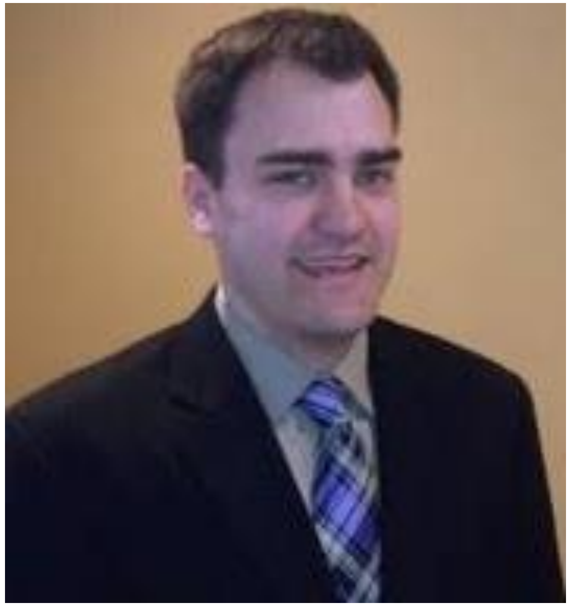

Technology Showcase: Electric Vehicle Innovation at the National Renewable Energy Laboratory

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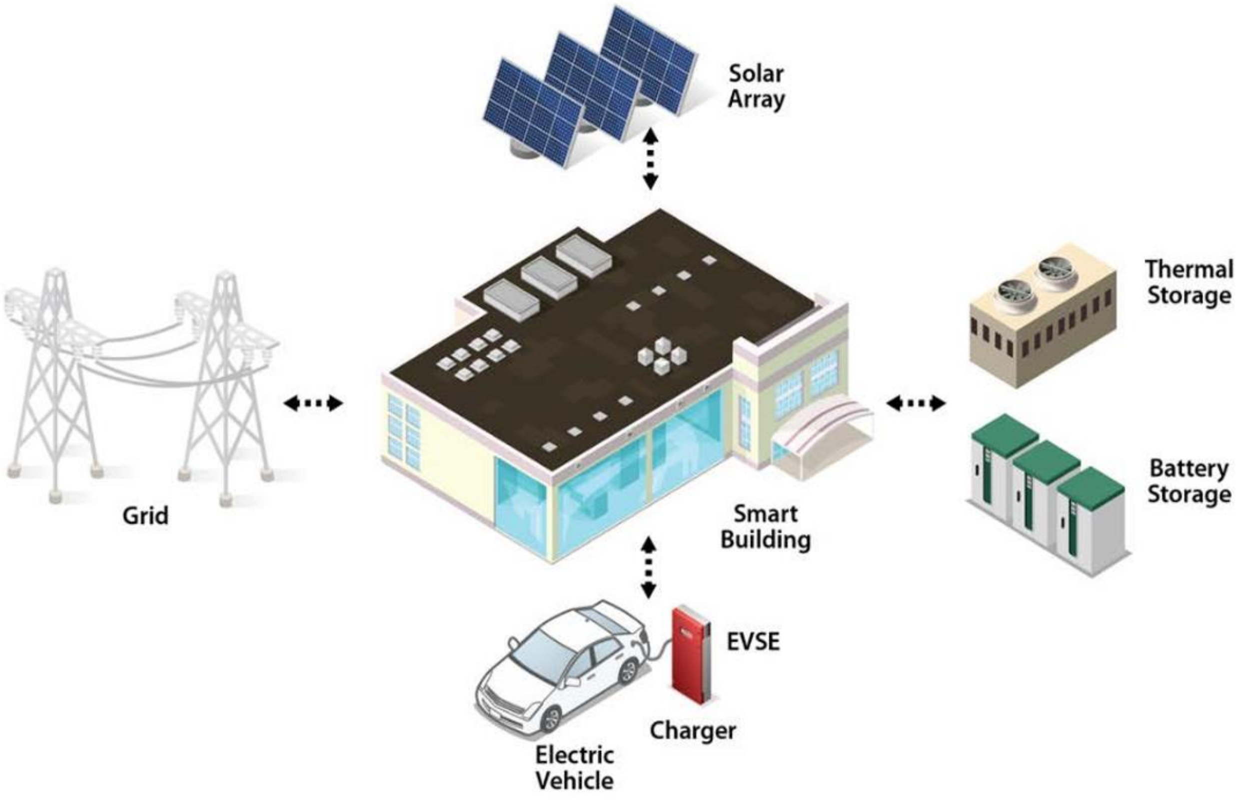
Problem Statement

