

# Microgrid feasibility study for Madison Streets and Engineering facilities

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**Slipstream**

Sustainable Madison Committee  
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# Agenda

## Introduction

- What is a microgrid?
- Project overview
- Site overview

## Microgrid optimization

- Fleet electrification
- Scenarios
- Results

## Next steps

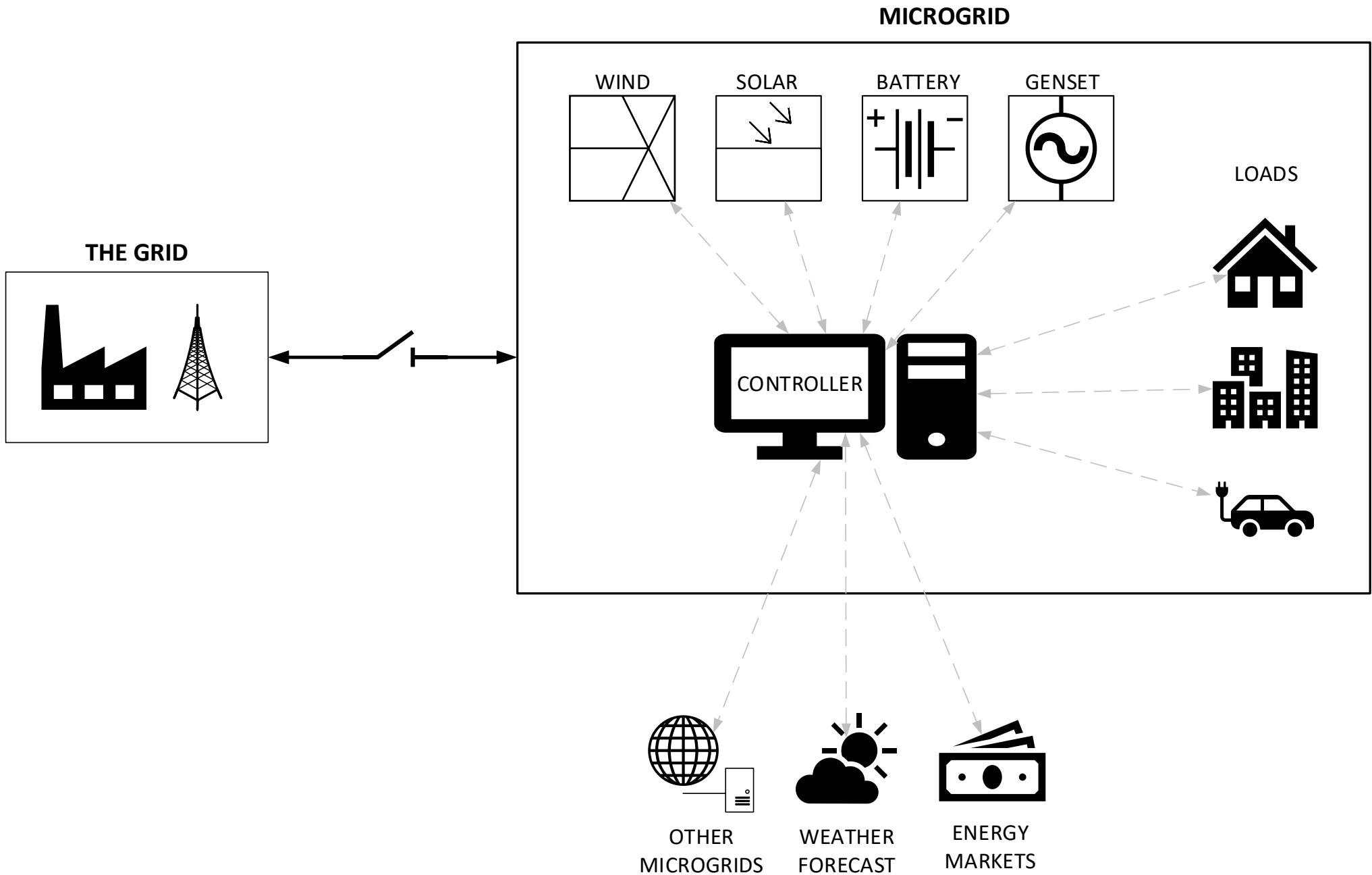




**“A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode”**

**DOE Microgrid Exchange Group**





# Key terms

## Islanding

The ability of a microgrid to disconnect from the grid while still serving loads internally

## Resiliency

The ability to withstand and reduce the magnitude and/or duration of disruptive events

## Net metering

A policy which compensates power sold back to the grid at the same rate as consumption

