

Welcome

Conservation Applied Research & Development (CARD) Webinar

November 10, 2020

Load shifting: the market potential for carbon and energy savings

Load shifting: the market potential for carbon and energy savings



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Webinar Basics

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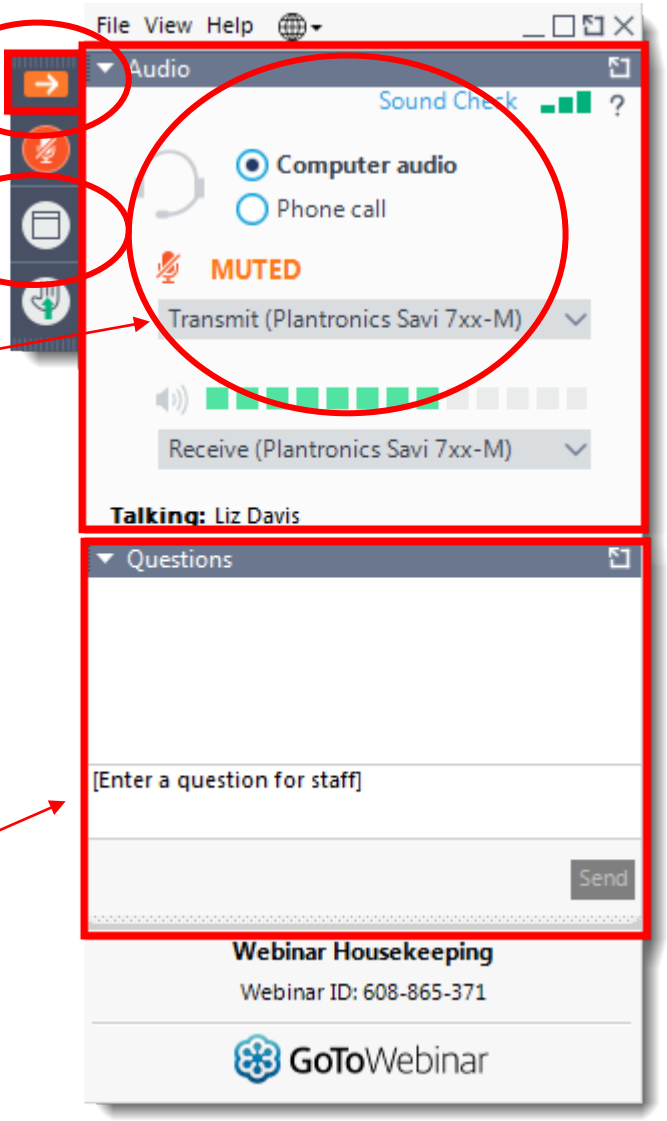
Screen
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Audio options
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  - Dial in and enter your access code
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Participation
Type in a question and hit “send” to ask a question.



Minnesota Applied Research & Development Fund

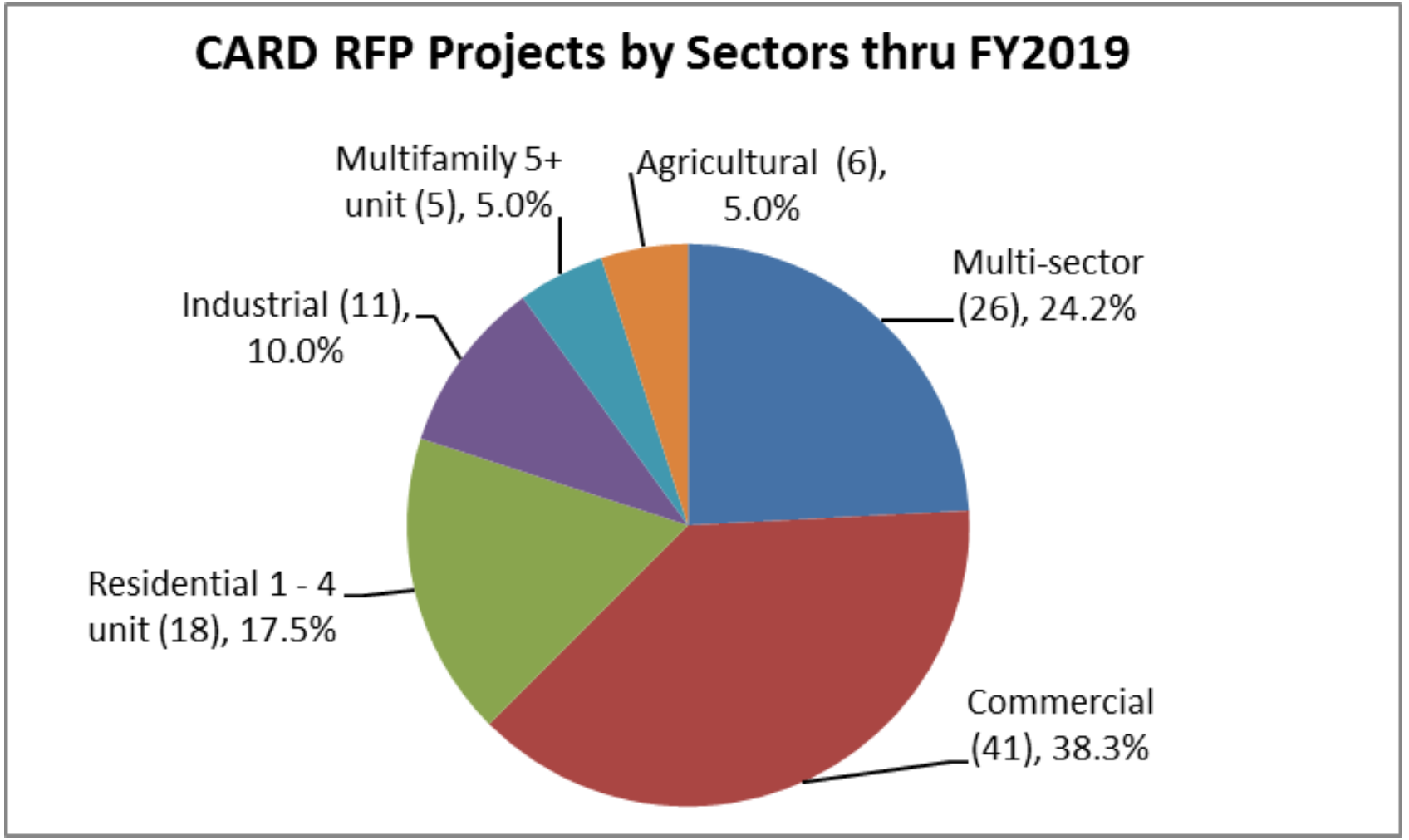
- **Purpose to help Minnesota utilities achieve 1.5% energy savings goal by:**
  - ***Identifying new technologies or strategies to maximize energy savings;***
  - ***Improving effectiveness of energy conservation programs;***
  - ***Documenting CO_2 reductions from energy conservation programs.***

Minnesota Statutes §216B.241, Subd. 1e

- **Utility may reach its energy savings goal**
  - **Directly through its Conservation Improvement Program (CIP)**
  - **Indirectly through energy codes, appliance standards, behavior, and other market transformation programs**

State Capitol Image: Courtesy Minnesota Department of Administration

CARD RFP Spending by Sector thru FY2019



RFP Summary

- 10 Funding Cycles
- 472 proposals
- 121 projects funded
- $27.4 million in research

Acknowledgments

Thank you to our research partners!







