NREL
NATIONAL RENEWABLE ENERGY LABORATORY

PEV Grid Integration Research

Vehicles, Buildings, and Renewables Working Together

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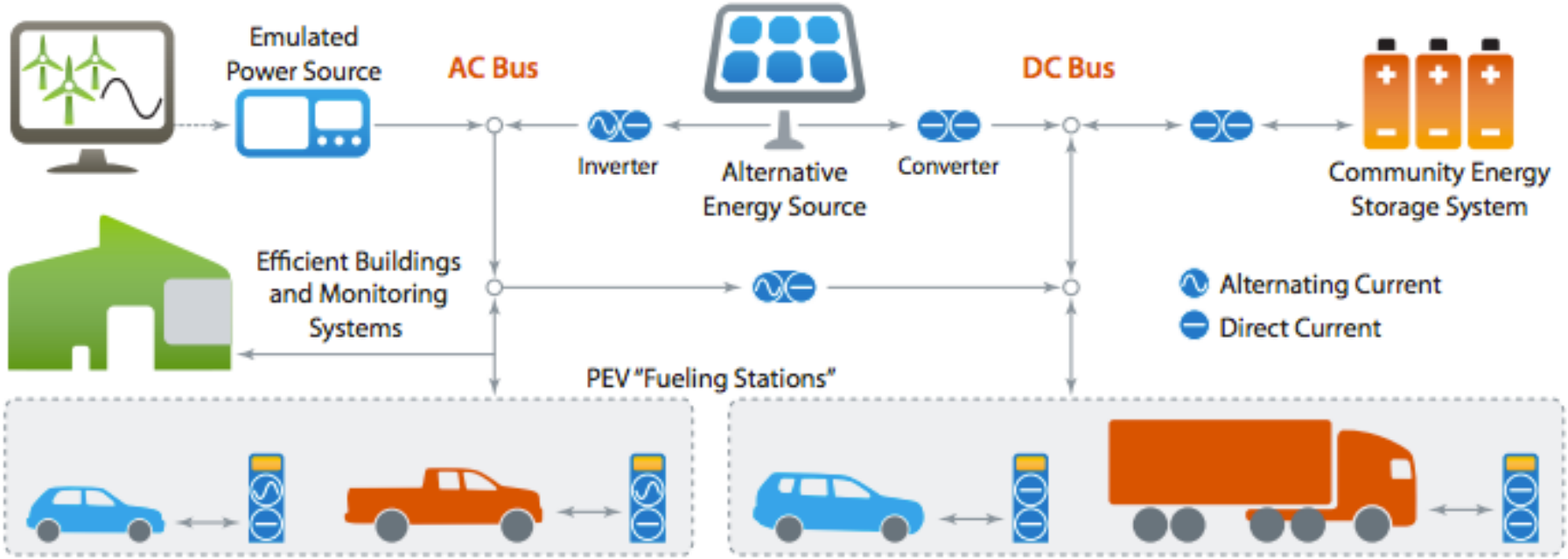
DOE EVGI and INTEGRATE Research Efforts

- **Electric Vehicle Grid Integration (EVGI) and INTEGRATE are addressing the opportunities and technical requirements for vehicle grid integration that will increase marketability and lead to greater reduction in the use of petroleum**

- **Address Core Questions**
  - Quantify use cases, performance, and life impacts of grid applications
  - Contribute to development of open interface standards
  - Identify and quantify potential grid integration values

- **Vehicle-related Research Focus Areas**
  - Managed charging systems providing flexibility, demand response capability
  - Bi-directional power to minimize local demand charge and grid frequency control
  - Local power quality monitoring and enhancement value
  - Emergency power system design enabling vehicles to support disaster recovery

VTIF Vehicle Grid Integration Test Bed: Used to explore vehicle, grid, renewables, and buildings working together