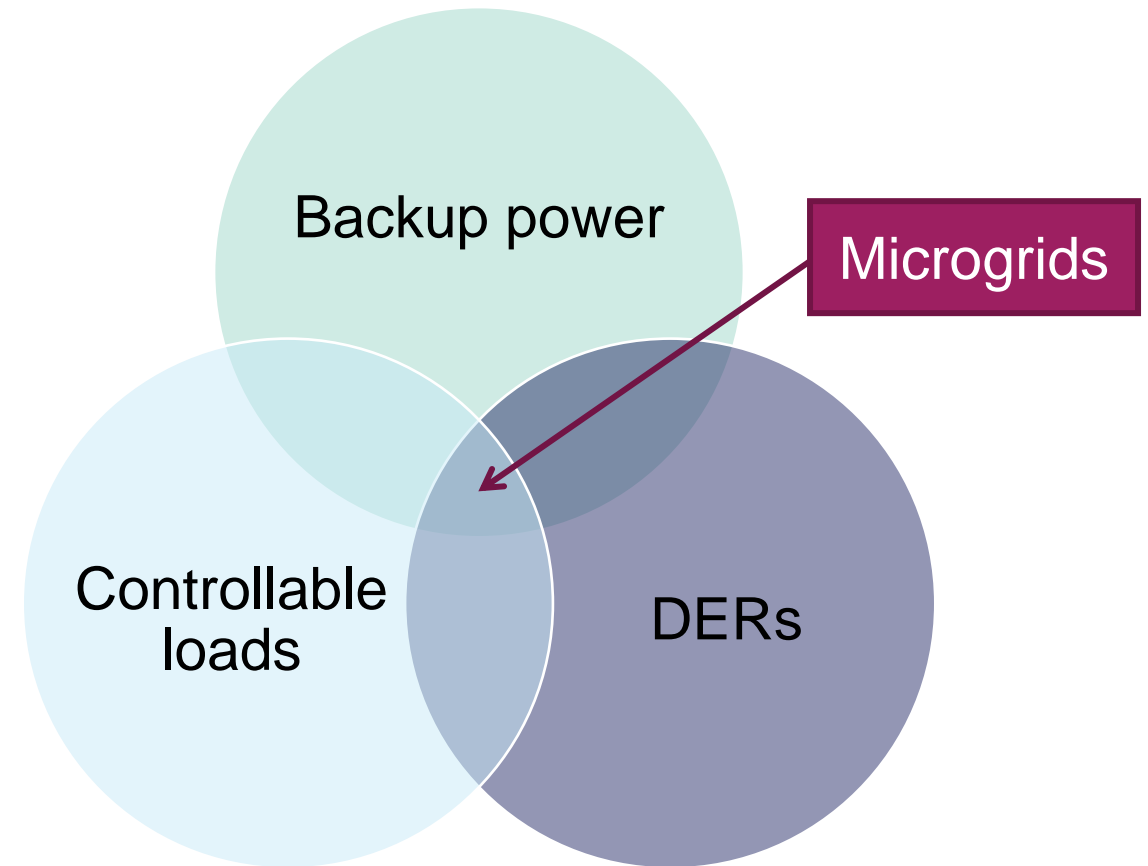
## Electrification

Conversion of fossil-fuel end uses (space- and water-heating) to electric



# Key concepts

- Microgrids are about more than just backup power
- Solar PV on its own cannot provide backup power
  - Interconnection rules (IEEE 1547) require inverters to stop producing power when grid disturbances detected





# What is the project?

- With increased fleet electrification, Madison anticipates
  - Higher electric bills
  - A need to upgrade electrical infrastructure
  - An opportunity to reduce grid emissions (in addition to reduced fleet emissions)
- The PSC's Office of Energy Innovation funded 15 feasibility studies to address "innovative pre-disaster mitigation through critical infrastructure microgrids."
- Slipstream and Madison submitted a proposal focusing on the Streets/Engineering site



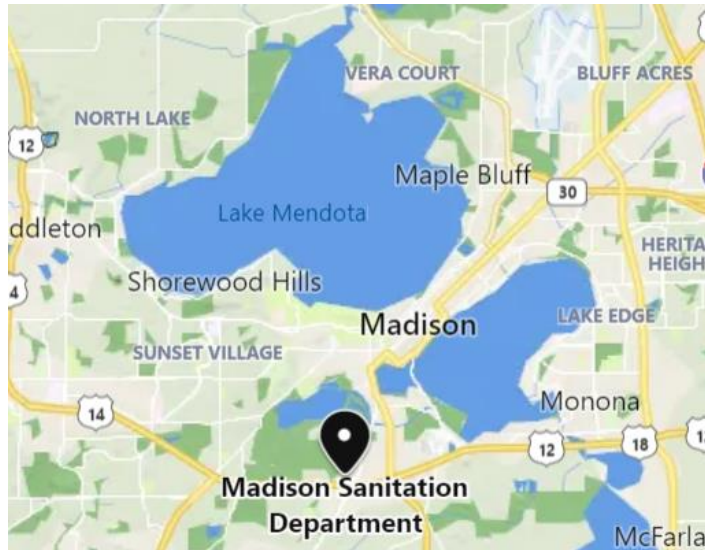
# Why this site?

