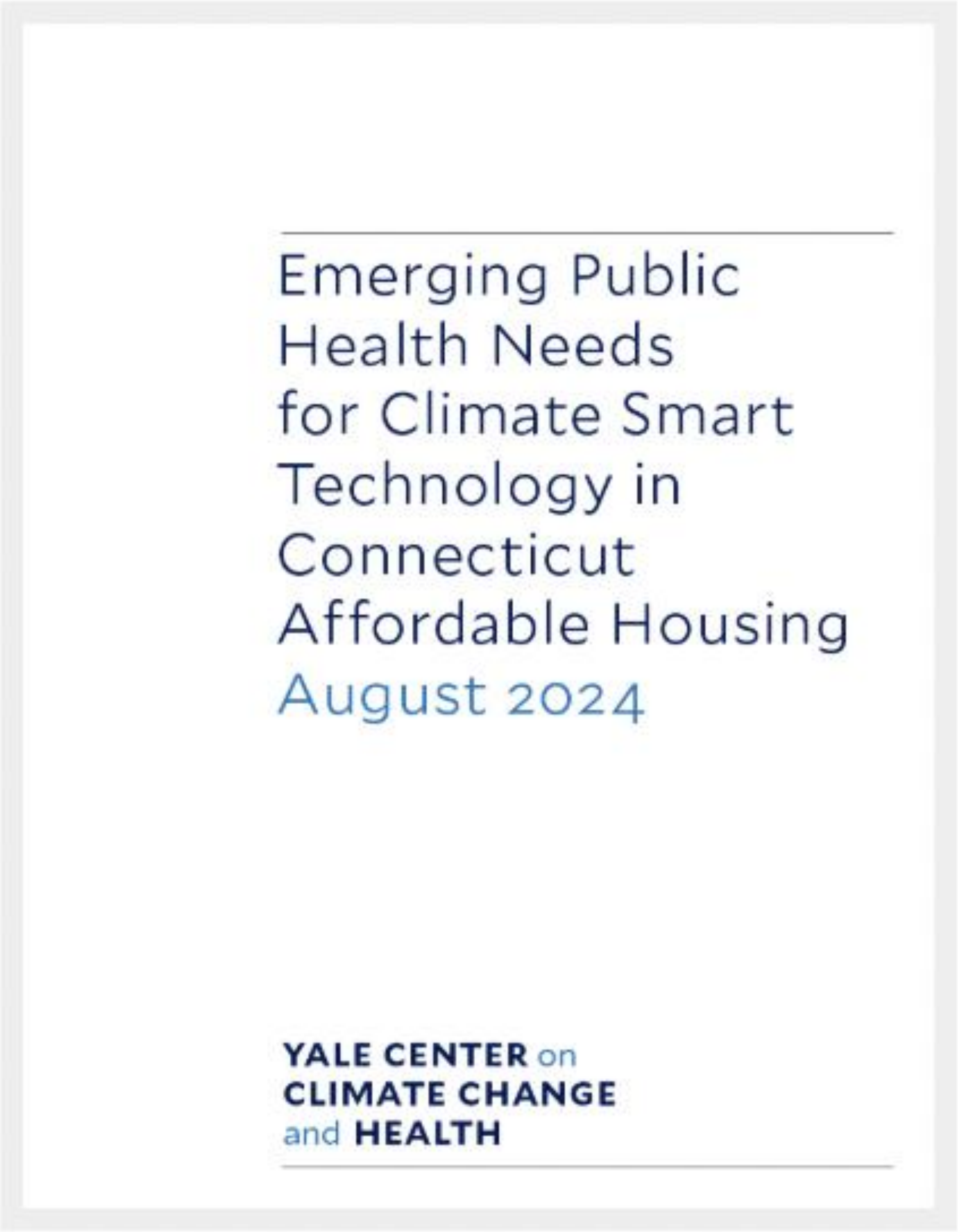
RESIDENT ENGAGEMENT:
Power Outage Concerns for Residents with Home Medical Devices


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

OPERATION FUEL

YALE CENTER ON CLIMATE CHANGE AND HEALTH

Focus Group Efforts & key takeaways:

1. Dependence on Electricity
2. Emotional Impacts
3. Financial Strain
4. Community and Preparedness
5. Broader Observations