Agenda

- Study Goals and Approach
- Results
  - Price Optimization
  - Emissions Optimization
- Recommendations
- Questions



Study goals and approach

Study Goals



To quantify the **energy, energy cost,** and **emissions** impacts of measures that shift load with or without saving energy

Minnesota context for this research



Energy efficiency saturation



Changing generation mix



Overlap between EE and load shifting

Study approach

SELECT	COLLECT	APPLY	SCALE
measures that represent a variety of load shifting effects	avoided costs and emissions data for current and future years	load shifting methodology	measures to achieve consistent savings

Measure Selection

Event-based load shift

Regularly-occurring shift

Energy efficiency

Measure Selection

Event-based load shift	Regularly-occurring shift	Energy efficiency
Smart thermostats + demand response control **(R)**		
Air source heat pumps + demand response control **(R)**		
Envelope measures + ASHP **(R)**		
Networked lighting controls + demand response control **(C)**		
Strategic Energy Management **(I)**		
Critical peak pricing **(R)**		

BUILDING TYPES

R = Residential
C = Commercial
I = Industrial

Measure Selection

Event-based load shift
Smart thermostats + demand response control **(R)**
Air source heat pumps + demand response control **(R)**
Envelope measures + ASHP **(R)**
Networked lighting controls + demand response control **(C)**
Strategic Energy Management **(I)**
Critical peak pricing **(R)**

Regularly-occurring shift
Phase change materials for space conditioning **(C)**
Phase change materials for refrigeration **(C)**
Active ice thermal storage **(C)**
Electric water heater controls **(R)**
Electric vehicles with charging controls **(R)**
Refrigeration load control **(C)**

Energy efficiency

BUILDING TYPES

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Measure Selection

Event-based load shift
Smart thermostats + demand response control (R)
Air source heat pumps + demand response control (R)
Envelope measures + ASHP (R)
Networked lighting controls + demand response control (C)
Strategic Energy Management (I)
Critical peak pricing (R)

Regularly-occurring shift
Phase change materials for space conditioning (C)
Phase change materials for refrigeration (C)
Active ice thermal storage (C)
Electric water heater controls (R)
Electric vehicles with charging controls (R)
Refrigeration load control (C)

Energy efficiency
Plug load controls (C)
Lighting efficiency and controls (C)

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Regularly-occurring Shift Definitions

Measure	Description
Phase change materials for space conditioning	Phase change materials (PCM) are 'melted' and 'frozen' at temperatures near the setpoint to shift load in conditioned places
Phase change materials for refrigeration	In refrigerated areas, PCM is frozen during non-peak hours and melted to cool goods during peak hours.
Active ice thermal storage	Cool thermal storage attached to a chilled water system; chillers make ice or chilled water at off-peak times for use during peak-times
Electric vehicles with charging controls	A managed controlled charging program that sets charging time between 9 pm and 5 am
Strategic energy management with demand focus	Programming common efficiency measures' controls, based on worker shifts to shift load
Refrigeration load control	Refrigeration system operators use the setpoints in refrigerated spaces to shift the time at which compressors run, without impacting food quality.

Event-based Measure Definitions

Measure	Description
Smart thermostats with demand response	Smart thermostat with demand response functionality, to run air conditioning less when loads are peaking, or utility prices are high.
Air source heat pumps with demand response control	ASHP with controls that allow utilities to remotely adjust heating or cooling load. Includes pre-cooling or pre-heating prior to the event and a recovery period after the event.
Envelope measures combined with ASHP	Deep envelope retrofits combined with the ASHP measure to show the impact of having a well-insulated home
Electric water heater controls	Use of more efficient heat pump water heater and pre-heat during off peak times to shift usage
Networked lighting controls with demand response	A lighting retrofit with controls that are digitally networked for additional lighting energy savings during peak times
Critical peak pricing to drive behavior change	Advanced notice of higher prices for certain hours of days when demand is expected to be high

Energy Efficiency Measure Definitions

Measure	Description
Plug load controls	Commercial plug load controls turn off computing equipment and peripherals, saving energy.
Lighting efficiency and controls	A typical LED retrofit along with daylighting, task tuning, and occupancy controls.