- 8 EVs currently, with plans to electrify all 200+ of the remaining vehicles
- Two backup generators with associated infrastructure and controls
- 200 kW of existing solar PV, with an additional 200+ kW planned





# Site overview



## LOCATION



## ENGINEERING OPERATIONS

60,940 square feet. Office, Service, Garage. Multiple additions (2006, 2017).



## STREETS WEST

75,922 square feet. Office, Service, Vehicle Garage. Ongoing retrofits.





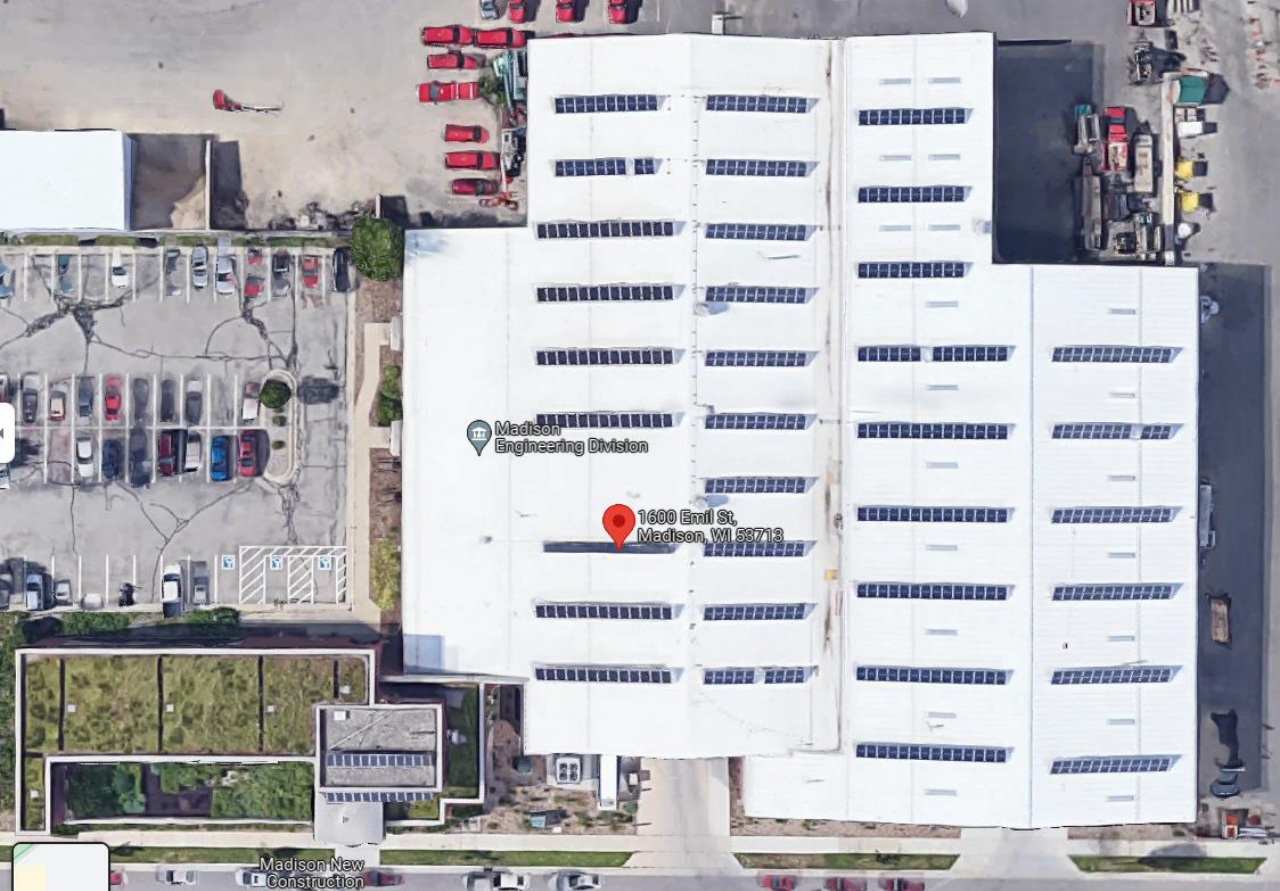
# Engineering Operations: Spaces





# Engineering Operations: Electric Vehicles





# Engineering Operations: PV (and more to come)





# Streets West: Spaces



Streets West: PV  
(and more to come)





# Microgrid optimization





# Research questions

What are the key functions the facility should be able to provide?

What are the additional benefits the City of Madison hopes to receive from the microgrid?

What are the potential system configurations to serve those functions?

- Length of outages to cover
- Load curtailment
- BESS capacity and duration
- Vehicle electrification schedule

What are the associated costs and benefits of each configuration?