Interviews	33
Focus Groups	9
Home Medical Device Users	78

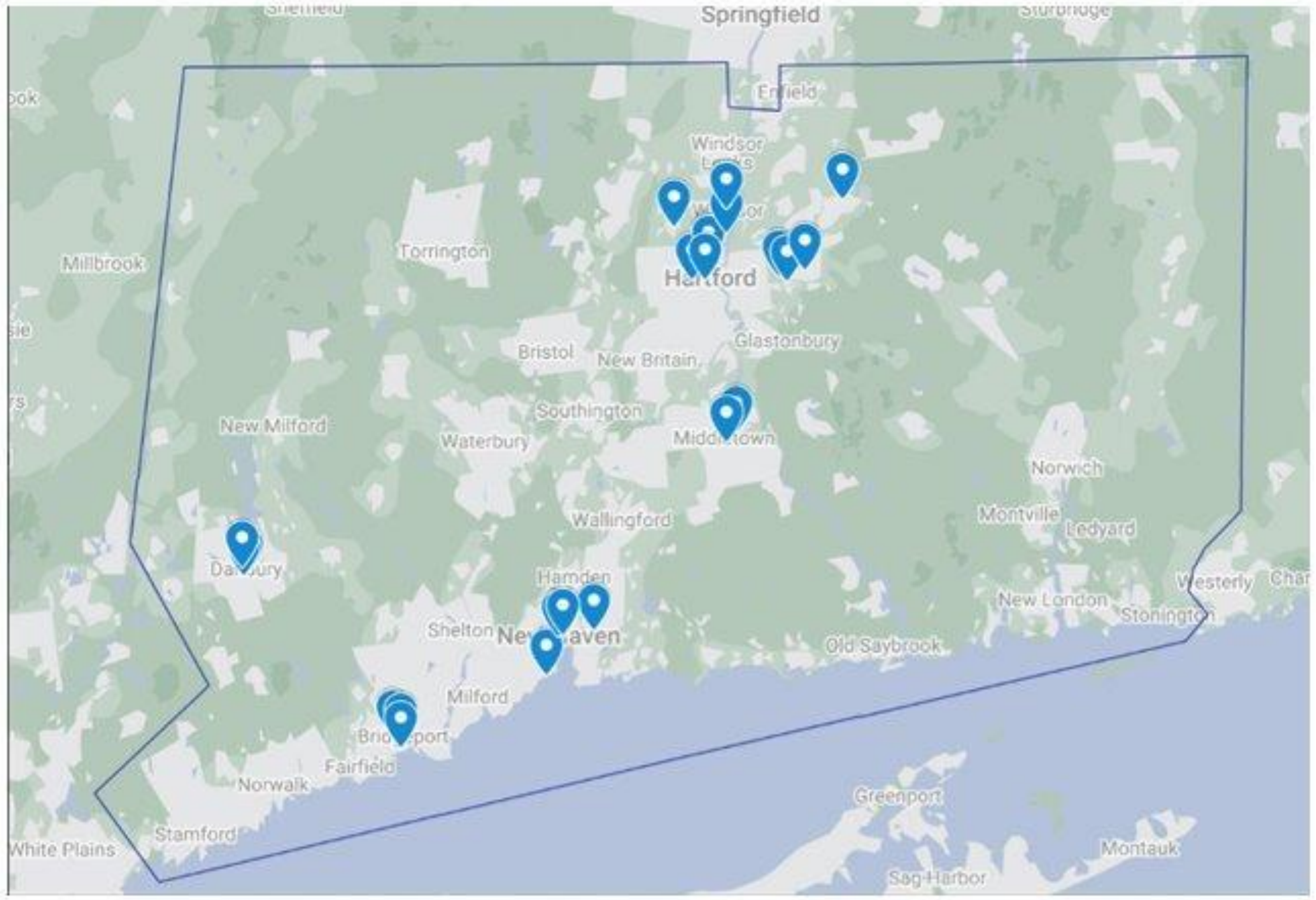


FIGURE 1: *Map of Building Locations*

Photo Caption/ Credit

Recommendations for next steps (based on feedback):

- **Expand HMD Classification:** Include devices for health monitoring, mobility, and communication.
- **Improve Awareness:** Enroll residents in utility alerts and educate them on financial protections.
- **Leverage Healthcare Support:** Engage home health aides and nurses in emergency planning.
- **Consider Backup Power Costs:** Account for financial strain on emergency services and healthcare.
- **Strengthen Emergency Planning:** Require housing providers to develop response plans and improve communication.
- **Create Safe Common Spaces:** Establish resource-equipped areas for temporary use during outages.
- **Encourage Community Collaboration:** Foster learning and support among residents and housing providers.
- **Utilize Funding & Incentives:** Access state and federal financing for implementation.
- **Invest in Resilient Infrastructure:** Promote public-private partnerships to support affordable housing solutions.