For load shape development, we relied on



EMPIRICAL DATA

from technology field tests and secondary sources and research

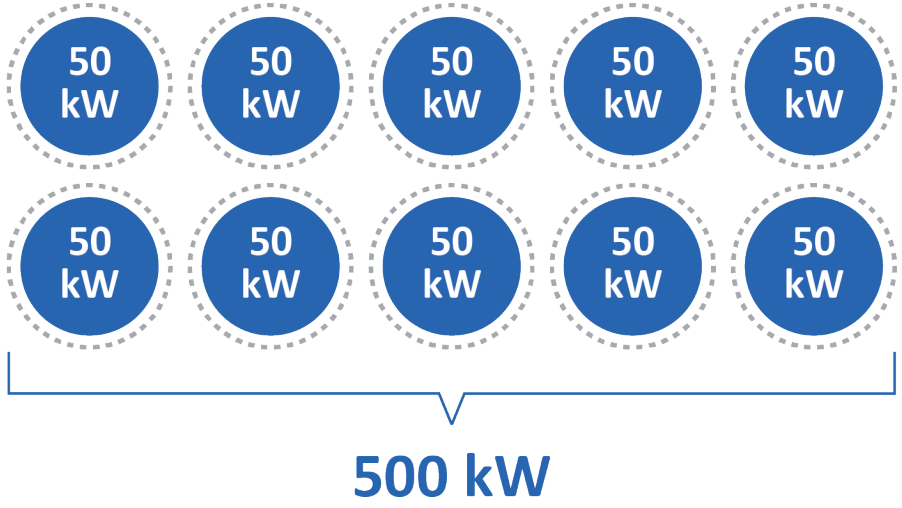


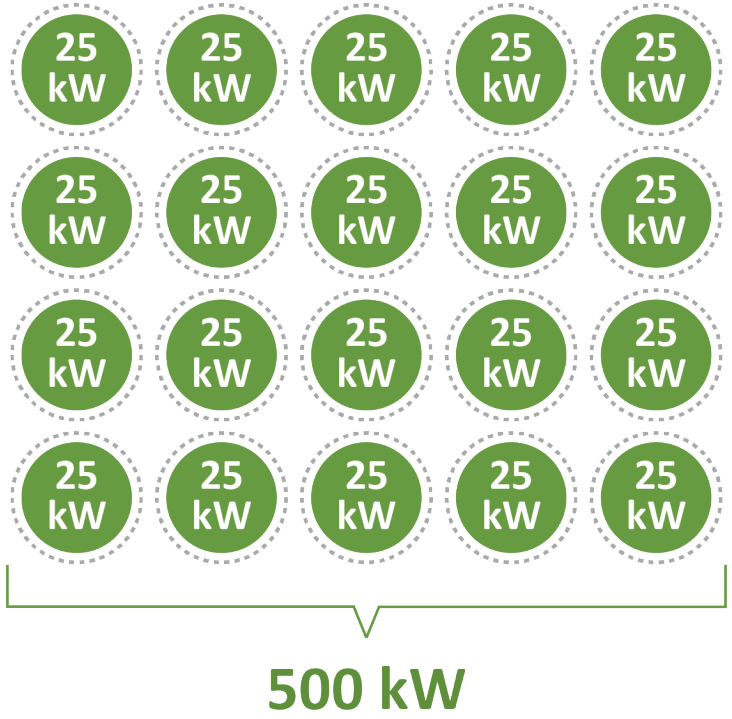
SECONDARY DATA

that combined Minnesota-specific assumptions with energy modeling

Scaled each measure to achieve **500 kW peak** savings state-wide

Controls for the variability in per-unit demand



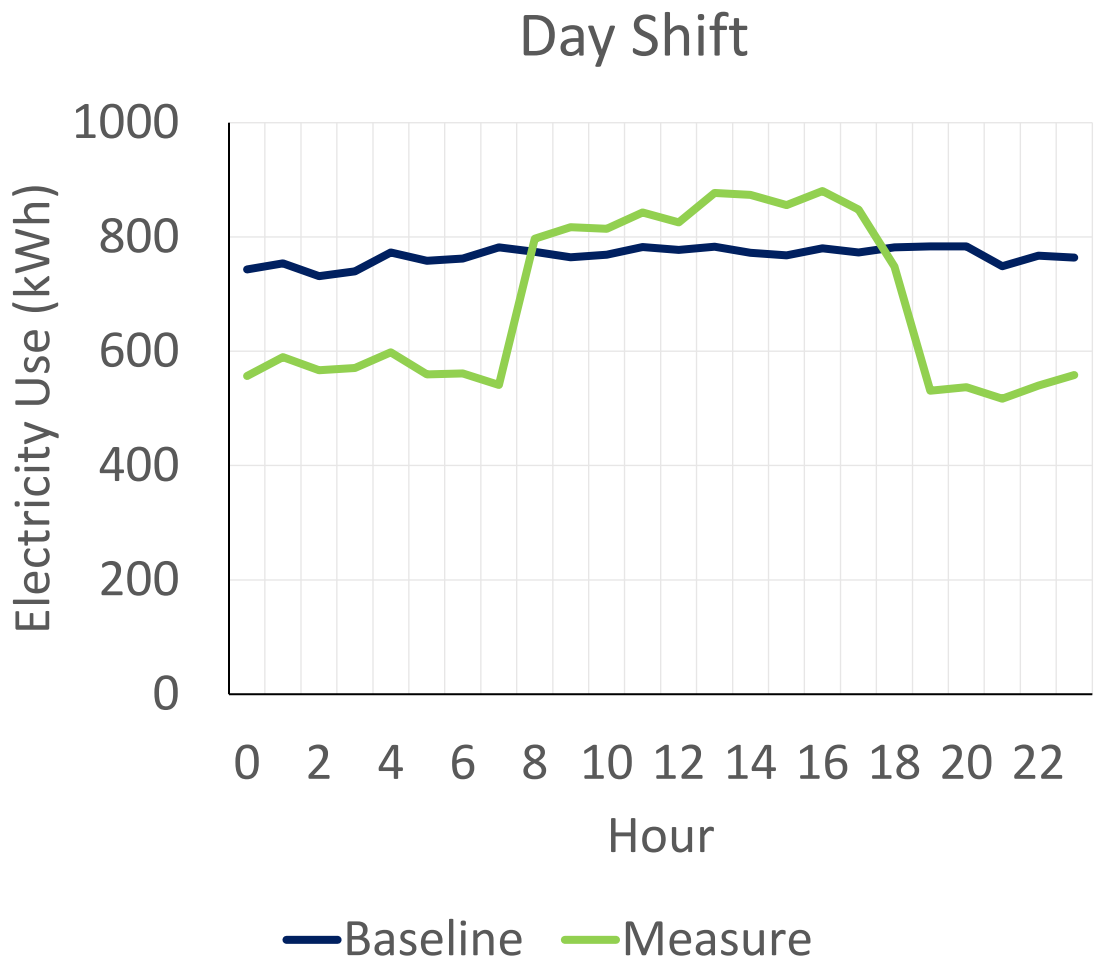


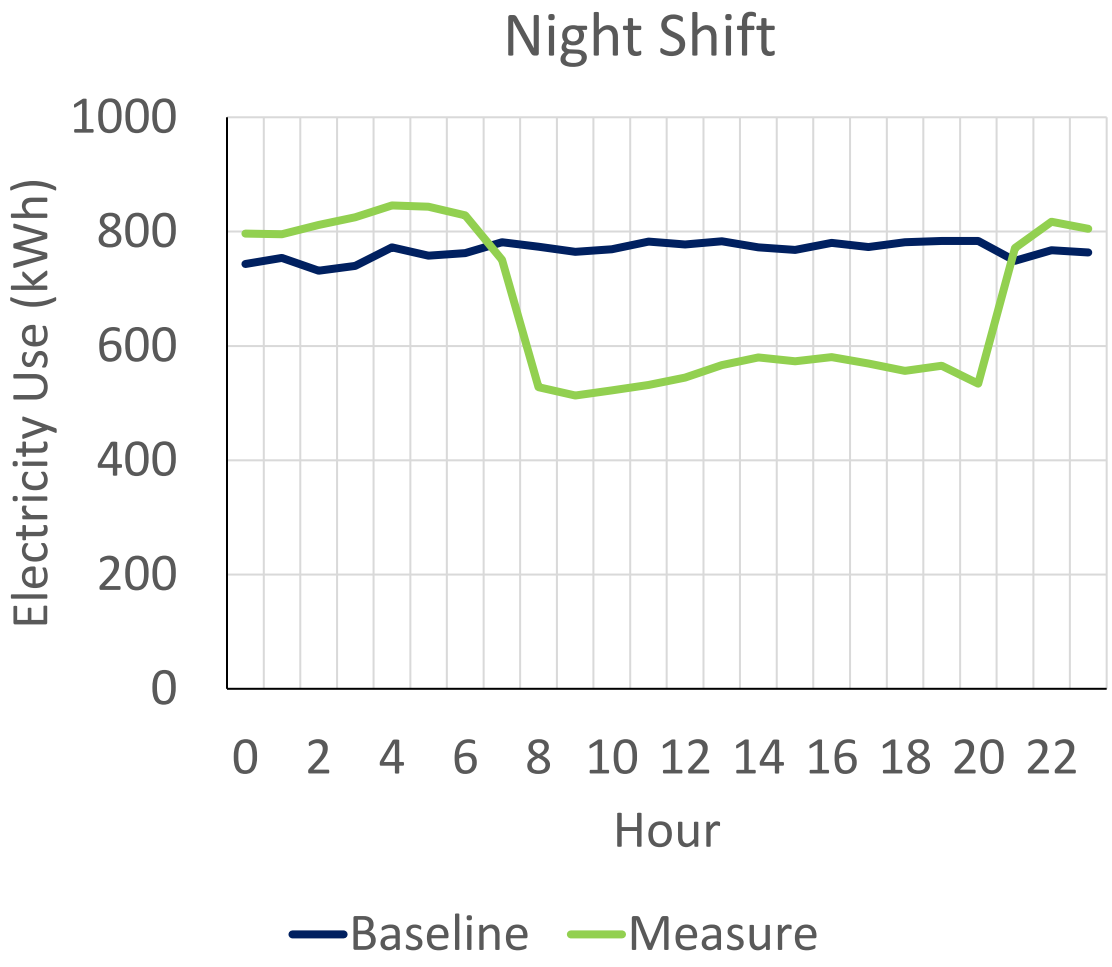
Load Shape Optimization

Regularly-occurring shift	Event-based shift	Energy efficiency
OPTION 1 Avoid energy use during the **middle of the day**	**OPTION 1** Shed energy during **high price hours** of top 20 days in a year	**Shed energy all day**
OPTION 2 Avoid energy use **during day or night**	**OPTION 2** Shed energy during **high emissions hours** of top 20 days in a year	