- Environmental benefits
- Capital cost
- O&M costs
- Bill savings or revenue potential

# Fleet electrification schedule

Load profile	Additional EVs	Additional kWh	Total kWh	Load growth vs baseline
Baseline	8	552,000	552,000	-
Phase 1	117	1,231,000	1,783,000	323%
Phase 2	105	3,656,000	5,439,000	985%
<b>Total</b>	<b>230</b>	<b>5,439,000</b>		

## Additional considerations:

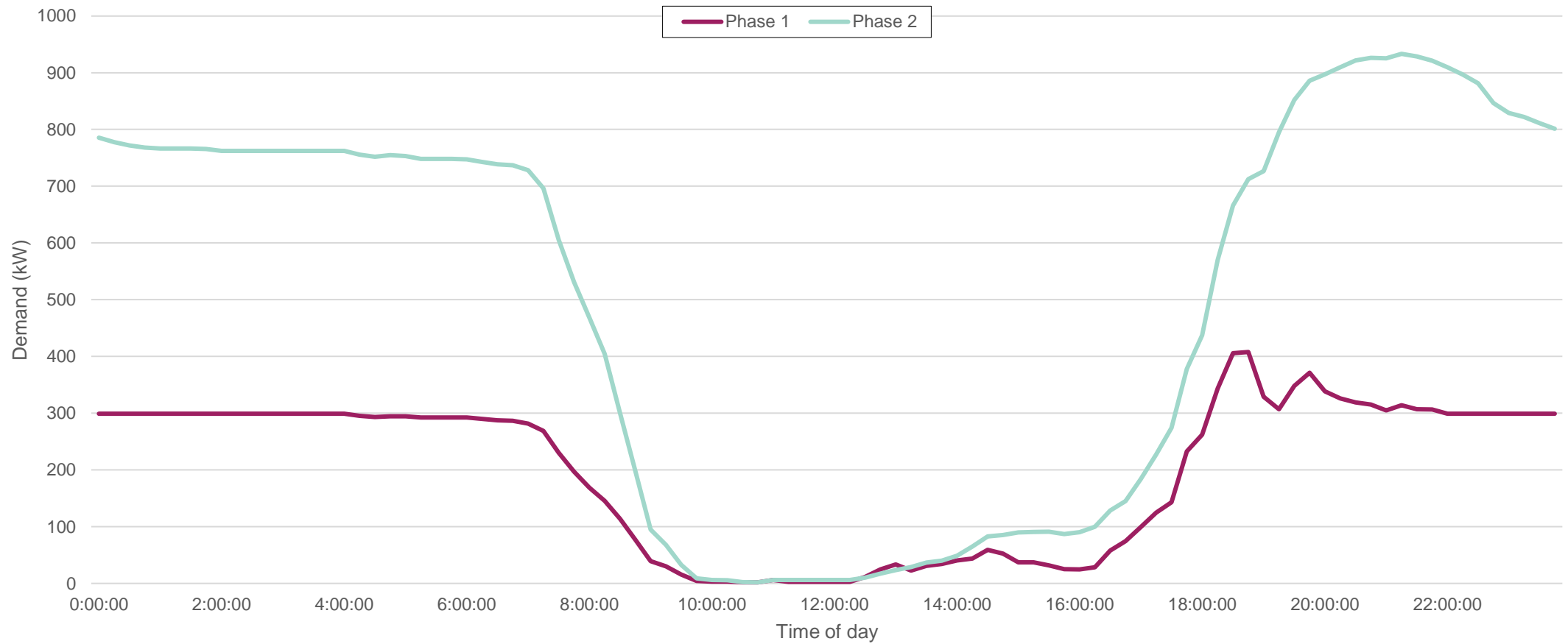
Will the fleet size change?

Which vehicles must charge during outages?

What about staff personal vehicles?