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TECHNICAL ASSISTANCE: Design and Process

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

AMERICAN MICROGRID SOLUTIONS

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Risk Score and Weatherization Assessment

ENERGY STAR® Statement of Energy Performance

Score: 71	
Building Characteristics	
Primary Property Type	Multifamily Housing
Gross Floor Area	23,848 ft2
Built	1980
Energy Consumption and Energy Use Intensity (EUI)	
Site EUI	66 kBtu/ft2
Source EUI	96.1 kBtu/ft2
Annual Energy by Fuel	
Electric – Grid	364,633 kBtu (23%)
Natural Gas	1,210,064 kBtu (77%)
National Median Comparison	
National Median Site EUI	76.1 kBtu/ft2
National Median Source EUI	110.8 kBtu/ft2
% Difference from National Median Source EUI	-13%
Annual Emissions	
Total GHG Emissions	90 Metric Tons CO2e/year

LEARN MORE AT energystar.gov

ENERGY STAR® Statement of Energy Performance

- The 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.
- ENERGY STAR® performance documents summarize important energy information and building characteristics. They can help you to:
    - Satisfy requirements for various green building certification programs, such as LEED, Green Globes, BREEAM, and IREM Certified Sustainable Properties.
    - Document performance in energy service contracts.
    - Communicate energy performance with tenants, owners, potential buyers/renters, and the general public.
    - Provide transparency and accountability to demonstrate strategic use of capital improvement funding.
    - Quickly and accurately demonstrate savings for an individual building.

FEMA Risk 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

Health Rubric

Purpose was to incorporate the health needs of residents into the solar+storage system design

Completed in partnership with the affordable housing provider prior to assessment

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

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Technoeconomic Analysis

1. Three affordable housing case study's – Small, Medium, and Large
2. Three resilient power scenarios, each designed to support the needs of electricity-dependent medical device residents
3. Economic implications of available incentives:
   - Connecticut Energy Storage Solutions
   - Connecticut Residential Renewable Energy Solutions
   - Federal Investment Tax Credit – 30% baseline and 50% adder scenarios

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

Three Resilient Power Scenarios

RP1: Solar+storage for a resilience hub

RP2: Solar+storage for in-unit "red plugs"

RP3: Solar+storage for both resilience hub and red plugs (RP1 and RP2 combined)

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ANALYSIS RESULTS

Solar+Storage Case Studies for Multifamily Affordable Housing


CASE STUDY 1

SMALL Multifamily Affordable Housing Facility

Description: The small MFAH case study represents properties that have 6–20 units.

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.

CASE STUDY 2

MEDIUM Multifamily Affordable Housing Facility

FIGURE 2

CASE STUDY 3

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 $476,581	Cash Flow $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 $354,354	Cash Flow $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 $509,463	Cash Flow $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/Meentimeter

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Considerations for Resilience Hubs

- Installation Cost:
  - Calculated based on prior experience
  - Costs are not proportional to size
  - Assumed outdoor installation in all cases
  - Solar is essentially independent economically

- Resilience Hub Use:
  - Estimated according to building type, actual bills, and physical/electrical layout
  - Adjusted based on health rubric (e.g., elevator inclusion)
  - Controllable uncertainty in usage
  - Centralized space for residents to gather

USDN: https://resilience-hub.org/what-are-hubs/

Considerations for Red Plugs

- Installation Cost:
  - Estimated flat rate per unit
  - Aesthetics can be harder to manage in retrofit vs. new construction
  - Master-metering vs. individual metering
  - Red plugs in common areas (e.g., hallways) may be a cost-effective alternative