Equipment Resources

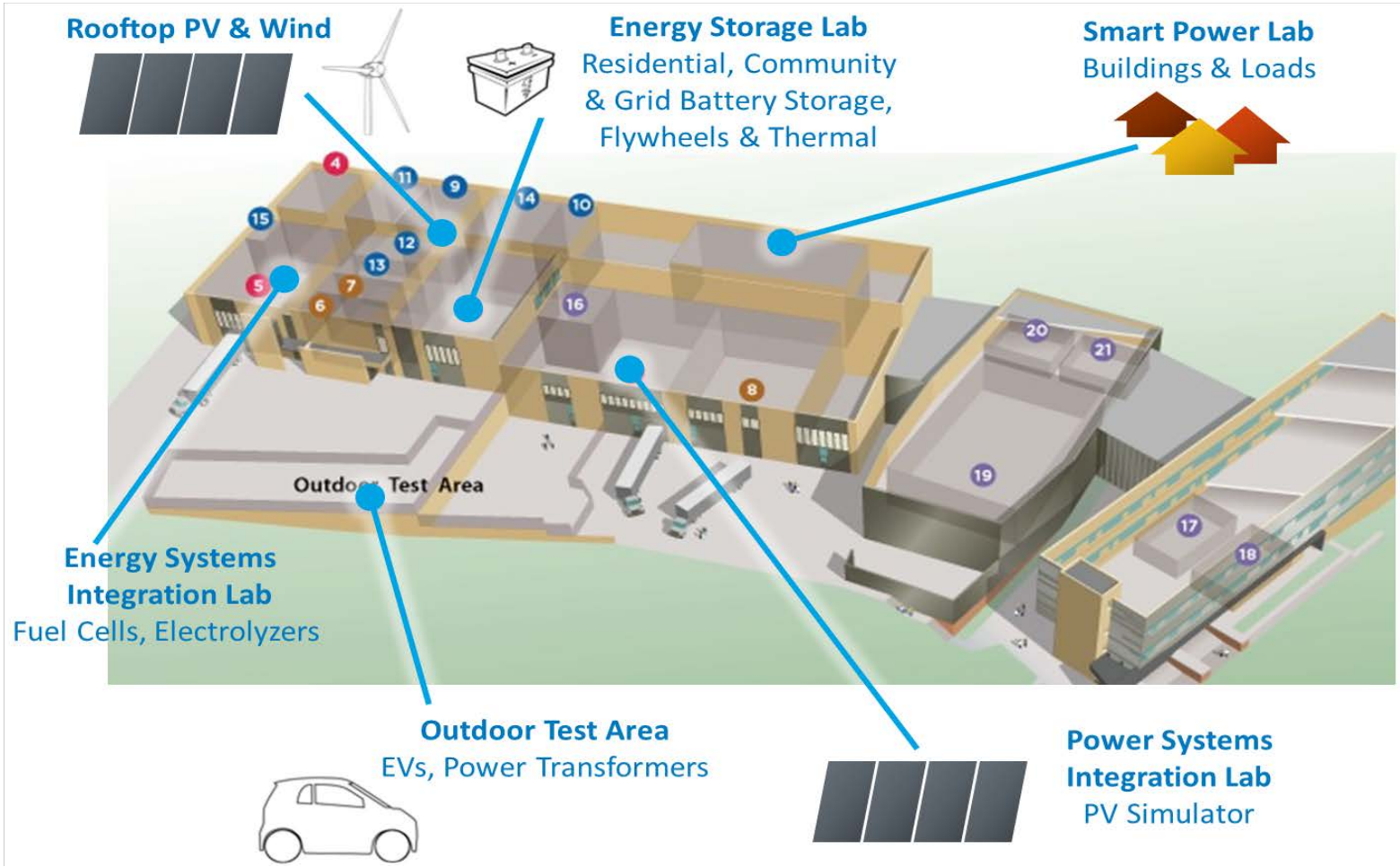
- SCADA-configurable AC and DC distribution buses
- More than 10 EVSE points
- 18-kW solar array
- Battery and hybrid inverters for V2G
- High-power fast chargers
- Load banks for building scenario integration
- Power supply/grid simulator

Source: NREL Dennis Schroeder

VTIF=Vehicle Testing and Integration Facility

Source: NREL Dennis Schroeder

ESIF Resources for Vehicle Grid Integration Research

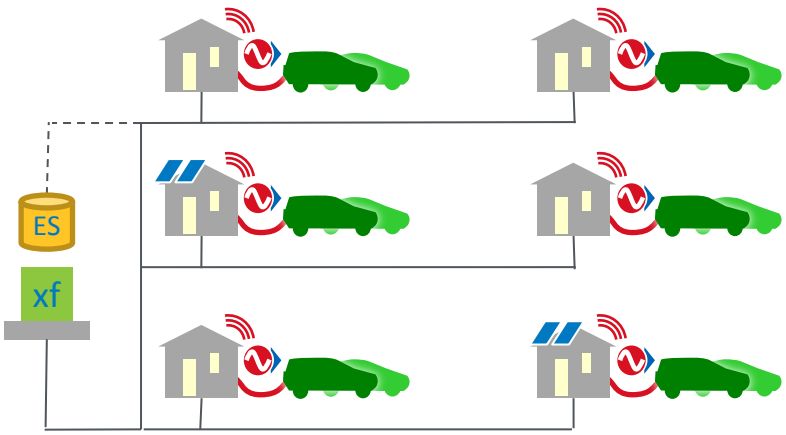


- More than 15 EVSEs accessible in lab spaces
- DC load bank to act as a programmable storage device
- Oscilloscopes for detail electrical system impacts analysis

ESIF=Energy Systems Integration Facility
EVSE=electric vehicle supply equipment

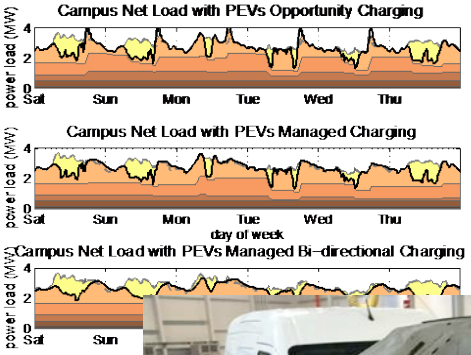
PEV Residential Distribution Testing

- Demonstrating grid impacts of simultaneous plug-in electric vehicle (PEV) charging on local distribution circuits
- 15 EVSE (charging stations) connected to ESIF's REDB, grid simulator, and load banks