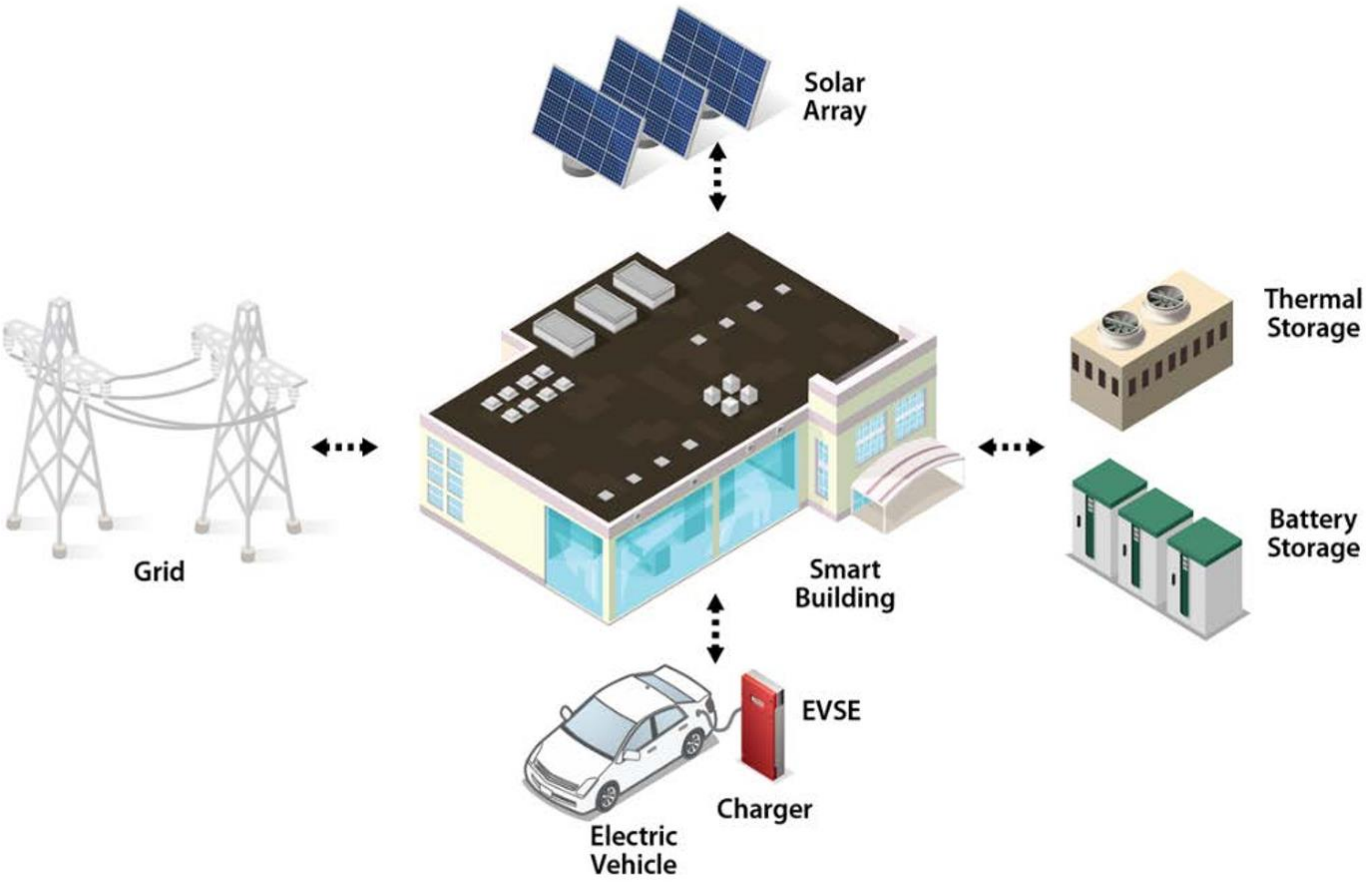
- **Electric Vehicles** may become the largest growth area for electrical load.
- Distributed energy resources such as **energy storage** and **photovoltaics** will increasingly be installed with **EV charging equipment** within buildings.