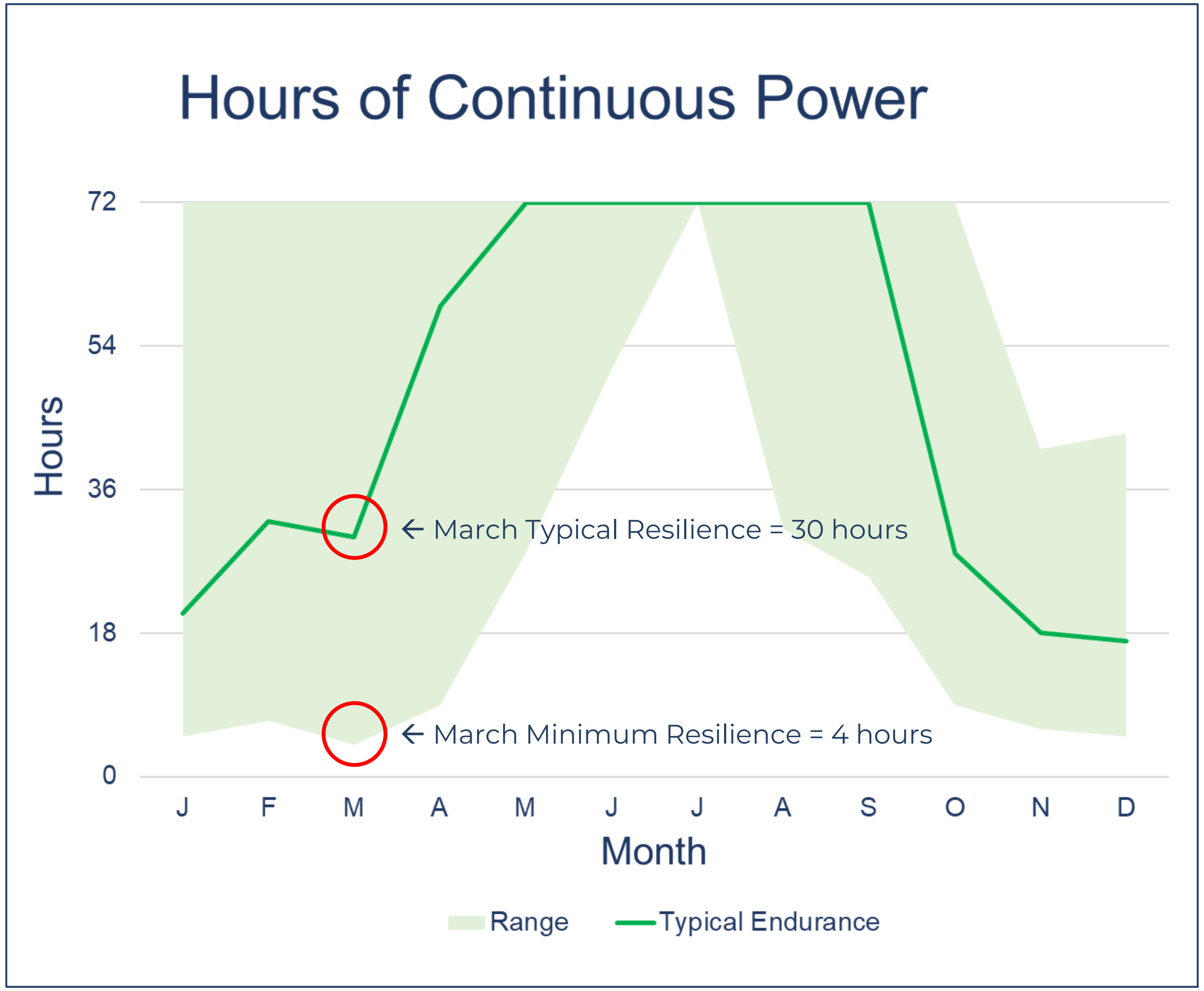
- Red Plug Use:
  - Estimated average use of 200 W / unit
  - Actual usage will vary, and is difficult to enforce – this is an electrical as well as forecasting challenge

Shutterstock/Badon Hill Studio

Typical Resilience vs Minimum Resilience

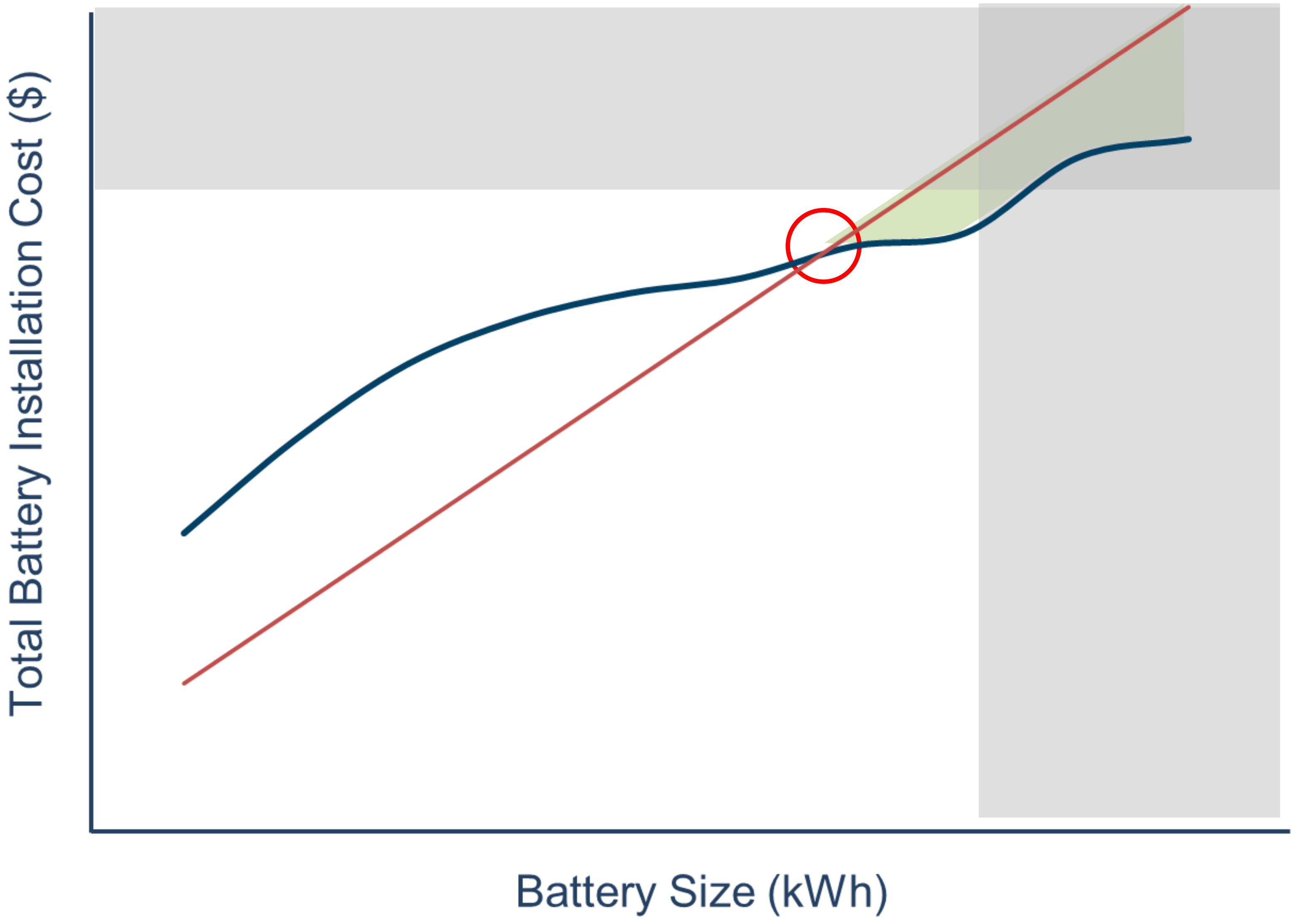
- Resilience varies on multiple time scales – hourly and seasonally