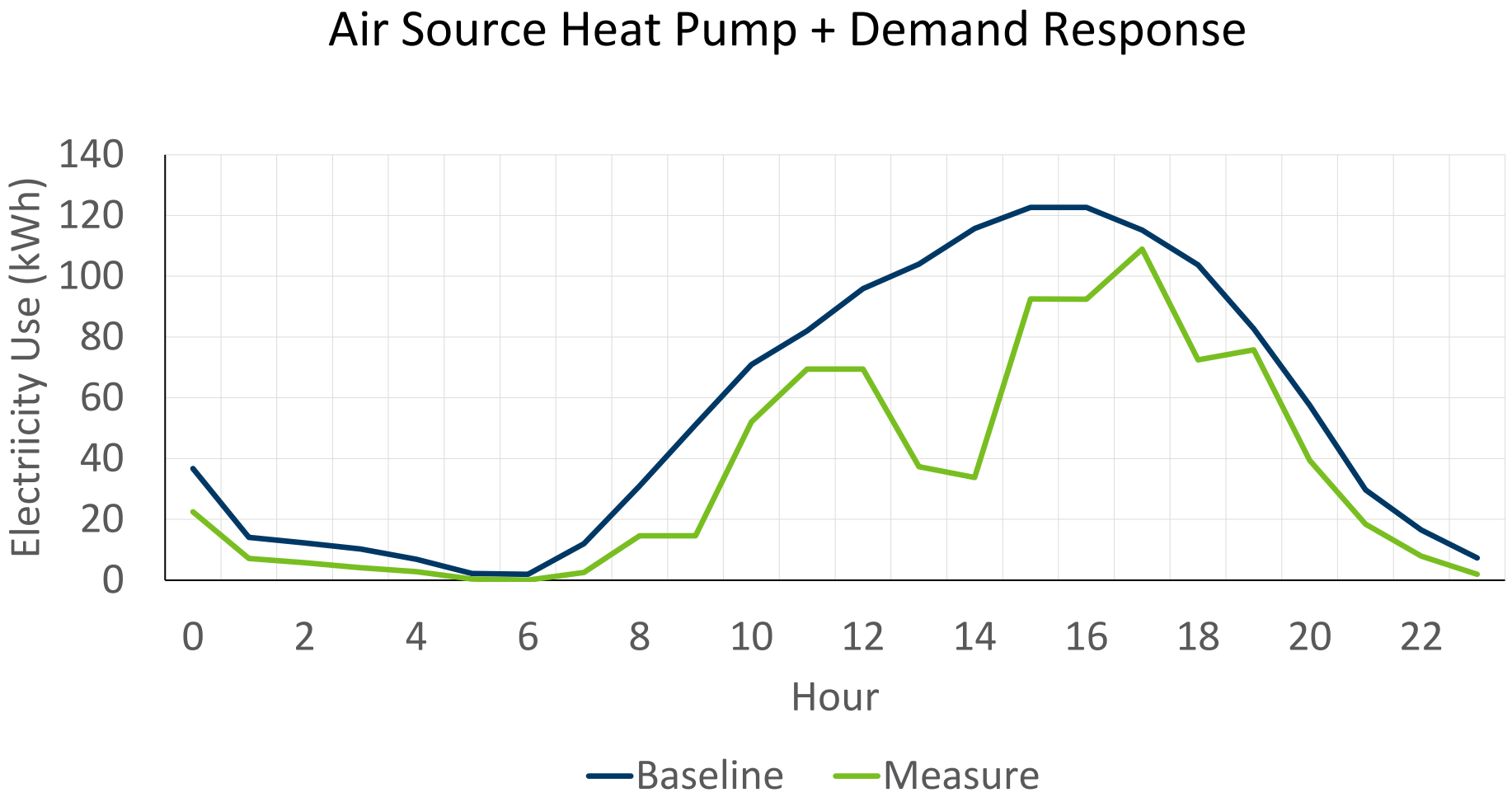
Regularly-occurring Shift Example

Phase Change Materials — Refrigeration

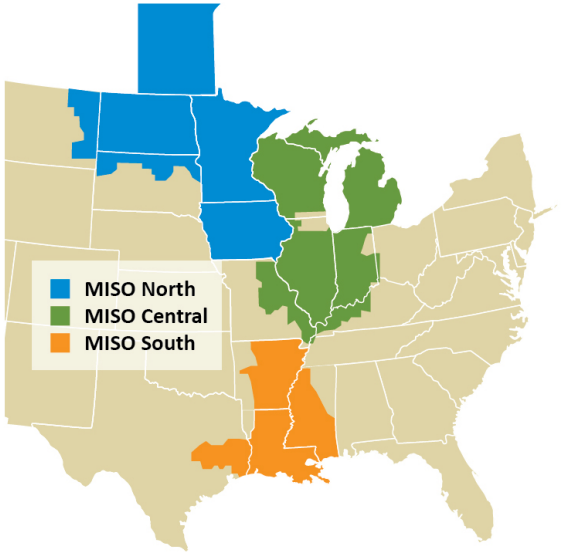




Event-based Example



Cost and Emissions Data Sources



Independent Service Operator

Current MISO Market and fuel mix/marginal plant data
Future data unavailable



Statewide

Current and forecasted emissions (EPA hourly emissions and known future retirements)



Utility specific

Current data and future costs and emissions: Integrated Resource Planning data



Price Optimization Results

Goal for Optimizing for Energy Cost

HIGH COST → LOW COST

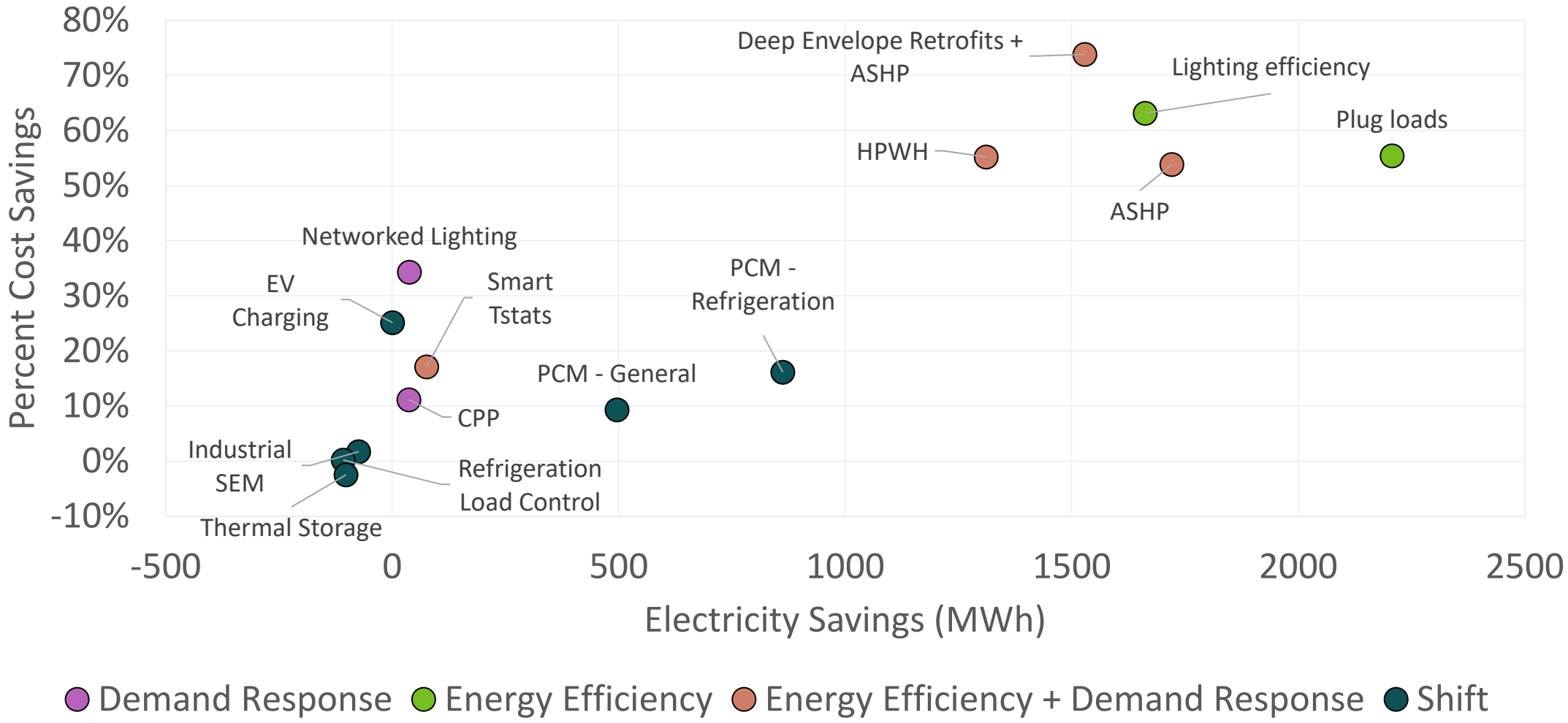


FOURTEEN MEASURES

Modeled three time periods (2018, 2026, 2034)