To mitigate the impact of these trends on the electric grid, we need an integrated research platform to investigate:

- **Intelligent efficiency**
- **Advanced controls**
- **Interoperability**
- **Demand flexibility**



The Electric Vehicle Research Infrastructure (EVRI), Commercial Buildings Research Infrastructure (CBRI) & Behind-the-meter Storage (BTMS)



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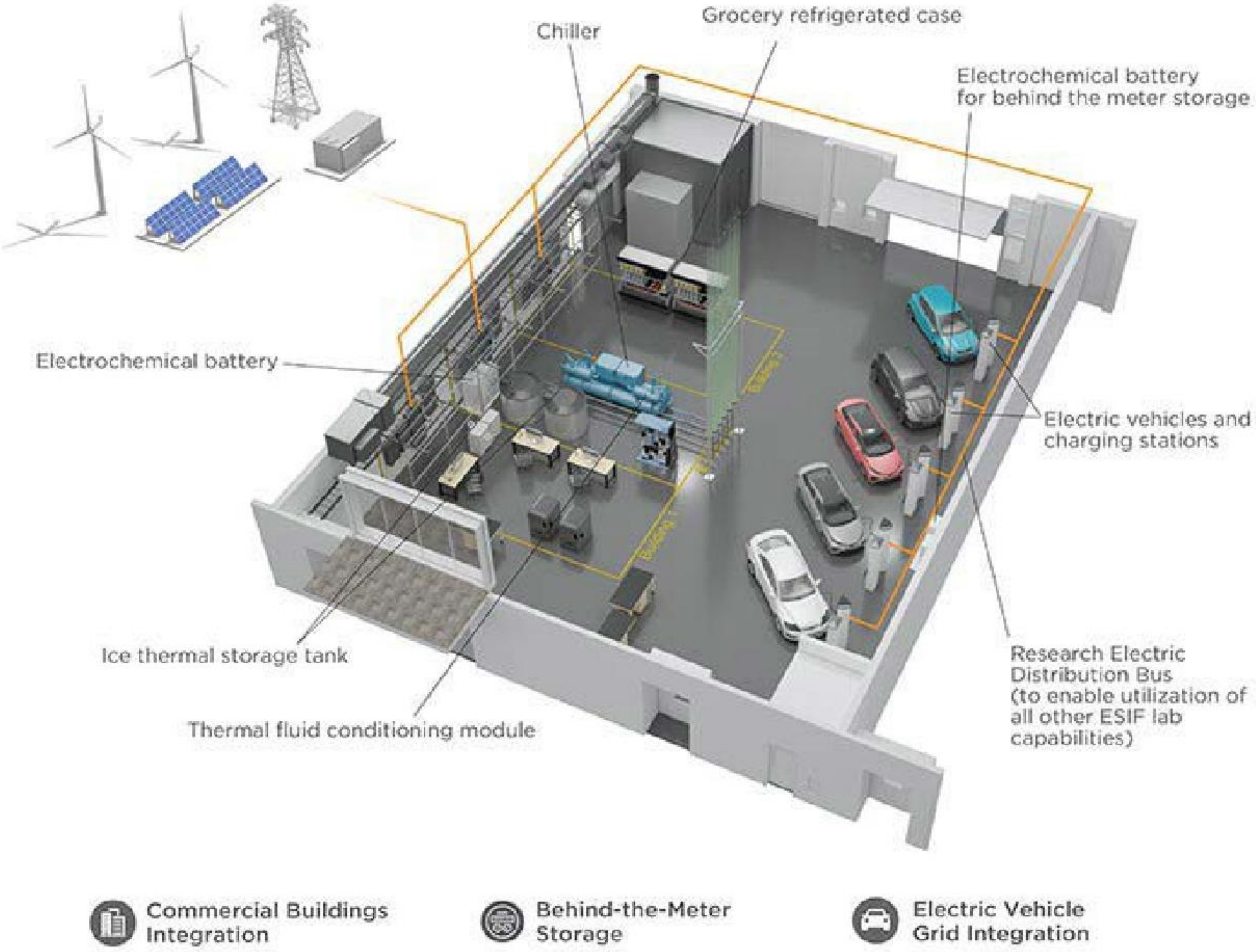
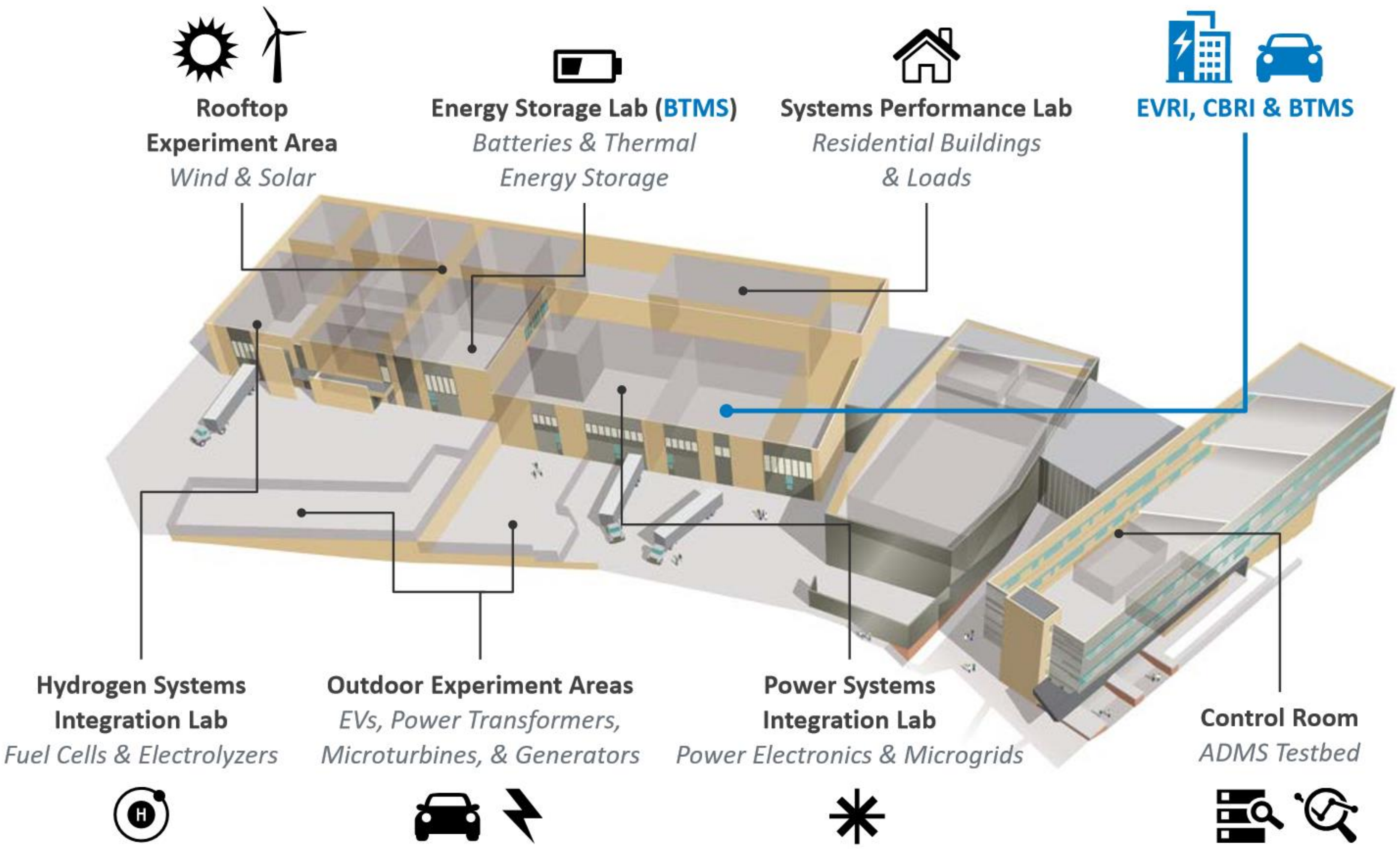