- Typical resilience:
  - The median result of all simulations over the course of the year (shown by month here)
  - Months with lots of sun and low load may achieve essentially indefinite resilience.
- Minimum resilience:
  - The worst-case forecasted combination of high load and low solar production.
  - This could be just a small period during the entire year –sometimes just a 1 or 2-hour window.



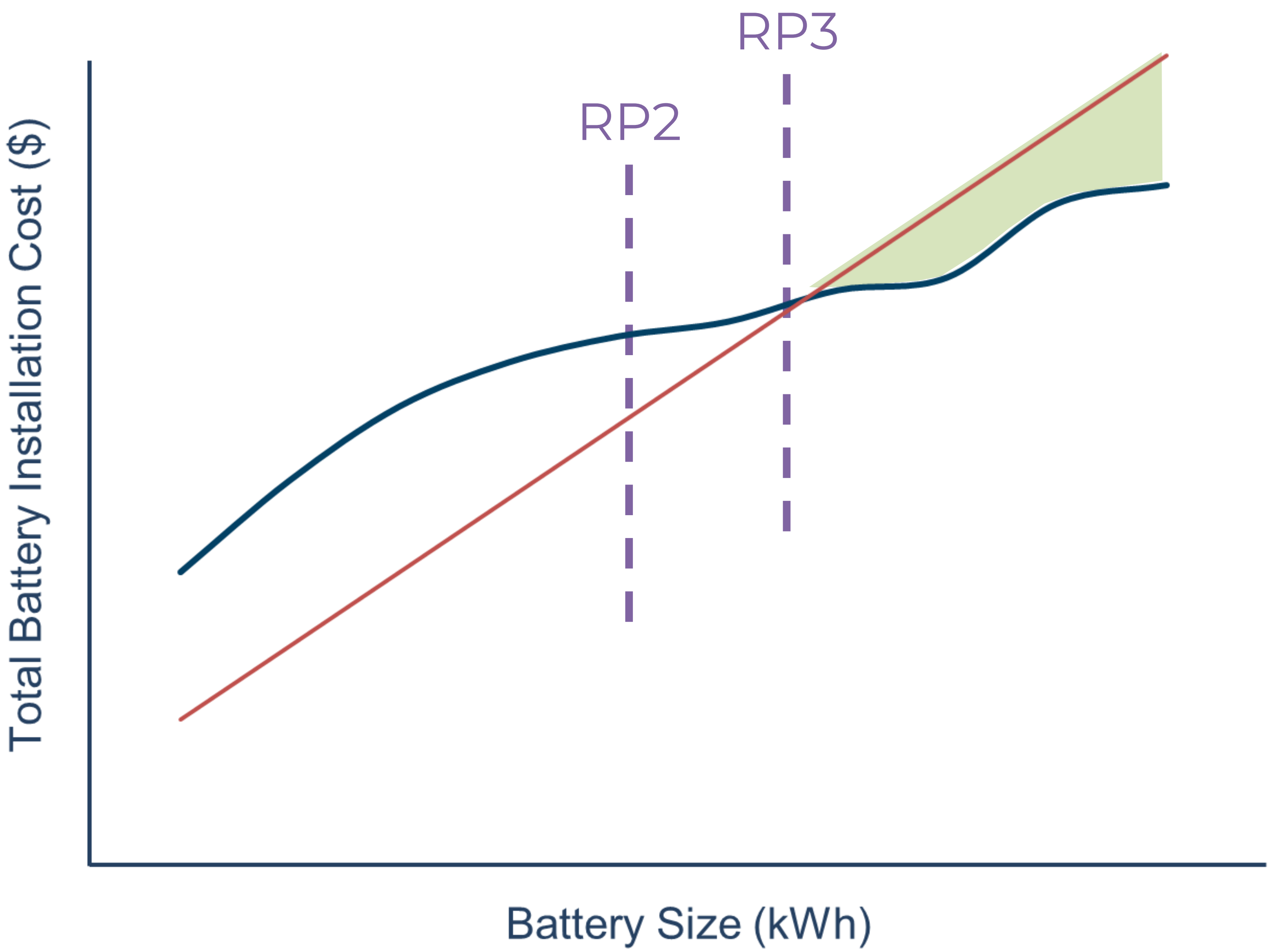
Evaluating Project Cost and Project Incentives