REDB = Research Electrical Distribution Bus

Laboratory Resources Applied to Tech Introduction



Scenario Simulation

Tech Development

Source: NREL, M. Simpson

Source: NREL, M. Simpson

System Confirmation

5x 60-kW Bi-directional Stations Integrated with Microgrid Operations

Source: Burns & McDonnell

VTIF

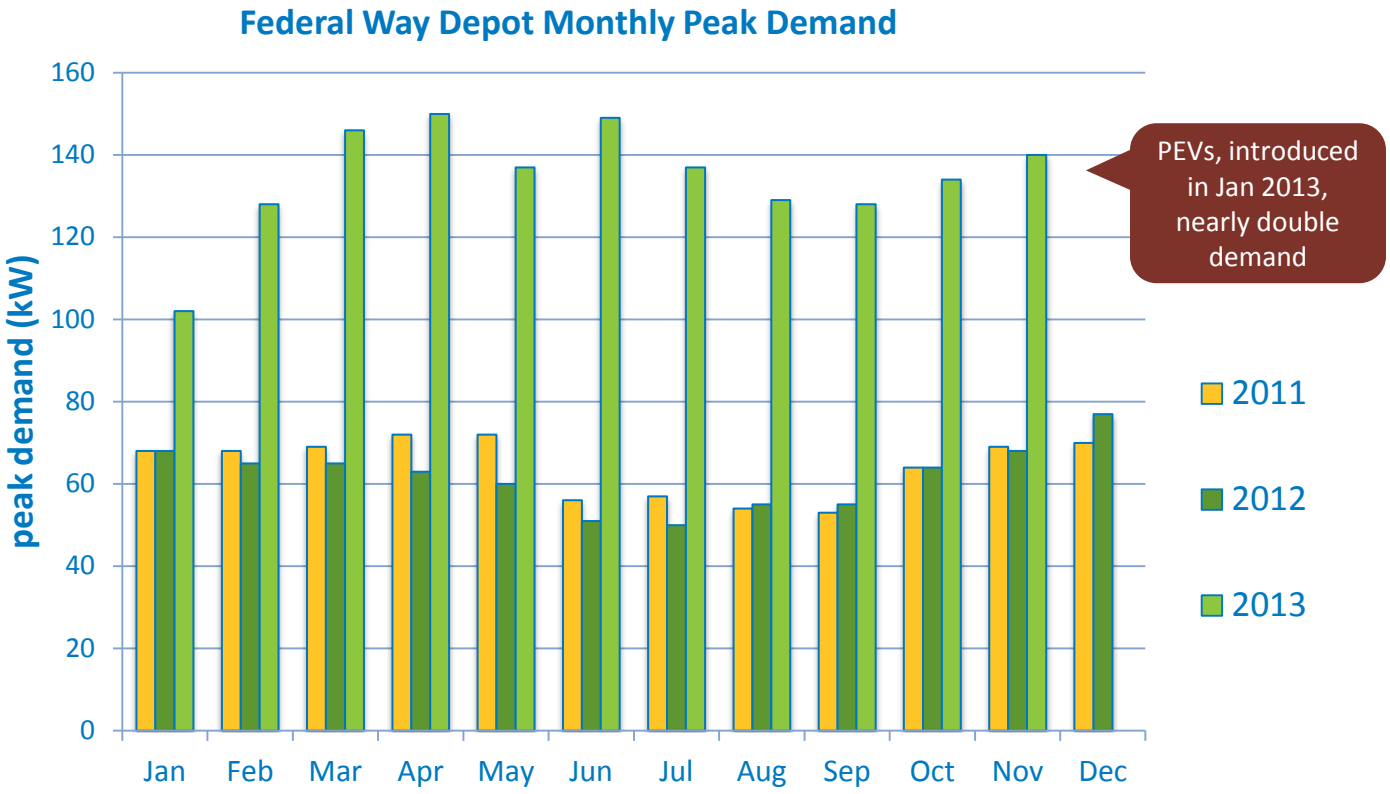
- Communications development and testing