Unique Resources for Grid Integration

- **2-MW emulation** capabilities with varying generation sources
- EVRI - electric vehicles, capability emulate and chargers (L1 to 350+ kW)
- CBRI - Capability to dynamically emulate air-side and water-side conditions for **HVAC & R equipment**
- Electric and thermal connections to other laboratories
- Connected to Advanced Research on Integrated Energy Systems **(ARIES)**.

Energy Systems Integration Facility (ESIF)

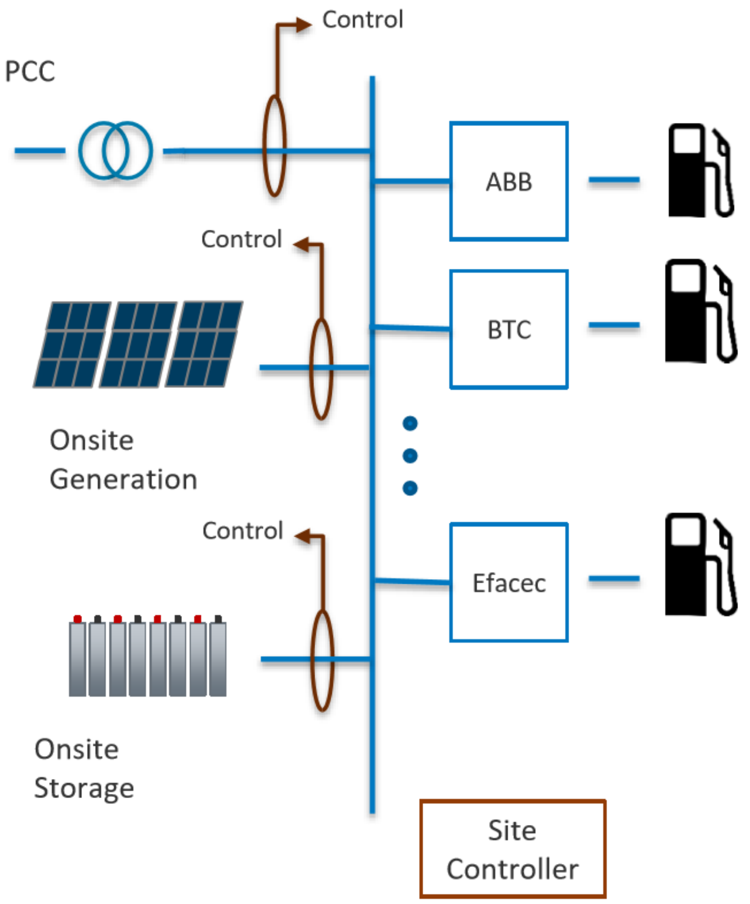


NREL

Extreme Fast Charging (xFC)

EVRI Capabilities at NREL's Energy Systems Integration Facility

Development of integrated control of XFC station / site



Load and generation estimation is required for optimal energy storage integration

- **XFC load** will vary depending on charging infrastructure and travel patterns
- Onsite **renewable generation** will be dependent on regional conditions

Control integration is required for energy system and onsite generation management

- **Interoperability** of communication and control across different vendor XFC systems.
- Resolving **multi-objective optimization** across the site, transportation, and grid interface.

Electrical Infrastructure:

- Up to 1 MW of connected EV charging
- Two 480V Sites with 208/120 V or 240/120 V transformer and panels

Charging Equipment:

- Four 350 kW DC Charging Systems from ABB, BTCPower, Efacec, and Tritium
- Up to four 50 kW charging systems with Tritium and Coritech V2G in lab.
- Connections for 100 kW and 30 kW DC charging as well as AC Level 2 and Level 1 at four stalls.

Distributed Energy Resources:

- Directly integrated 30 kW / kWh Li-ion Stationary Storage and 30 kW PV

Hardware-in-the-Loop:

- AC-side grid emulation capability through ESIF RED-B 1 MW or 200 KW Systems
- DC-side vehicle emulation capability through 500 kW or 250 KW Systems

