

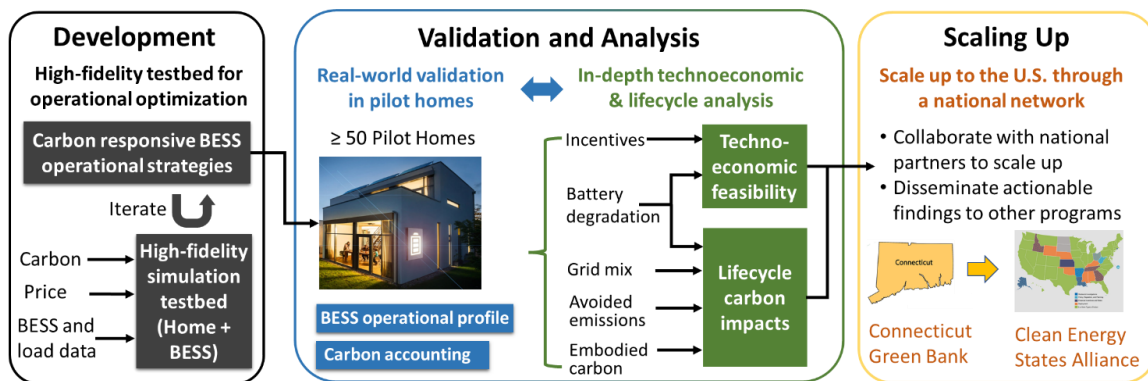
Buildings Energy Efficiency Frontiers & Innovation Technologies (BENEFIT) – 2022/23	
FOA: DE-FOA-0002788	
Concept Paper	
Project Title:	Equitable Deployment and Carbon-Responsive Operation of Battery Energy Storage Systems for Achieving Net-Zero Emissions in Connecticut and Beyond
Topic Area:	Subtopic 3B: Net-zero Emissions BESS Validation and Analysis
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Team Member Organizations:	<u>Core Team:</u> <ul style="list-style-type: none">• University of Connecticut (UConn)• National Lab: National Renewable Energy Laboratory (NREL)• Green Bank: Connecticut Green Bank• Utilities: Eversource Energy, Avangrid <u>Industry Partners:</u> <ul style="list-style-type: none">• Battery Manufacturers: Sonnen, Generac• Energy Service Company: EnergyHub, Enbala, Sunnova• Carbon Data Provider: Singularity Energy <u>Partners to Scale Up Solution:</u> <ul style="list-style-type: none">• Clean Energy States Alliance• Coalition for Green Capital• Smart Electric Power Alliance

A. Technical Description

Proposed Technology: The team proposes to develop, and field demonstrate a scalable solution for equitable deployment and carbon-responsive operation of battery energy storage systems (BESS) to achieve net-zero carbon emissions while retaining economic and resilience benefits. This project will build on ongoing research by UConn and NREL as well as Connecticut’s [Energy Storage Solutions](#) (ESS) program. ESS program is co-administered by the Connecticut Green Bank, Eversource Energy, and Avangrid to support the deployment of 580 MW of BESS to residential and commercial customers with a minimum of 40% of residential systems to be deployed in low-income homes or vulnerable communities. This project will: 1) leverage data from utility partners’ existing fleet of 850+ BESS to develop a high-fidelity testbed to evaluate carbon-responsive operational strategies and quantify the tradeoffs among emission reduction, energy affordability, and grid benefits; 2) build on the existing ESS program that offers a zero-down leasing program for underserved communities as well as incentives for all participating households to recruit at least 50 pilot homes, field validate the carbon-responsive BESS operation, and track avoided emissions in real time; 3) perform in-depth technoeconomic and lifecycle analyses incorporating factors such as embodied carbon, BESS life degradation, future grid mix, incentives, and financing programs; and 4) collaborate with Clean Energy States Alliance, Coalition of Green Capital, and Smart Electric Power Alliance to disseminate the learning and scale up the impact nationally.

Current State-of-the-Art, Challenges, and Solutions: Despite successes in load shifting and resilience, BESS deployment faces the following limitations and challenges:

- **Increased Emissions:** Current BESS deployment programs prioritize dispatching BESS to reduce peak demand. This results in BESS being a net source of emissions over its lifetime.
- **Misaligned Use Cases:** Today, residential customers primarily adopt BESS for outage support. Prioritizing resilience may negatively impact economics (utility bill savings) and emissions.
- **High Upfront Cost:** High upfront cost is the main barrier to wide adoption of BESS. Low-income customers or those in vulnerable communities are less likely to be able to afford BESS.



As depicted in the diagram, our proposed solution can effectively address those challenges by:

1. **Operational optimization of BESS for enhancing carbon reduction, energy affordability, and grid benefits.** Using existing BESS fleet data from the ESS program, we will develop a high-fidelity BESS testbed based on NREL’s [OCHRE™](#) tool to refine the team’s earlier work on [carbon-responsive operational strategies](#) that charge/discharge BESS following grid carbon intensities. We will incorporate load profile, utility rate structure, occupant behavior, grid generation mix, and BESS degradation in the testbed. We will work with Energy Service

Company partners such as EnergyHub and Enbala to implement carbon-responsive operation strategies to balance tradeoffs among decarbonization, affordability, and demand flexibility.