ESIF

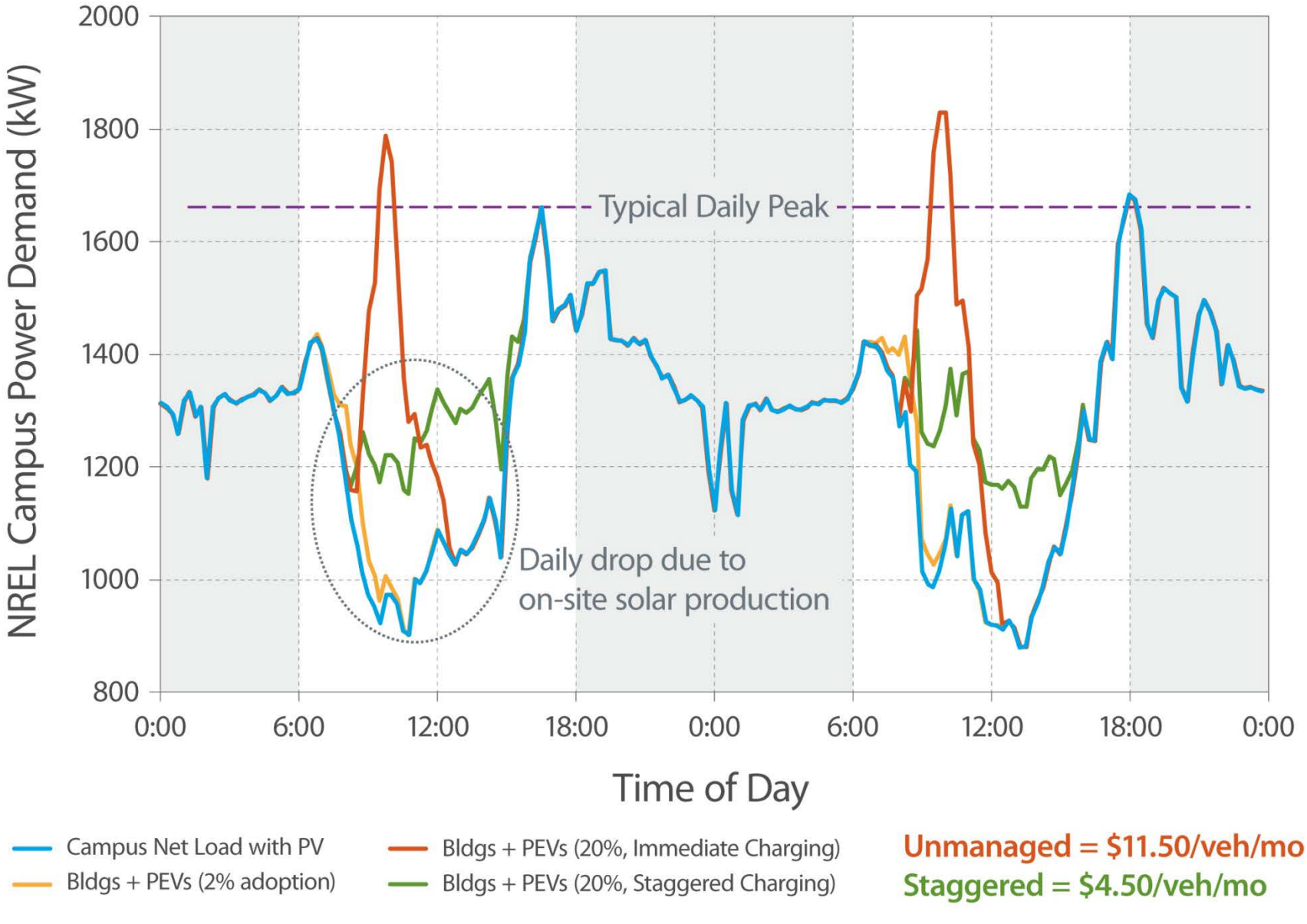
- Grid integration component verification

Frito-Lay EV Delivery Truck Case Study – Importance of Charge Management to Avoid Peak Demand Increase

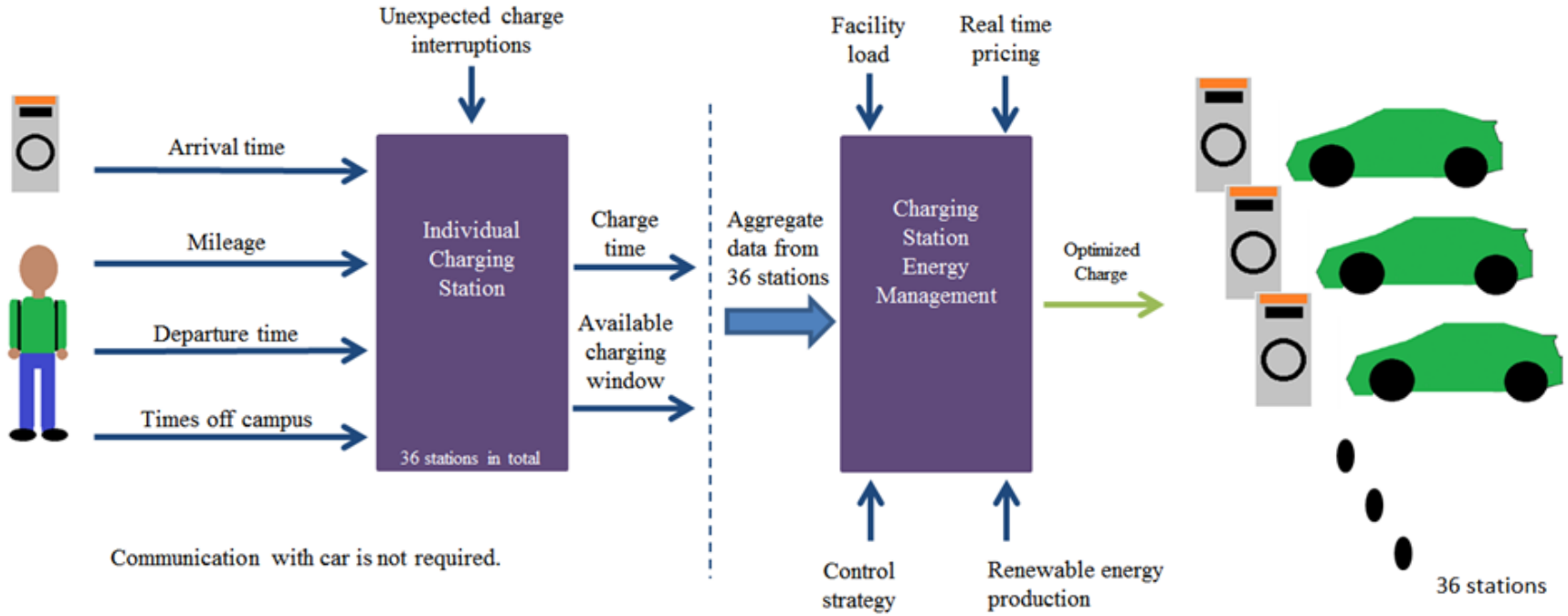
- Frito-Lay North America (FLNA) operating fleet of 269 all-electric delivery vehicles
- Operational data from Smith EVs in FLNA's fleet are monitored and reported to NREL as a part of Smith's ARRA grant