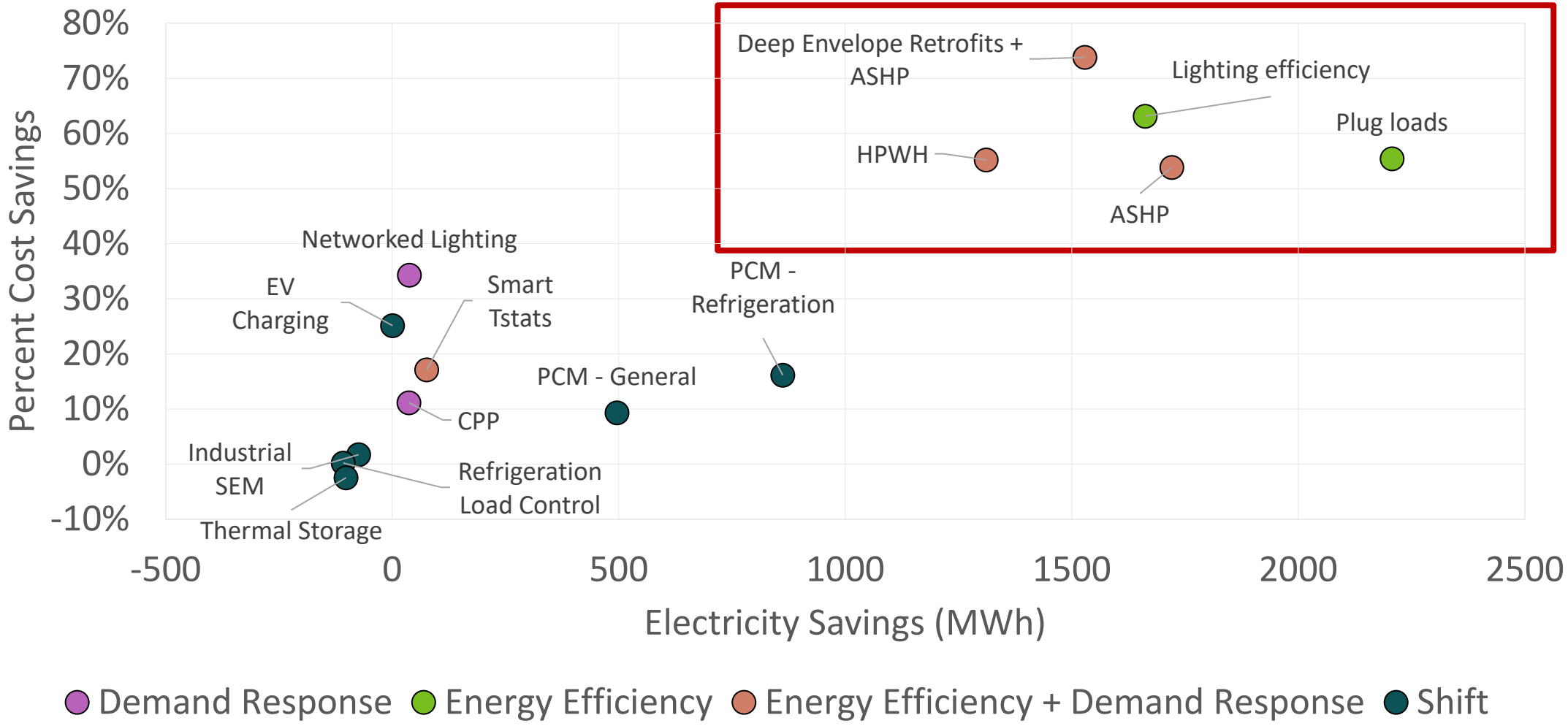
Percent Cost Savings

Percent cost savings vs. annual energy savings



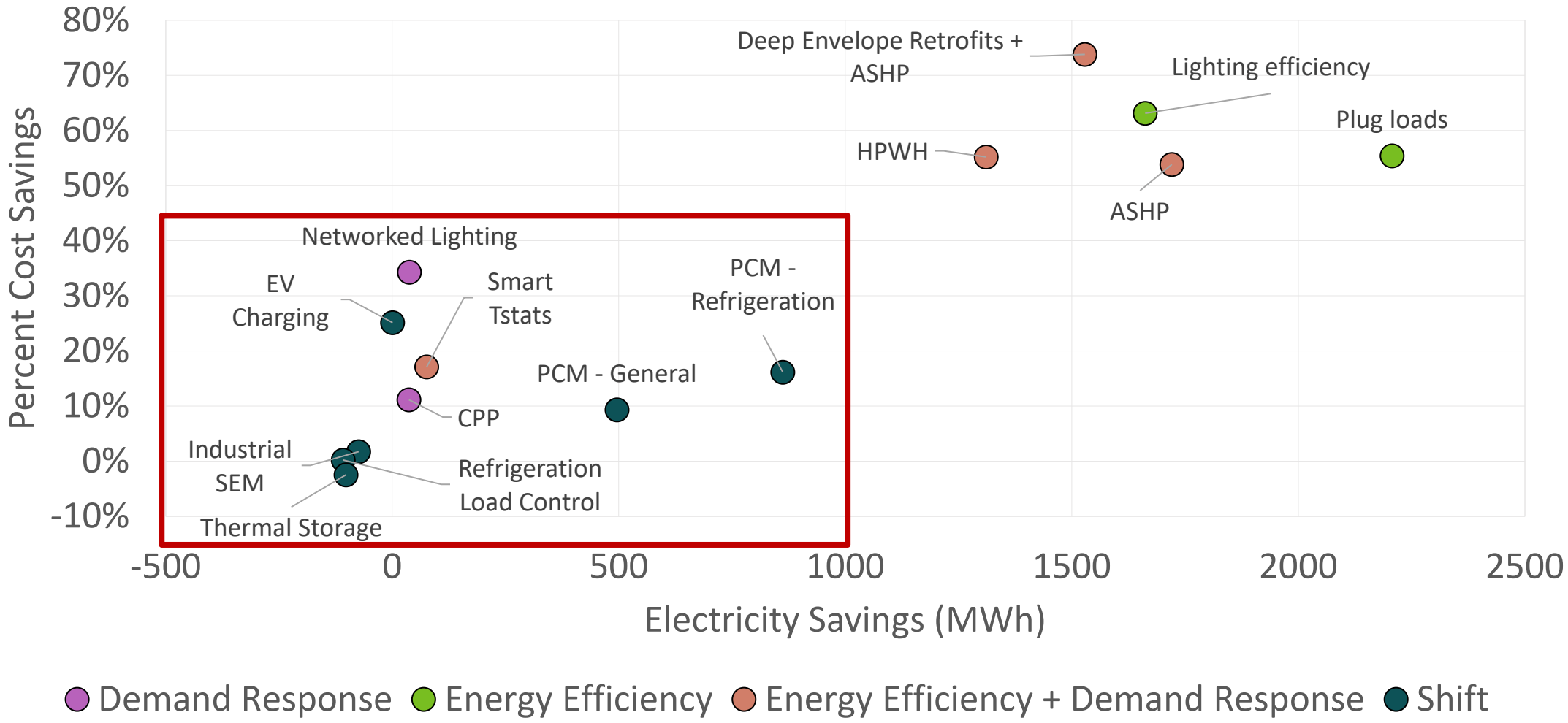
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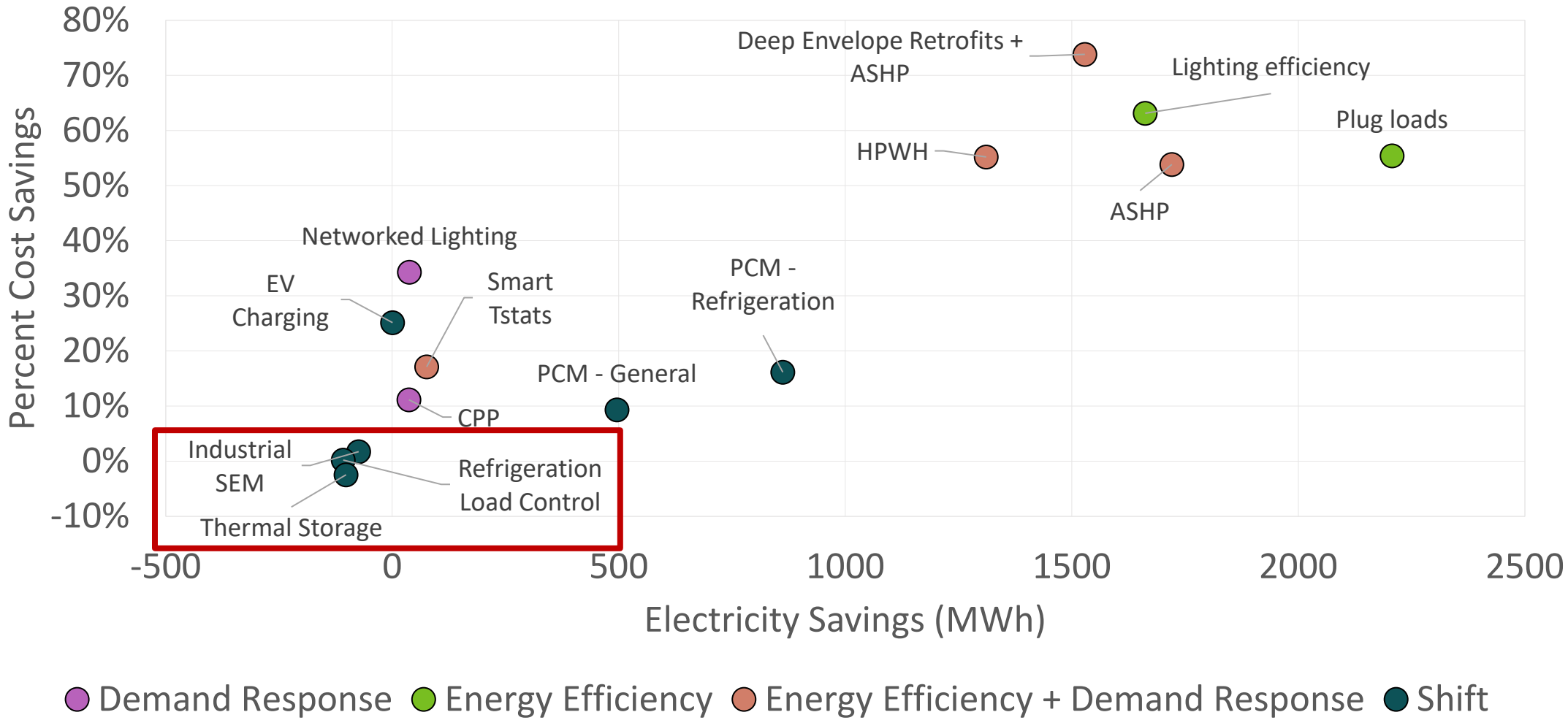
Percent Cost Savings