2. **Real-world validation of operational strategies in a pilot program.** We will design an equitable pilot program to demonstrate how carbon emission reduction can be incorporated into a BESS response program, such as Connecticut’s ESS. We will evaluate how utility bills and demand flexibility would be impacted by incorporating an emissions-focused lens into a BESS program. At least 40% of pilot homes will be recruited from underserved communities and the team will use a zero-down-payment leasing model to ensure BESS affordability. All participants are eligible for ESS’s upfront and performance-based incentives. The avoided carbon emissions will be tracked based on BESS operational data and grid generation mix.
3. **In-depth technoeconomic and lifecycle analysis on net-zero emission operation.** Using forecasted future grid mix data from [NREL’s Cambium tool](#) and the baseline Connecticut emissions data, the team will evaluate lifecycle carbon impacts and technoeconomic feasibility for net-zero emissions BESS operation. We will collaborate with battery manufacturers to quantify the embodied carbon of typical lithium-ion BESS, evaluate the avoided emissions under various decarbonization scenarios, and identify potential gaps for BESS to achieve net-zero emissions operation. We will also work closely with the Green Bank to optimize incentive program design to maximize customer participation and retention.
4. **Scaling up from Connecticut to the U.S. through a national network.** We will collaborate with national partners to ensure that our findings are actionable for other BESS programs, such as Clean Energy States Alliance, the Coalition for Green Capital, and the Smart Electric Power Alliance. We will disseminate the learning via webinars and community outreach.

Target Level of Performance: We plan to achieve the following targets by the end of the project:

- **Equity:** Ensure **at least 40%** of the pilot homes are from underserved communities.
- **Real-time carbon accounting:** Track avoided emissions at **15-minute or better** resolutions.
- **Net-zero emission operation:** Lifecycle carbon impact analysis showing the avoided carbon emissions from carbon-responsive operation can **offset 100% of embodied carbon** in BESS.
- **Payback time:** **0% increase in payback time** for customer-owned BESS while participating in the carbon-responsive operation program and providing decarbonization benefits.

B. Impacts

Potential Impact: The team will produce a framework for state and utility BESS program administrators to quantify the cost effectiveness (both to the adopter and to the program administrator) of BESS programs that target net-zero carbon emissions, flatten load curves, and enhance resiliency, especially in underserved communities. The pilot program can yield a novel, scalable financing tool to accelerate BESS adoption while achieving the carbon emission reduction goals set by utilities and state governments.

Risks and Mitigations: The greatest risk to the project is customers’ willingness to participate in the field pilot program and adopt the proposed technology. The team plans to mitigate this risk by leveraging existing ESS customer engagement networks, customer education, and incentives.

EERE Funding Impact: EERE funding will not only support the field demonstration of innovative BESS operational strategies and tools for addressing energy affordability, utility needs, and BESS carbon emission impacts, but also advance the development of innovative and scalable financing tools to accelerate the equitable deployment of BESS, in particular in underserved communities.

Addendum (Team, Experience, Facility)

Research Team:

UConn will be the primary recipient of the award and coordinate with other team members. Dr. Junbo Zhao will serve as the PI. He has extensive experience with BESS-grid integration and building energy efficiency via projects funded by DoD ESTCP and DOE. He also holds a joint appointment at NREL. Dr. Amy Thompson has been funded by BTO and Eversource Energy for building energy efficiency and SmartBuildings CT program. Dr. Ravi Gorthala is an expert in energy efficiency and building energy system management with projects funded by DOE and industries.

NREL develops tools such as OCHRE™ (control-oriented building energy modeling) and Cambium (future grid mix forecast) and also has strong expertise in BESS lifecycle analysis that accounts for embodied carbon and life degradation. Dr. Xin Jin, the Sensors & Controls lead of NREL's Buildings Program, has led multiple DOE projects on building-grid integration and building/BESS controls.

Energy Storage Solutions Program Administrators:

Eversource Energy has a rich history of collaboration with UConn on projects in improving building energy efficiency, grid resiliency and reliability. Eversource's SMART program is the first in the nation to provide additional incentives for solar installations that include energy storage.

Avangrid is an energy services and delivery company and serves about 3.1 million customers throughout New England, and New York in the United States.

The **Connecticut Green Bank** is the nation's first green bank established by the Connecticut General Assembly in July 2011. The Green Bank seeks to support the equitable deployment of cleaner, less expensive, and more reliable sources of energy.

Industry Advisory Team:

Singularity Energy is a carbon emission data company that provides high-granularity (15-minute resolution; 5-minute resolution for some regions) grid emission data, and a suite of innovative products such as developer APIs, and intelligent tools for grid operators, utilities, and service providers to build data-driven decarbonization solutions. Singularity Energy has been a carbon data provider for Eversource Energy and will support the carbon accounting work in this project.

Sonnen and **Generac** are leading BESS manufacturers for homes and small businesses. **Sunnova** is one of the largest residential battery and solar installers and a leading Energy as a Service (EaaS) provider. **EnergyHub** and **Generac** are each currently providing BESS dispatch platforms to ESS. Those partners will support the validation and analysis work of this project by providing BESS operation data, access to BESS control, and relevant data on embodied carbon of BESS.

Potential Partners to Scale Solution:

The **Clean Energy States Alliance** is a national, nonprofit coalition that works with state leaders, federal agencies, industry representatives, and other stakeholders to develop clean energy programs and inclusive renewable energy markets and facilitates the sharing of best practices between state program administrators. The **Coalition for Green Capital** supports the development of Green Bank finance institutions and facilitates the sharing of best practices between banks. The **Smart Electric Power Alliance** is a nonprofit organization that envisions a carbon-free energy system that is safe, affordable, reliable, resilient, and equitable and facilitates the sharing of best practices on clean technology.