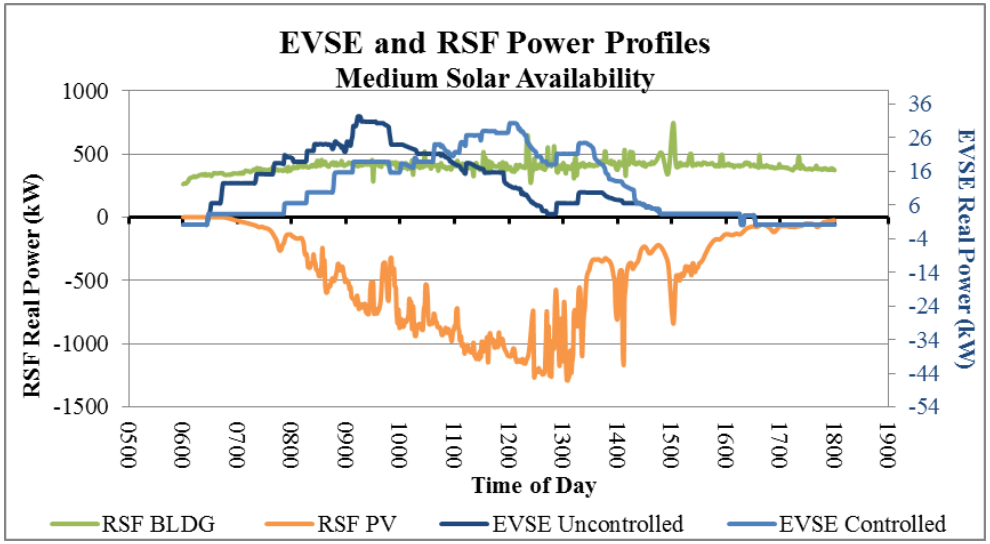
Planning for PEVs on a Highly Renewable Campus



Expanding Charging Data Streams and Interaction to Automate PEV Charge Management with Renewable Sources



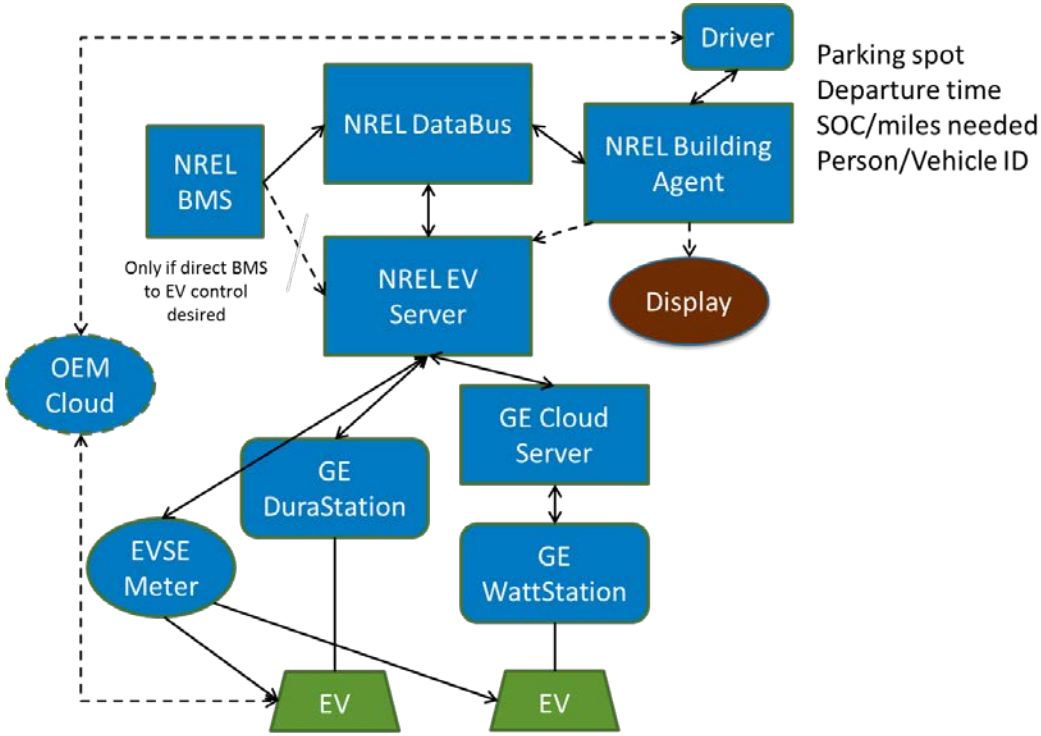
Provide simple interface with least information necessary to create managed individual and aggregate scenarios with status display



RSF = Research Support Facility

Building Integrated Charge Management Implementation Strategy

Significant challenge in collection and aggregation of driver and vehicle needs and attributes