# Fleet electrification load

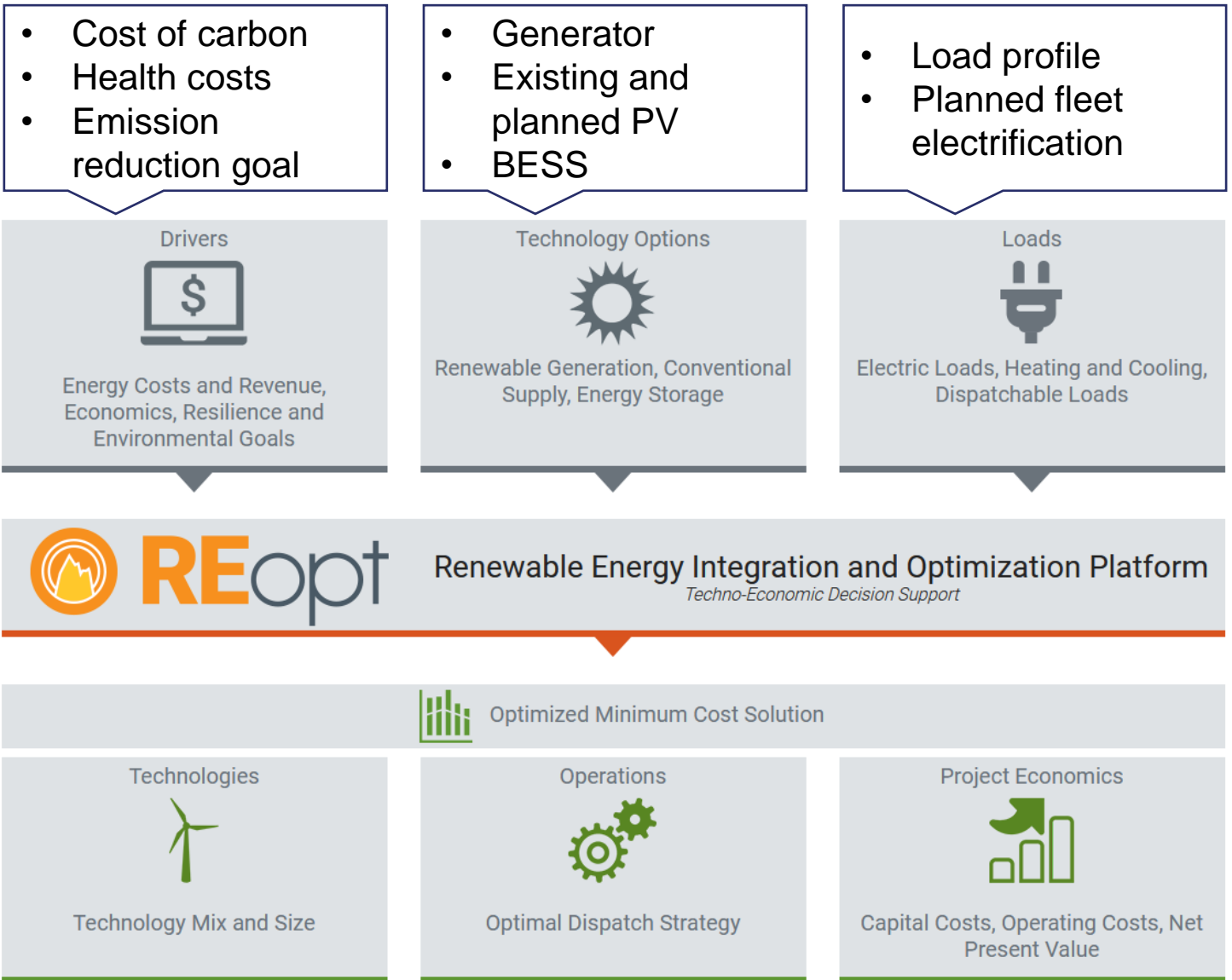


# This is what 200 kW of PV looks like

~500 kW is the limit of solar potential on rooftops at this site



# REopt Optimization



## Constant Inputs

Variable	Input	Source
Load	Interconnected facilities	
Solar PV capacity	483 kW	Existing and planned
Net metering limit	100 kW	
BESS \$/kWh	\$388	NREL + Lazard
BESS \$/kW	\$775	NREL + Lazard
Utility Rate (\$/kWh)	On-peak: \$0.114 Off-peak: \$0.053	MGE CG-4 C&I TOU Level B Three-Phase
Wholesale Rate (\$/kWh)	On-peak: \$0.047 Off-peak: \$0.034	MGE
Emissions data	Hourly values for Upper Midwest	AVERT
Carbon Price	\$51/ton	Federal value
Health costs (\$/ton)	NO <sub>x</sub> : \$19,452 SO <sub>2</sub> : \$40,551 PM2.5: \$139,804	NREL defaults based on CACES EASIUR model