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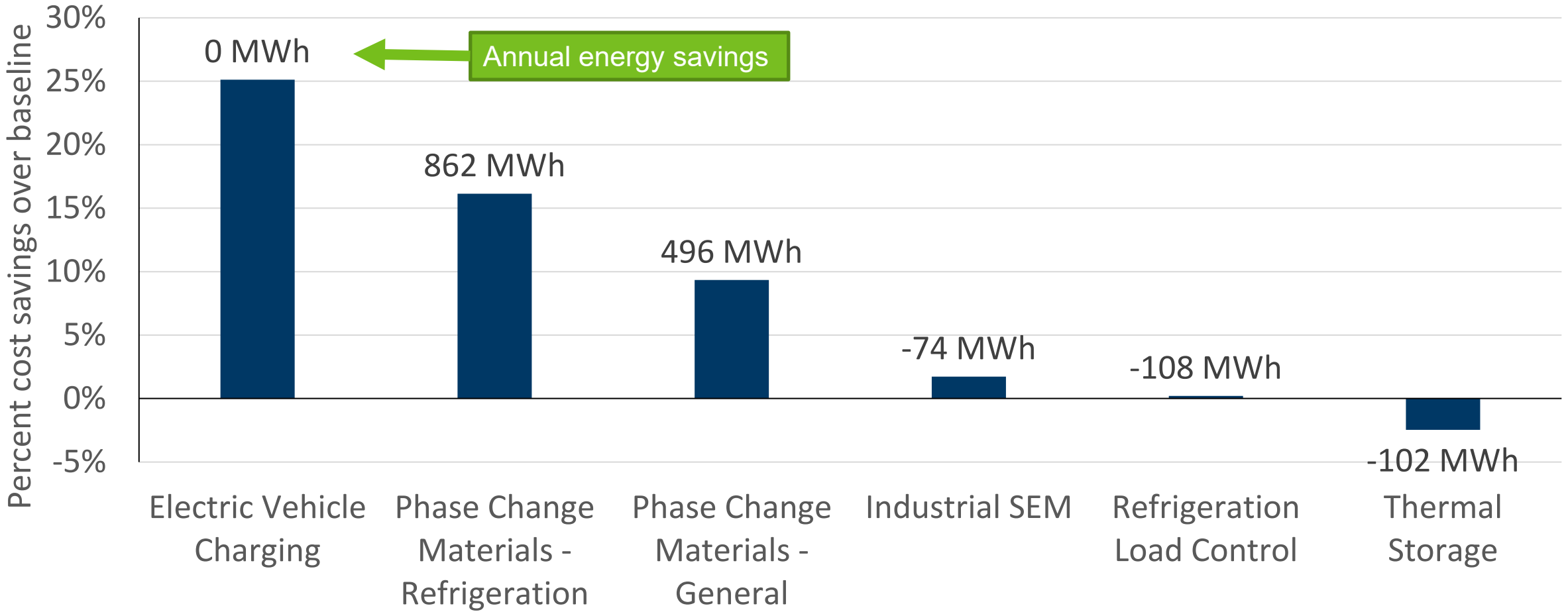