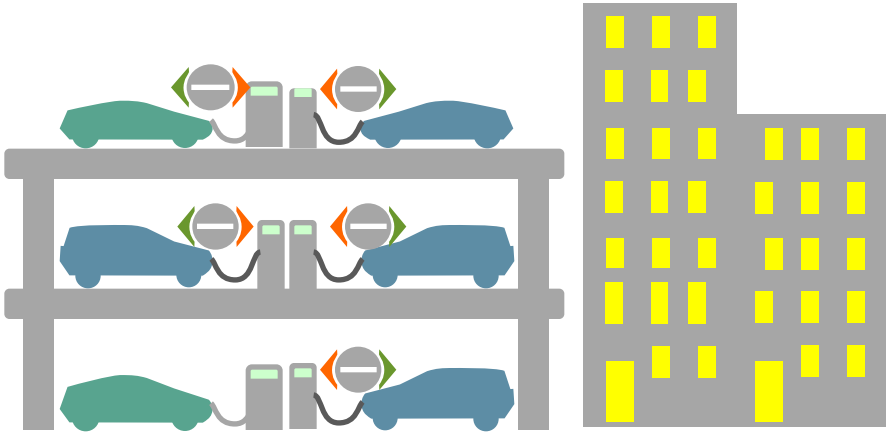
Primary parameters

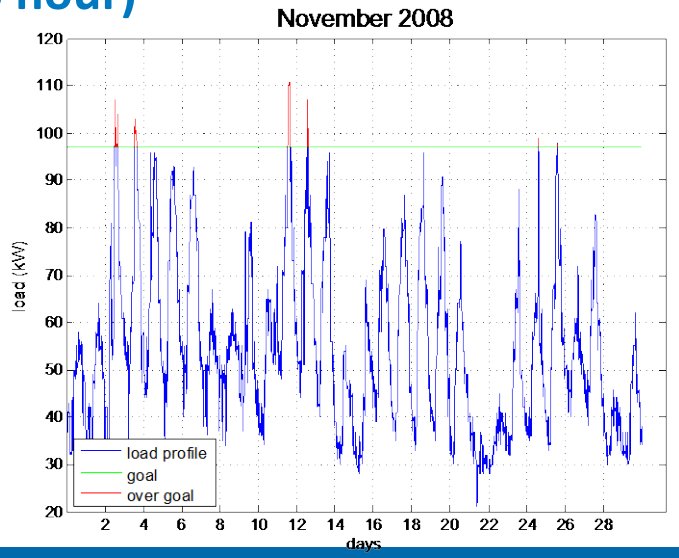
- Parking location
- Research vehicle?
- Person ID → vehicle type
- Current time
- Next departure time
- Target energy/miles remaining to be delivered

- Calculate a "flow reservation"
  - Schedule when energy will be delivered and at what rate

Why Integrate Vehicles with Buildings

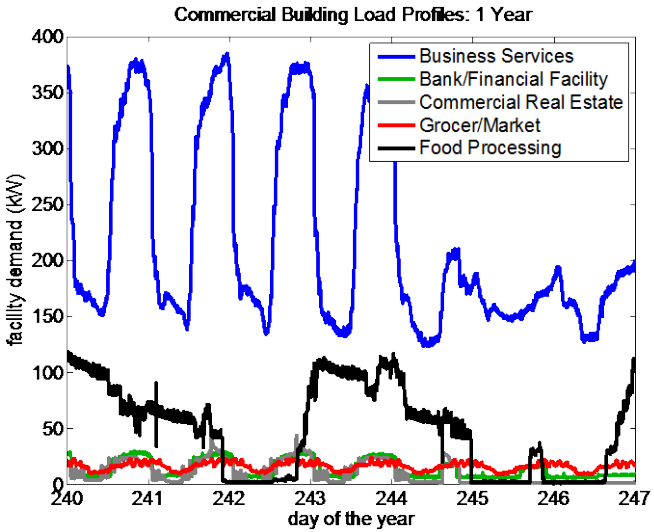
- **Building demand charges make up 20%–40% of typical electricity expenditures**
  - Demand charges are based on peak load during 15-min window, a few events per month
  - $132B/yr in commercial electricity expenditures
    - 1% demand charge market ~$420M/yr
- **V2B operates "beneath the meter"**
  - Minimal need to interact with utilities or markets
  - Can make local use of local assets (such as distributed renewables)
- **Requires short duration discharges (often <1.5 hour)**