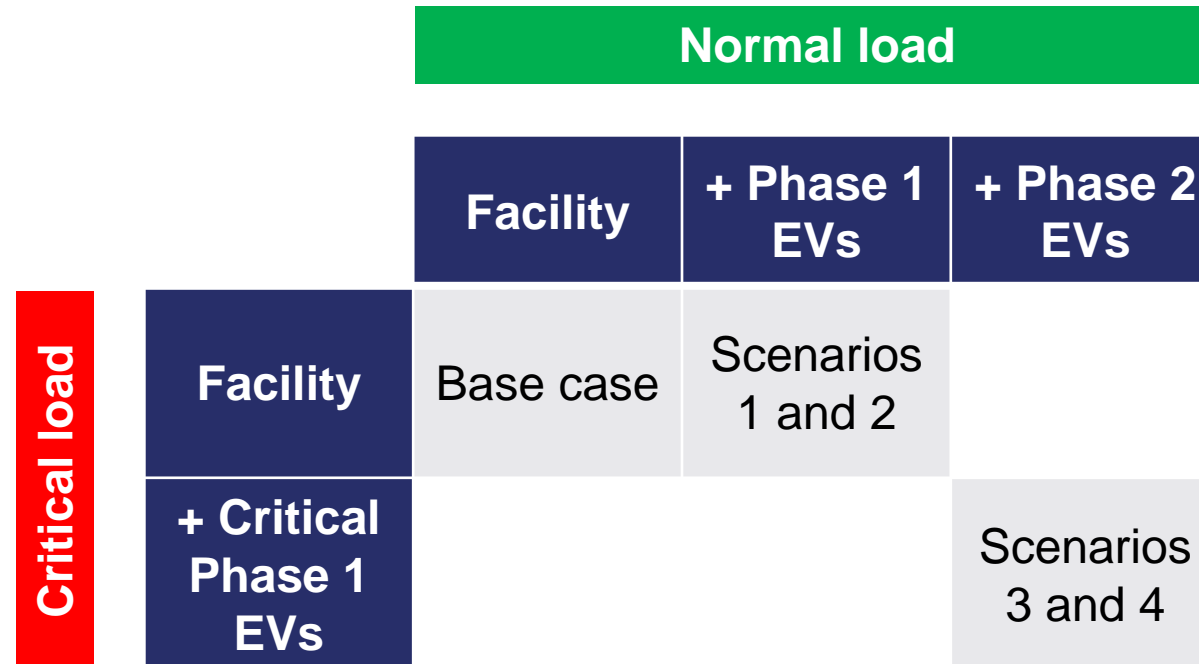
# Scenario details

Inputs	Base case	Phase 1	Phase 1 BESS	Phase 2	Phase 2 BESS
Normal load profile	Facility	Facility + phase 1 EVs	Facility + phase 1 EVs	Facility + phase 2 EVs	Facility + phase 2 EVs
Critical load profile	Facility	Facility	Facility	Facility + phase 1 EVs	Facility + phase 1 EVs
Battery constraint	<10 MWh	<10 MWh	=10 MWh	<10 MWh	=10 MWh
Annual kWh	552,000	1,780,000	1,780,000	5,430,000	5,430,000





# Load profiles: Four basic scenarios



# Scenario results

Scenario	Base case	Phase 1	Phase 1 BESS	Phase 2	Phase 2 BESS
<b>BESS capacity (kW)</b>	40	49	417	73	1,308
<b>BESS energy (kWh)</b>	52	65	10,000	96	10,000
<b>Initial Capital Costs</b>	\$51,000	\$63,000	\$4,203,000	\$94,000	\$4,894,000
<b>Net present value</b>	\$5,700	\$8,200	-\$6,272,000	\$7,500	-\$5,443,000
<b>Simple Payback</b>	0	0	17	1	>25
<b>Annual Total Renewable Energy</b>	110%	34%	33%	11%	11%
<b>Lifecycle CO<sub>2</sub> emissions (tons)</b>	-1,300	22,400	19,600	92,700	84,800
<b>Emissions reduction</b>	-	2%	14%	1%	9%
<b>Resiliency Hours (Avg)</b>	218	218	3,240	10	97



# Scenario results: Base case

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Net zero energy

Net zero emissions

5 days of backup power

Generator fuel costs <\$100



# Scenario results: Minimal BESS

Scenario	Base case	Phase 1	Phase 1 BESS	Phase 2	Phase 2 BESS
BESS capacity (kW)	40	49	417	73	1,308
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Increased load and emissions

Positive NPV

Fast payback

Reduced resiliency



# Scenario results: Maximize BESS

Scenario	Base case	Phase 1	Phase 1 BESS	Phase 2	Phase 2 BESS
BESS capacity (kW)	40	49	417	73	1,308
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Reduced emissions