- Battery costs taper at large size, with a large portion of the initial cost essentially fixed.
- CT incentive revenues are depicted, with larger batteries offering proportionally higher revenues.
- There are limits at both the high and low ends of the graph based on facility limitations and system effectiveness.



Case Study 3: Large MFAH

- RP1 - Resilience Hub:
  - System: 130 kW solar & 125 kW / 330 kWh battery
  - CapEx: $953,000
  - Payback: 8.5 Years
  - Cash Flow: $610,000 without ITC adders
- RP2 - Red Plugs:
  - System: 130 kW solar & 90 kW / 185 kWh battery
  - CapEx: $818,000
  - Payback: 9.9 Years
  - Cash Flow: $515,000 without ITC adders
- RP3 - Resilience Hub & Red Plugs:
  - System: 130 kW solar & 200 kW / 558 kWh battery
  - CapEx: $1,128,000
  - Payback: 7.8 Years
  - Cash Flow: $641,000 without ITC adders



Case Comparison

	Case 1	Case 2	Case 3
CT ESS offset	37%	60%	67%
Utility offset	(34%)	11%	46%
OPEX adds	(43%)	(41%)	(45%)
Solar offset	(9%)	51%	86%
Total	**(49%)**	**81%**	**154%**

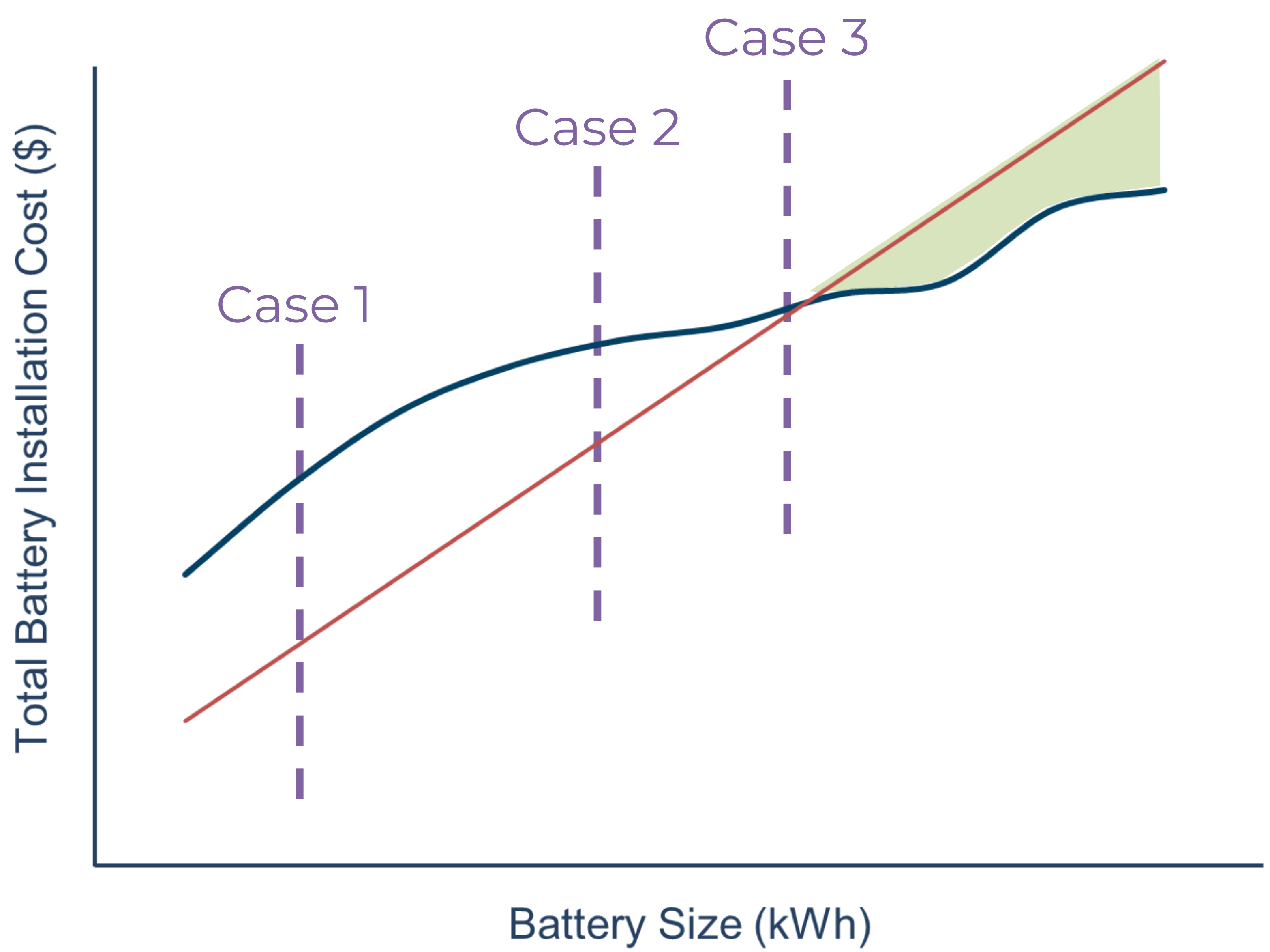
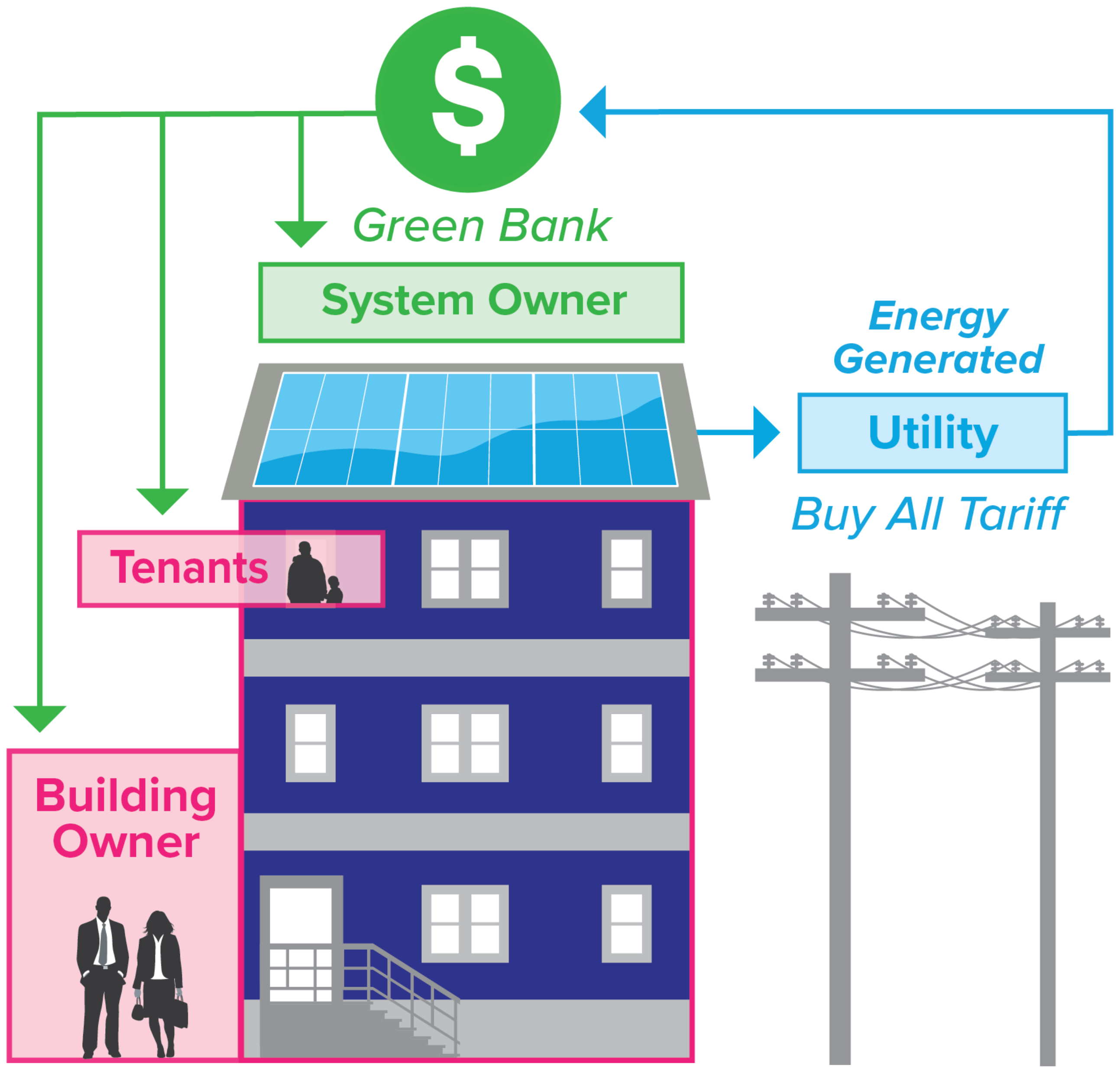