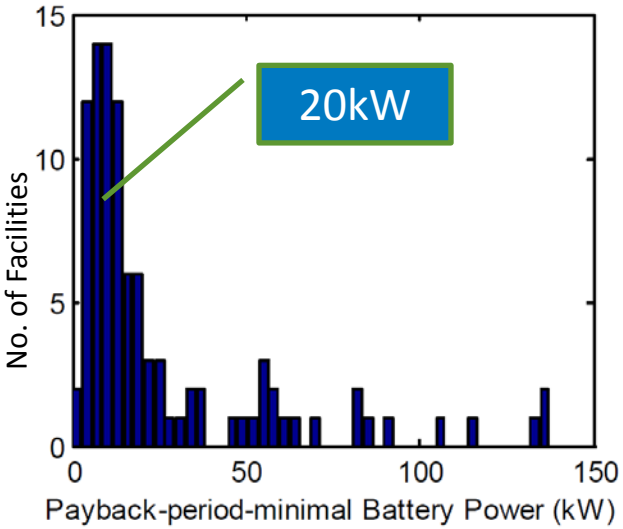


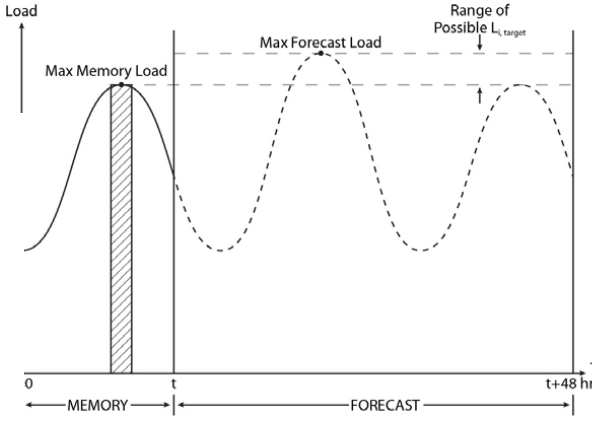


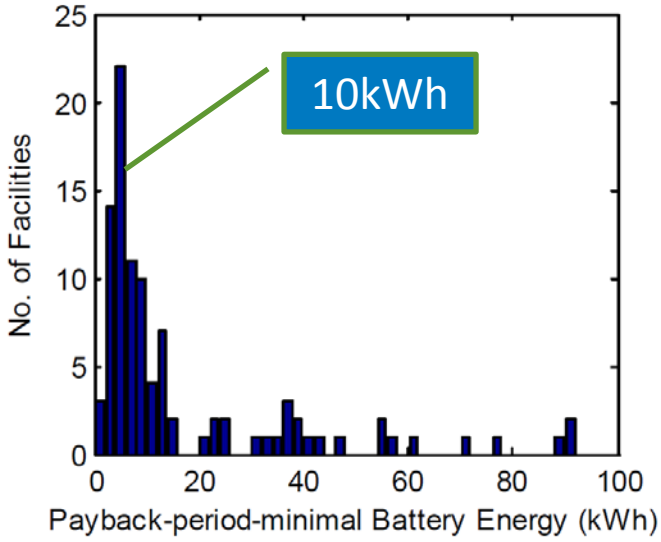
Demand Charge Management in Commercial Facilities

- Assessed 98 facilities using 1 year of historical 5-min interval data from Enernoc
- Optimal system sizes were generally less than 20 kW and 10 kWh – well suited for BEV and PHEV batteries