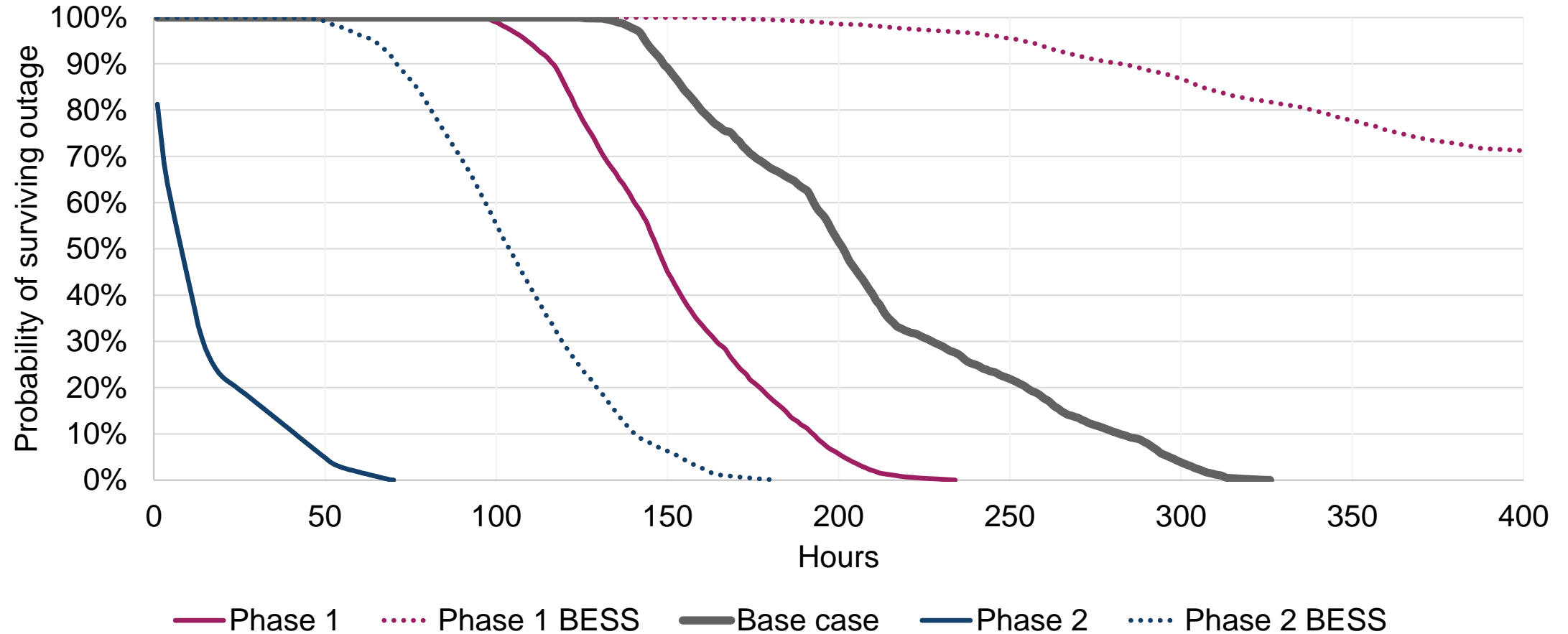
Negative NPV

Long payback

Resiliency increases



# Outage survivability as a microgrid



# Accounting for resiliency and emissions

	Base case	Phase 1	Phase 2	Phase 1 BESS	Phase 2 BESS
<b>Total cost</b>	\$122,200	\$208,600	\$211,000	\$7,503,000	\$8,210,400
<b>Energy benefit</b>	\$319,600	\$274,400	\$233,500	\$388,900	\$282,400
<b>Resiliency benefit</b>	\$2,248,900	\$2,746,700	\$916,200	\$2,746,700	\$6,633,300
<b>NPV with resiliency</b>	\$2,446,300	\$2,812,500	\$938,700	-\$4,367,400	-\$1,294,700
<b>Emissions benefit</b>	\$0	\$91,200	\$92,500	\$924,800	\$2,285,200
<b>NPV with emissions + resiliency</b>	\$2,446,300	\$2,903,700	\$1,031,200	-\$3,442,600	\$990,500





# Conclusion



# Next steps

<p>Implement microgrid-ready inverters</p>	<p>Plan for a BESS</p>	<p>Implement managed EV charging</p>	<p>Electrically interconnect Streets and Engineering</p>
<ul style="list-style-type: none"><li>• Upgrade existing inverters</li><li>• Specify microgrid-ready for future inverters</li></ul>	<ul style="list-style-type: none"><li>• Perform a site survey to identify locations</li><li>• Consider replacement strategies factoring in fleet electrification</li></ul>	<ul style="list-style-type: none"><li>• Upgrade existing chargers</li><li>• Implement smart charging</li></ul>	<ul style="list-style-type: none"><li>• Share one BESS</li><li>• Eliminate diesel generator</li><li>• Collectively manage loads and sources</li></ul>



# Next steps: DOE Connected Communities project

## Implement microgrid-ready inverters

- Upgrade existing inverters
- Specify microgrid-ready for future inverters

## Plan for a BESS

- Perform a site survey to identify locations
- Consider replacement strategies factoring in fleet electrification

## Implement managed EV charging

- Upgrade existing chargers
- Implement smart charging

## Electrically interconnect Streets and Engineering

- Share one BESS
- Eliminate diesel generator
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# DOE Connected Communities