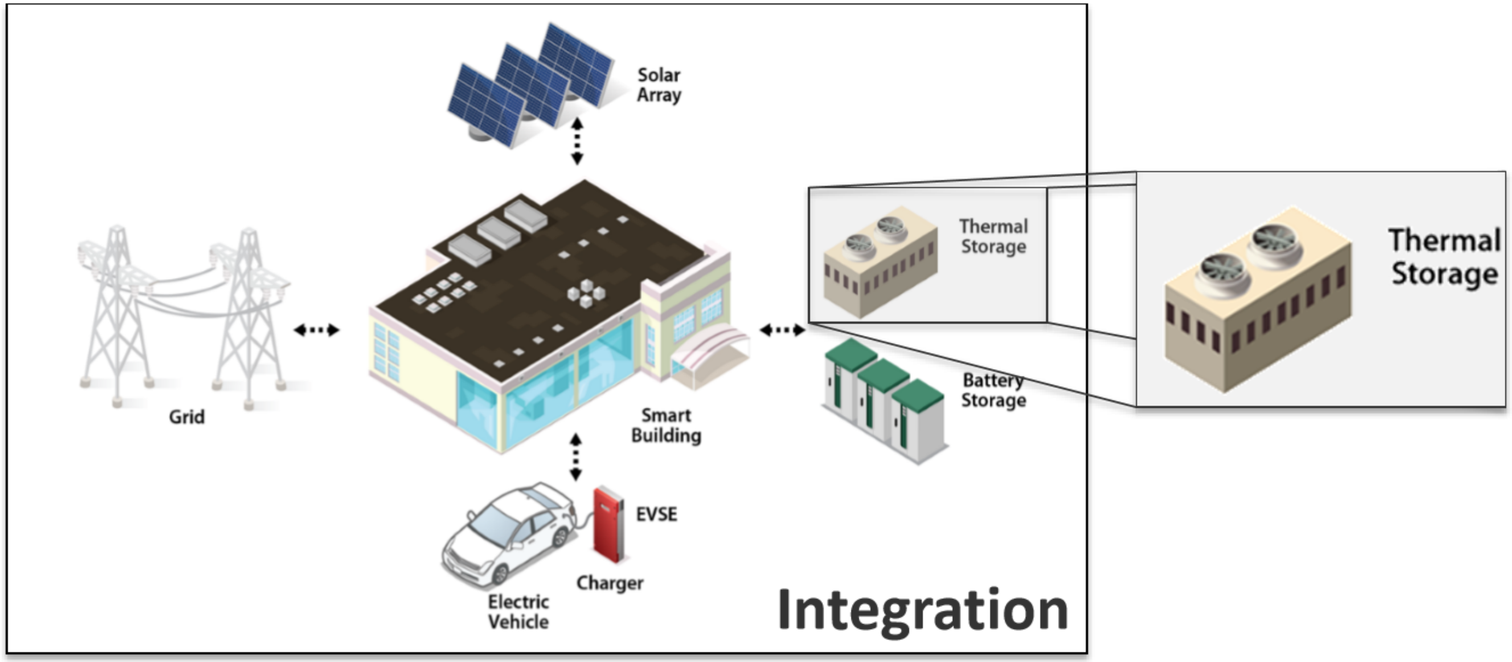

Digital Real Time Simulator (Opal-RT)
Site Controller
480 V System
Metering and AC Grid Interface
208 V System
Charging Emulation Interface
Charging Emulation Interface

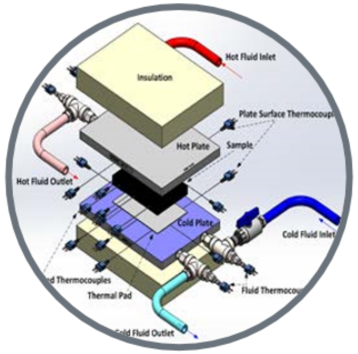
Behind-the-Meter Storage

A focus on novel critical-materials-free batteries for EV charging, solar power, and energy-efficient buildings

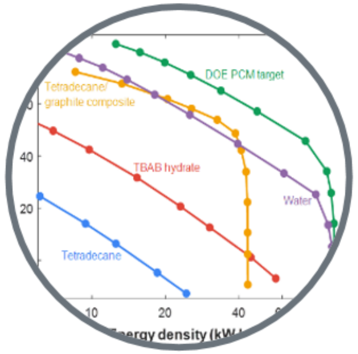
Behind-the-meter storage (BTMS)

Early-stage research guided by system level thinking

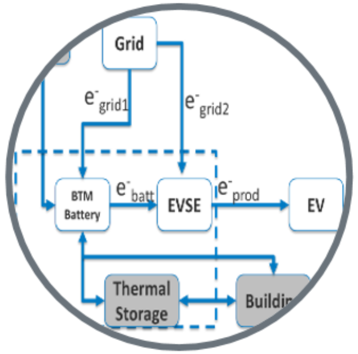




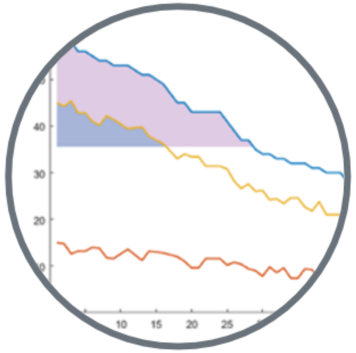
Multi-scale characterization techniques



Material target determination



Integrated system model



Optimal design and control of BTMS

Integration experiments


EV chargers
Thermal storage tank
(560 kWh$_{th}$)
Li-ion battery
(40 kWh$_e$)
30-ton
chiller
Building management
system (BMS)