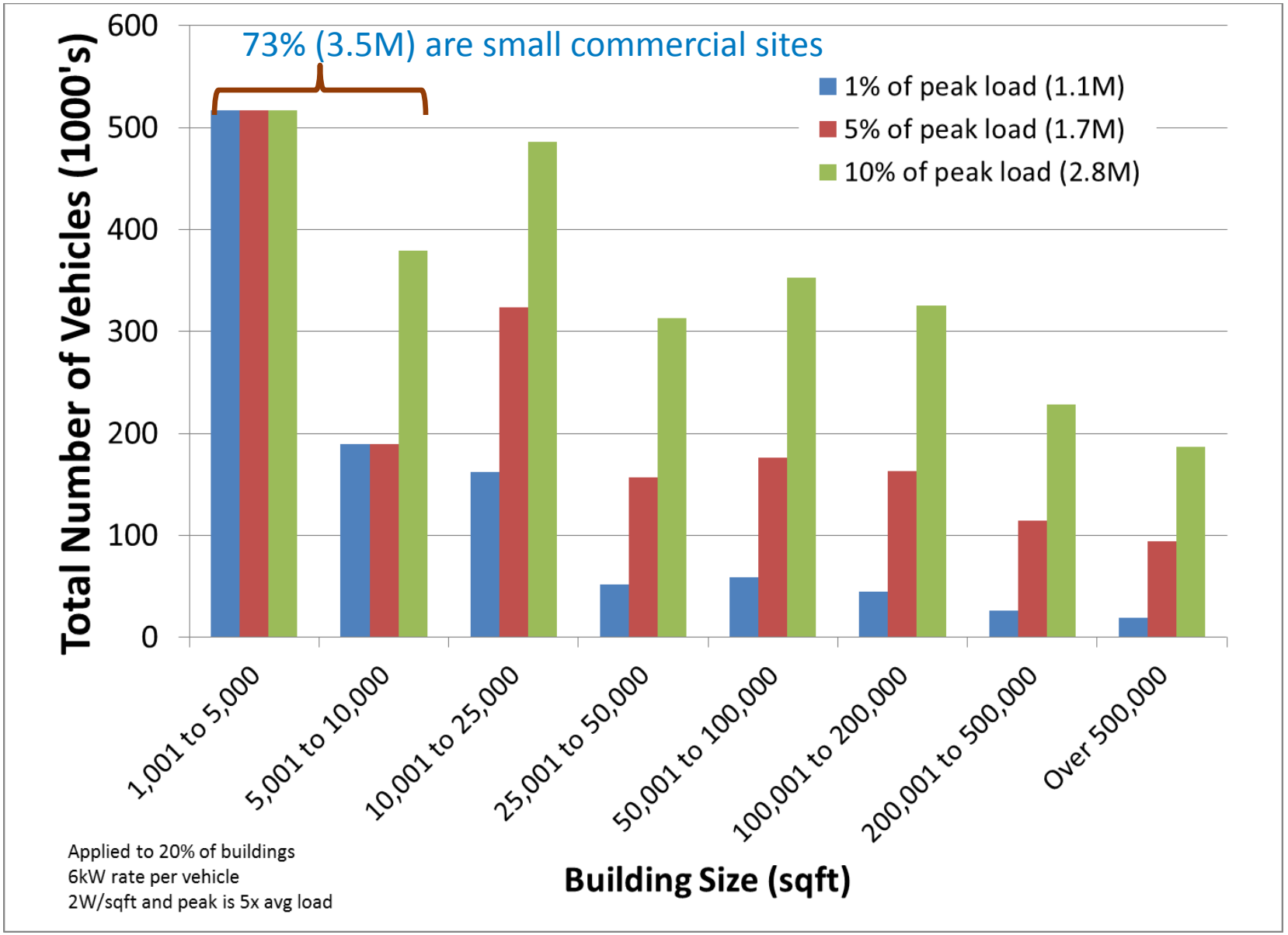




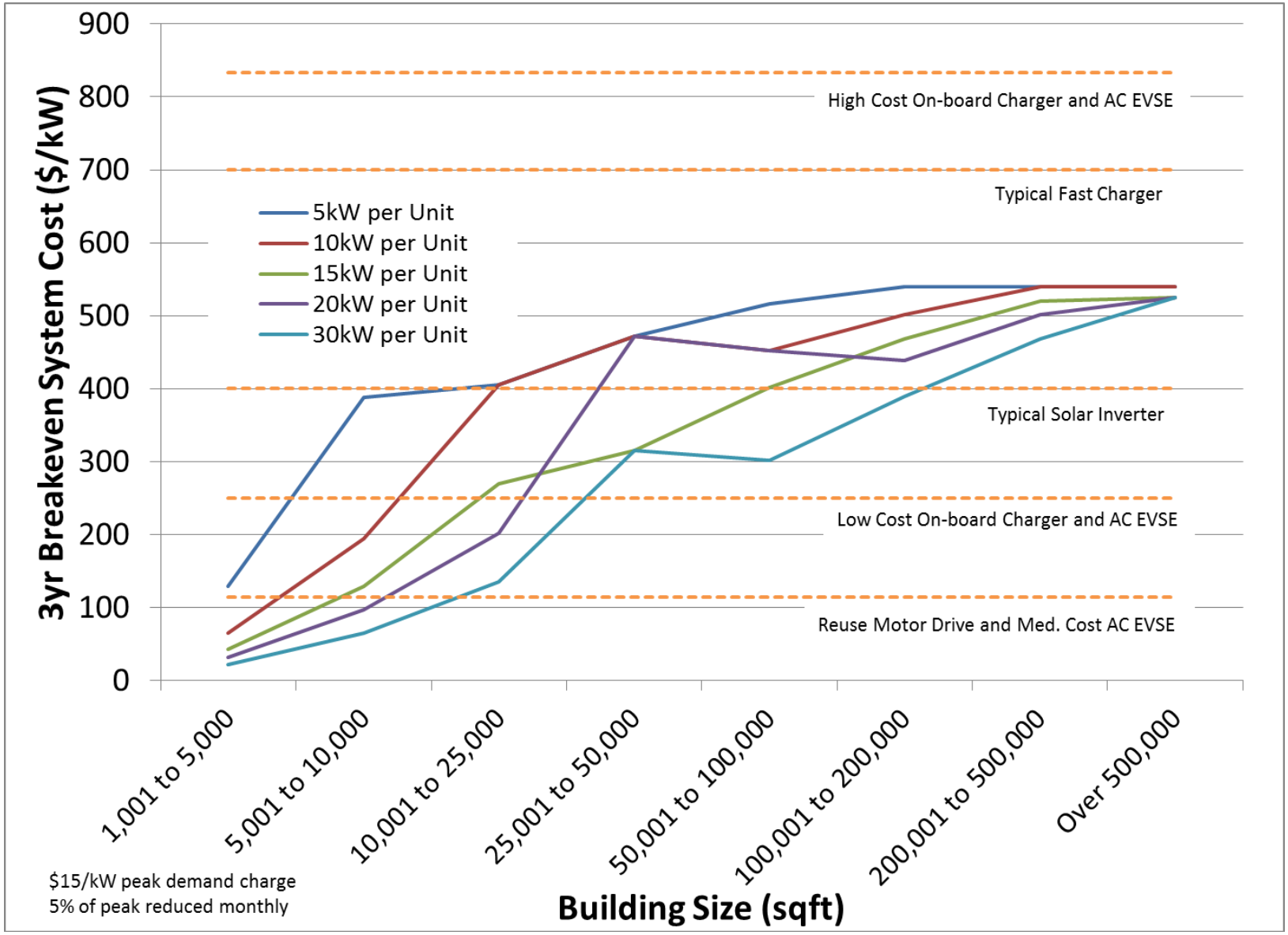


Journal publication in process.

V2B Application to 20% of Buildings Suggests at Least 1–2.5M 6-kW Capable Vehicles Could be Needed



Value is Reasonable to Support Low-Cost Implementation Strategies



Vehicle Grid Integration Research Summary

- **VTIF and ESIF are unique facilities for the development and testing of Vehicle Grid Integration systems and strategies**

- **Vehicle-to-building integration (charge only and bidirectional) offer interesting value propositions with broad applicability and scales**
  - Need to address vehicle availability – able to leverage datasets

- **DOE R&D efforts to address core questions:**
  - Quantify use cases, performance, and life impacts of grid applications
  - Contribute to development of open interface standards
  - Identify and quantify potential grid integration values