## DOE Invests \$61 Million for Smart Buildings that Accelerate Renewable Energy Adoption and Grid Resilience

OCTOBER 13, 2021

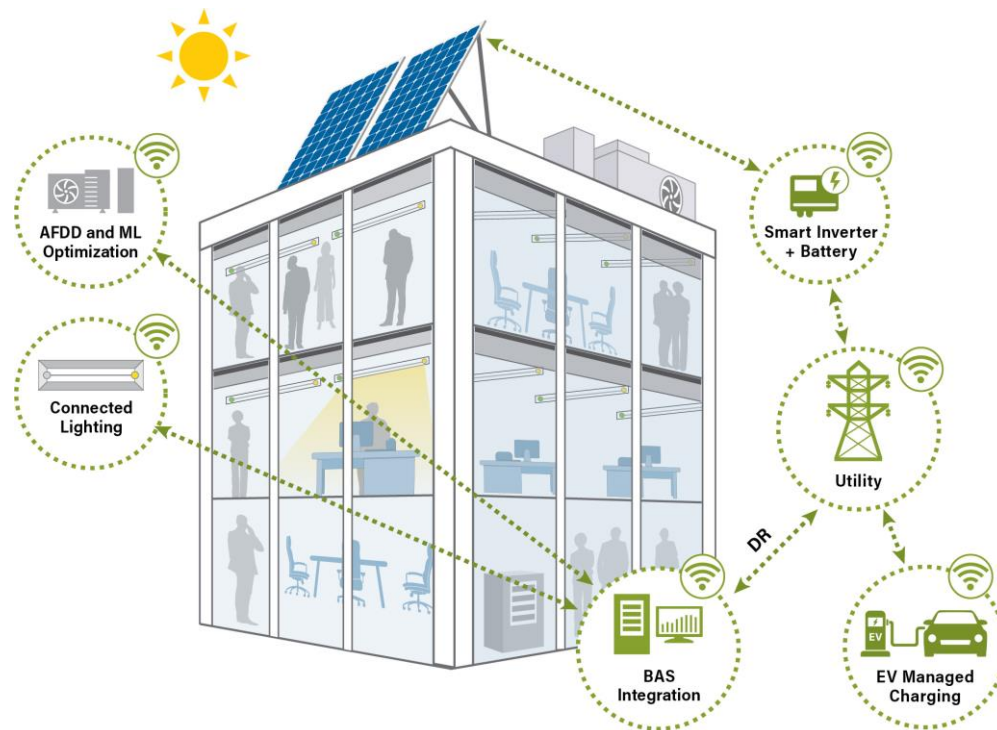
[Energy.gov](#) » DOE Invests \$61 Million for Smart Buildings that Accelerate Renewable Energy Adoption and Grid Resilience

*Ten "Connected Communities" Will Equip More than 7,000 Buildings with Smart Controls, Sensors, and Analytics to Reduce Energy Use, Costs, and Emissions*

# Connecting Communities for Sustainable Solutions

## Project Summary

This project will demonstrate GEB in Madison's publicly owned facilities. It will deploy reliable and cost-effective efficiency and demand flexibility strategies in buildings, behind-the-meter electric vehicle charging, and solar energy production. We will then scale the lessons learned to a broader audience. **This Connected Community project will support increased integration of renewables into the grid, better maintain voltage limits on the transmission and distribution system and improve both the resilience of utility customer infrastructure and financial outcomes.**



## Key Partners

Slipstream (lead)                      RMI  
 MGE    ACEEE  
 City of Madison

## Baseline

Existing conditions: typical lighting (fluorescent with minimal controls), HVAC (VAV and RTU with DDC), EV chargers (unmanaged Level 2), and PV w/o batteries or smart inverters.

## Project Goals and Impact

Application	Energy Savings (kWh)	Peak Load Shed (kW)	Continuous Demand Management (kW)	Load Shift (kW/kWh)
<b>Building Load Shaping</b>	1,420,000	250	590	n/a
<b>EV Managed Charging</b>	n/a	n/a	245	96/192
<b>Smart Inverters + Batteries</b>	n/a	n/a	120	120/240
<b>Total</b>	1,420,000	250	955	216/432

- Reduce emissions by 889 ton CO<sub>2</sub>e and utility cost by \$472,000 with a simple payback under 11 years.
- Improved IEQ, occupant and operator satisfaction.
- Scale through broader market transformation efforts.

GEBs for a mid-size utility in a mid-size city

**2022 – 2024:** Demonstrate GEB elements in City of Madison facilities.

Application	Quantity	Strategies Demonstrated
<b>Building Load Shaping</b>	5-6 municipal buildings; 300,000 ft <sup>2</sup>	Enhanced energy efficiency of HVAC and lighting
		Load shed via Automated Demand Response (ADR) of HVAC and lighting
<b>EV Managed Charging</b>	20 Level 2 chargers serving 40 EV passenger vehicles	Load shift via managed charge and supplemental batteries
<b>Smart Inverters + Batteries</b>	Upgrade to smart inverters on 10 photovoltaic (PV) systems; Add batteries to 2 sites	Smart inverter functionality Load shift via batteries

**2023 – 2025:** Develop a utility pilot GEB program for medium-to-large commercial and industrial customers.

- 10 buildings (500,000 square feet), EV charging stations (750 kW), and battery systems (80 kW/160 kWh).
- Centrally managed and optimized through a Demand Response Management System.

**2025 - 2026:** Scale these impacts

- Define replicable GEB implementation models for building owners, designers, operators, Midcontinent Independent System Operator (MISO) and policy makers

# Questions?



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