BTMS Integration Experiments

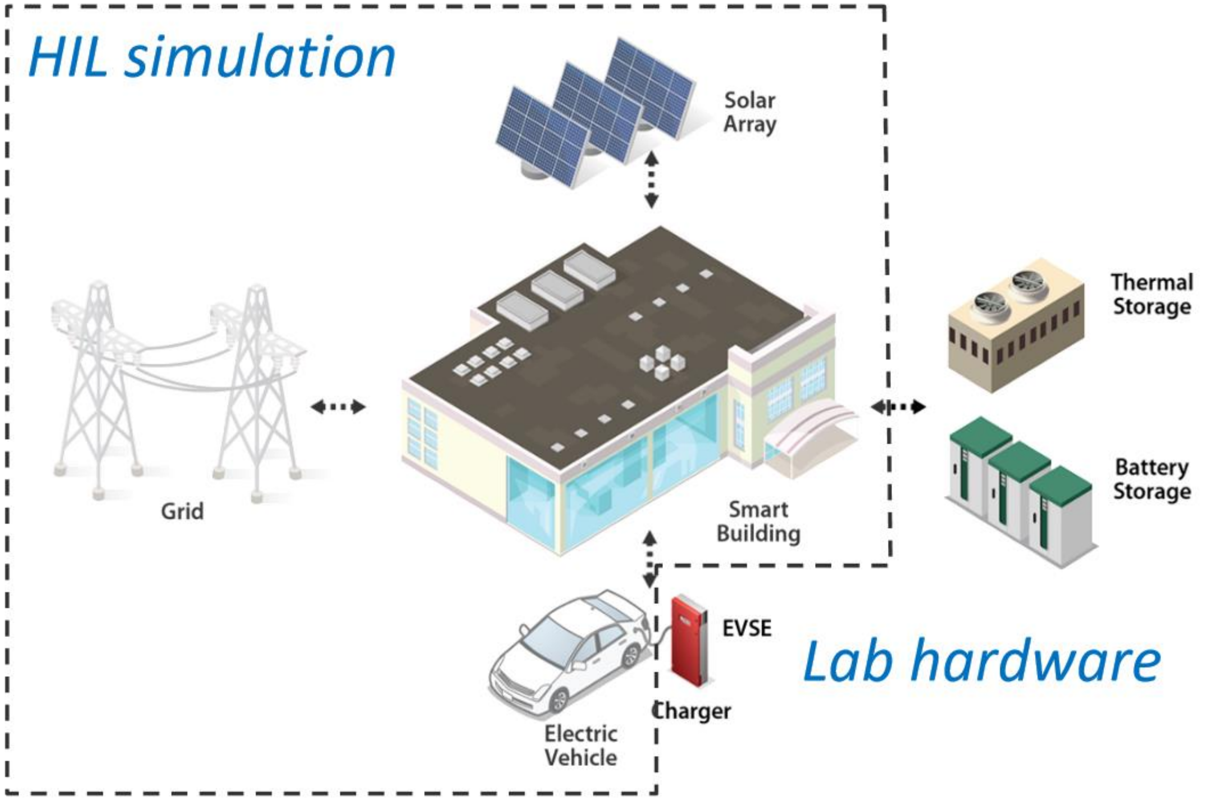
High-level research question:

- What is the optimal combination of thermal and electrochemical BTM storage?

Modeling used for optimization, but need experiments to answer:

1) How do we connect disparate control systems from each BTM resource to ensure system-level optimal control?
2) Are the simplifying assumptions in building and grid models adequate to predict the impact of electrochemical and thermal energy storage?

BTMS Integration Experiments



Thank You

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NREL Transforming ENERGY

PEV HIL Simulator – DC Fast Charging (0- 660 kW)

DC Fast Charging Simulator will allow for PHIL simulations to emulate LD and MD vehicles up to 660kW DC charging power with any battery size. Experiments for both PEV and EVSE charging control will be enabled with this capability. Evaluations of control and communication methods at the PEV – EVSE interface and EVSE – Grid will allow for full system research and development activities. This platform could be leveraged for electrification motor and inverter projects to analyze driveline technologies