Percent Cost Savings

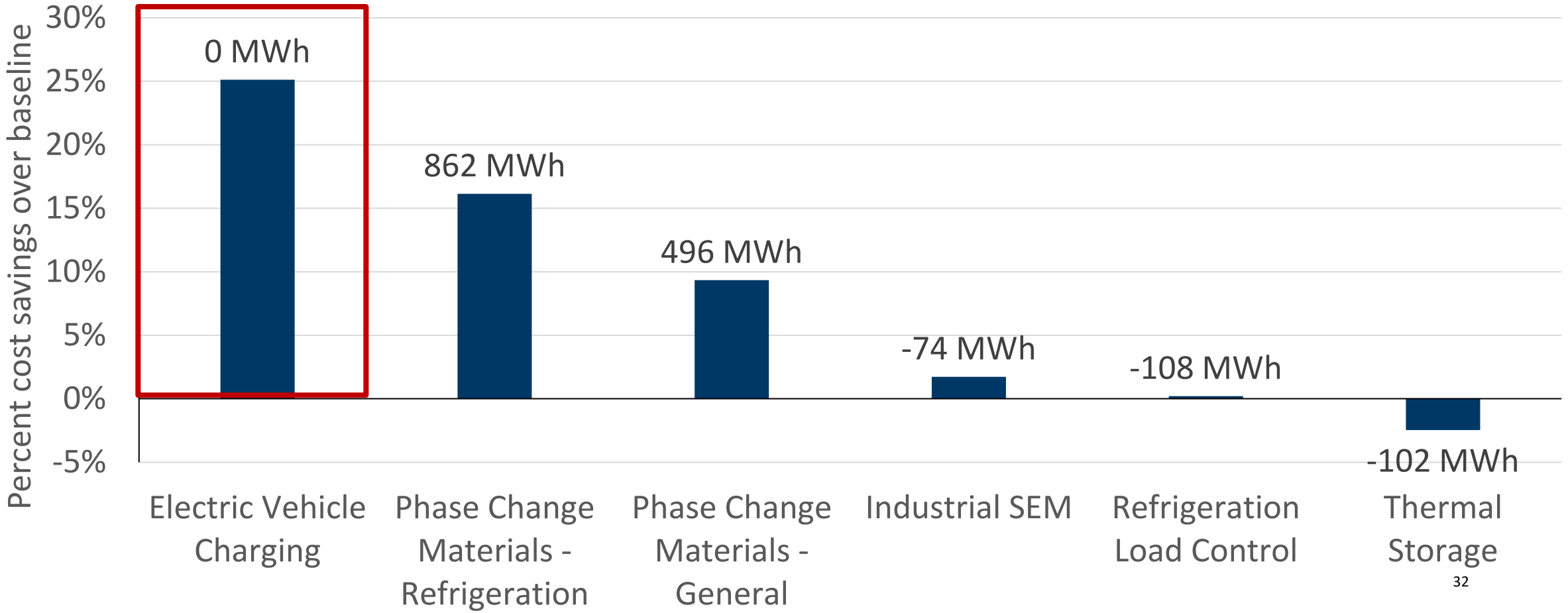
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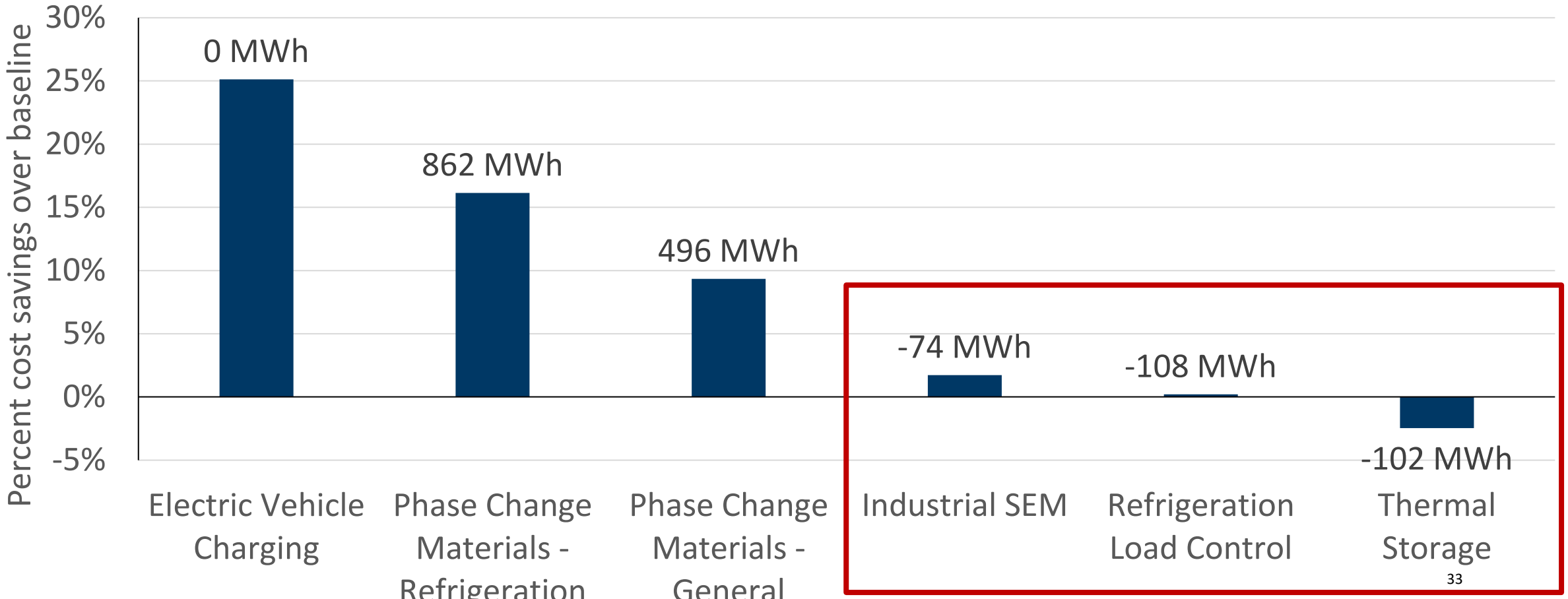
Regularly-occurring shifts: Percent cost savings over baseline



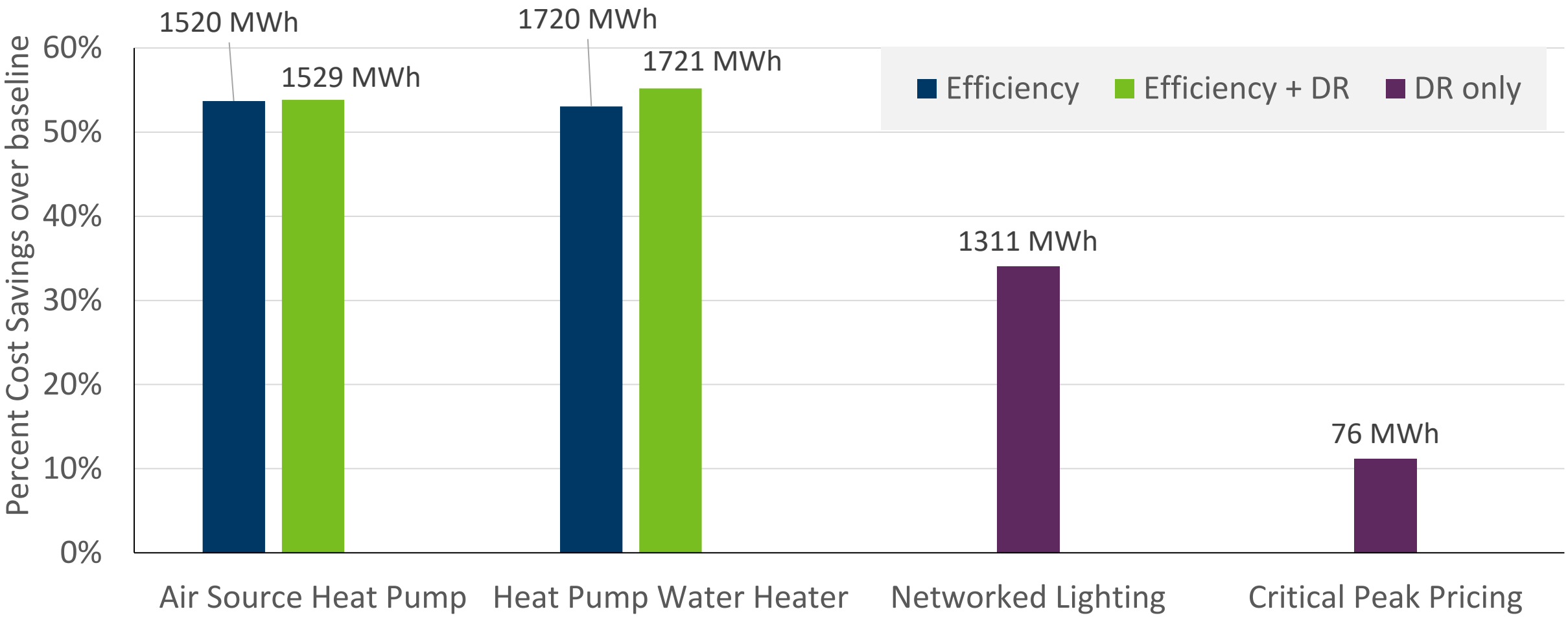
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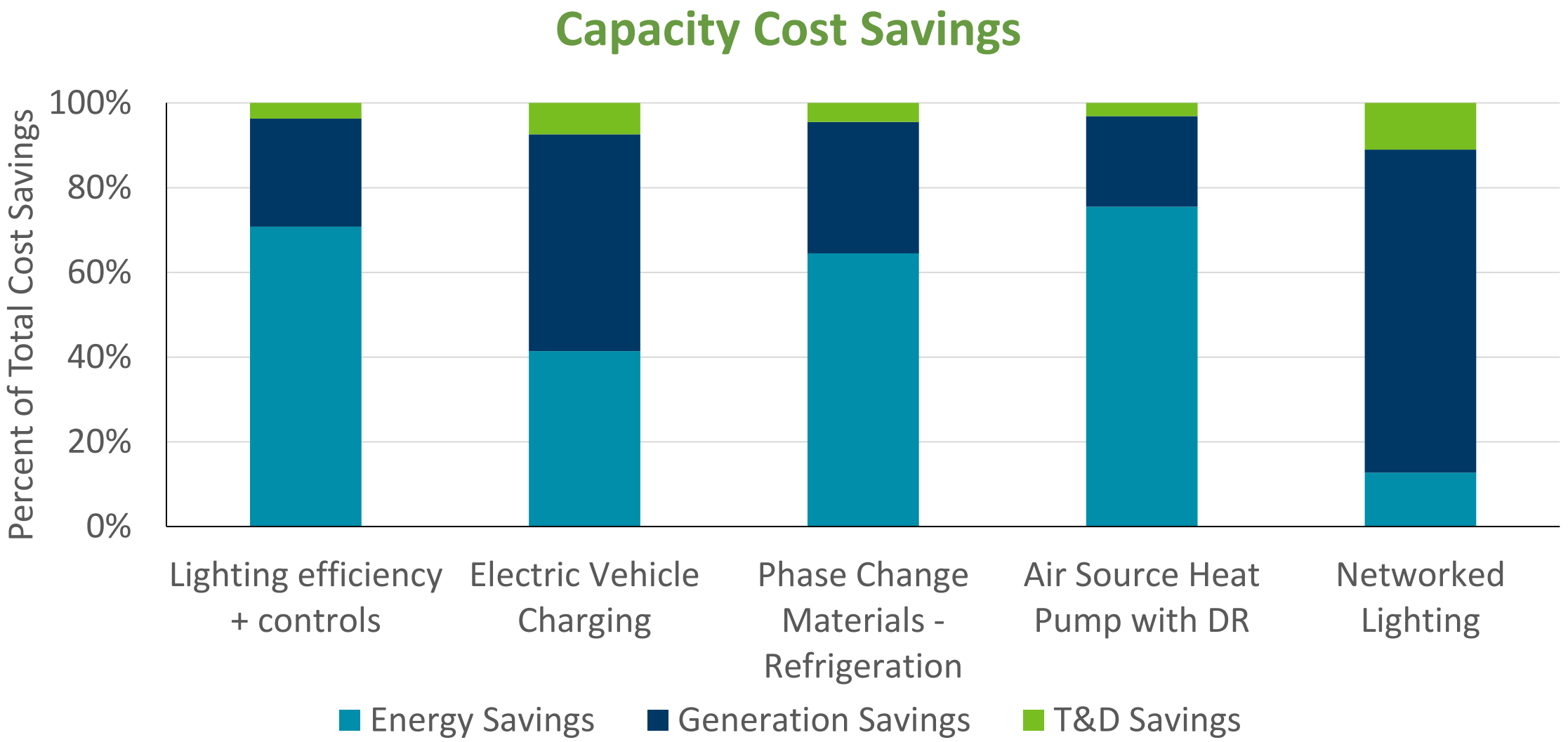
Regularly-occurring shifts: Percent cost savings over baseline