Photo Caption/ Credit

Green Bank Multifamily Affordable Housing Solar Lease

- Structured as a revenue share agreement to allow tariff revenue to System Owner, Property Owner, & Tenants
- No capital requirement from property owner
- Tenants receive credits on their electric bill from production (i.e., RRES)
- Green Bank owns and maintains asset, and bears risk



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Case Study #3: Large Solar + Storage

Large Solar + Storage		
Technology	Solar	Storage
System Size (kW)	130 KW DC	125 KW
Year 1 Production (kWh)	158,366 kWhs	330 kWh
System Cost ($)	$953,163	
ITC Assumption	30% ITC	

Cumulative Financial Benefit: $90,853	**Tenant $171,189***	**Property Owner $90,853**
Resident Share of Tariff	*$0.00. Site is master-metered so the tenant benefit is the Net Present Value (NPV) of 25% of the tariff, provided to tenants as an upfront upgrade. **The 25% NPV of the tariff is $171,189 and is modeled as reduction in the battery cost**.	
Property Owner Share of Tariff	$4,822 year 1 (8.4%)	

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KEY TAKEAWAYS

"The results from the analysis indicate that supportive policies and programs…can both result in improved project economics for solar+storage and also encourage more robust systems and energy resilience solutions for medically vulnerable populations."

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

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	50% ITC	Cash Flow
125 kW/330 kWh	$953,163	$285,949	$610,164	$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	50% ITC	Cash Flow
90 kW/185 kWh	$818,020	$212,612	$514,601	$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	50% ITC	Cash Flow
200 kW/558 kWh	$1,128,239	$305,678	$640,518	$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.

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.

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Comprehensive Incentive Programs Include Technical Assistance

Summary Results

	Solar-Only	Resilient Power$_1$ Critical Loads	Resilient Power$_2$ Critical Loads + Red Plugs
Solar	64 kW	64 kW	64 kW
Battery	--	60 kW / 185 kWh	90 kW / 246 kWh
Generator (existing)	75 kW	75 kW	75 kW
Financial (forecasted)			
Capital Cost	$316,074	$681,474	$801,791
Capital Cost After ITC Rebate	$189,645	$408,884	$481,074
Y1 Utility Savings & Incentives	$26,927	$153,494	$194,869

Battery

The battery is selected to provide at least four hours of backup power without the generator

Solar

Storage

Design	Resilient Power$_1$	Resilient Power$_2$
Power	60 kW	90 kW
Energy	185 kWh	246 kWh
Turnkey Installation Cost	$1,980 / kWh ($365,400)	$1,974 / kWh ($485,716)
O&M (software, maintenance)	$3,738 / year	$3,984 / year
Inverter/Module Replacement, year 12	$53,445	$73,710
Operating Incentives	CT Energy Storage Solutions	
Location	Outside enclosure	
Chemistry	Lithium-ion battery	
Applications	✓ Peak shaving ✓ Resilience ✓ Demand Response Participation ✓ Time-of-Use Management	
Notes	• All designs are preliminary and conceptual • The additional effort required to place the battery modules on an elevated platform is included in the price forecast. • The overlap between loads supported by the generator and those supported by the battery is unknown; this analysis assumes that the battery operates independently of the generator.	

(Note: this analysis is vendor-agnostic, and the example shown is meant to be representative, not a product recommendation).

Pilgrim Towers

25 Washington Court,
Stamford, Connecticut 06902

Resilient Power Feasibility Analysis

September 2024

American Microgrid Solutions

AMERICAN MICROGRID SOLUTIONS

CleanEnergyGroup

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

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**

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

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**

CleanEnergyGroup

Thank You

Marriele Mango
Project Director
Clean Energy Group
Marriele@cleanegroup.org

Anna Adamsson
Project Manager
Clean Energy Group
Anna@cleanegroup.org

Upcoming Webinars

Load Growth and Electric System Reliability (April 22)

A Climate Resilient Energy Code for Multifamily Affordable Housing (April 29)

Solar+Storage Financing Options for Nonprofits (May 7)

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www.cleanegroup.org | info@cleanegroup.org