Event-based shifts: Percent cost savings over baseline



Capacity Cost Savings



Other Findings

Future

- Mostly stable percent cost savings across time
- Regularly-occurring shifts experience declines in cost savings
  (Due to lower prices in middle of day from renewable integration)

Carbon emissions

- Most measures save emissions when compared to the baseline
- Exception: those measures with an energy penalty

Key Takeaways

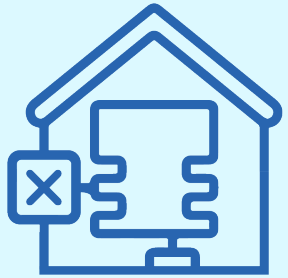
- **Energy efficiency** dominates both cost and emission savings opportunities
- Measures that increase energy use can **save energy costs through shifting**
- The timing of shifts may need to **change in the future to** respond to changes in price profiles
- **Capacity costs can have a significant impact** on cost savings for pure demand response and shifting measures



Emissions Optimization Results

Goal for Optimizing for Carbon Emissions

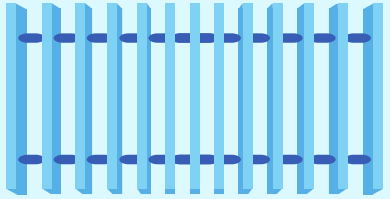
HIGH EMISSIONS → LOW EMISSIONS



air source heat pumps



electric vehicles

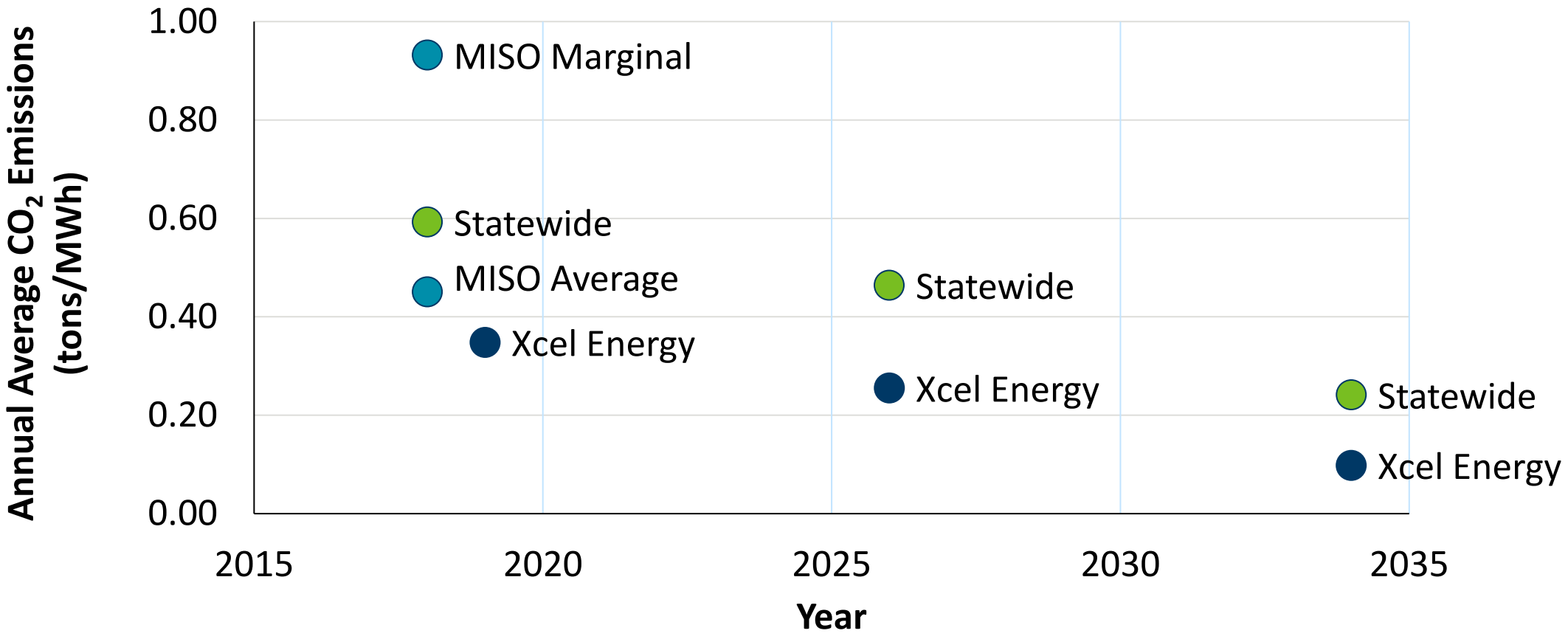


phase change materials for refrigeration

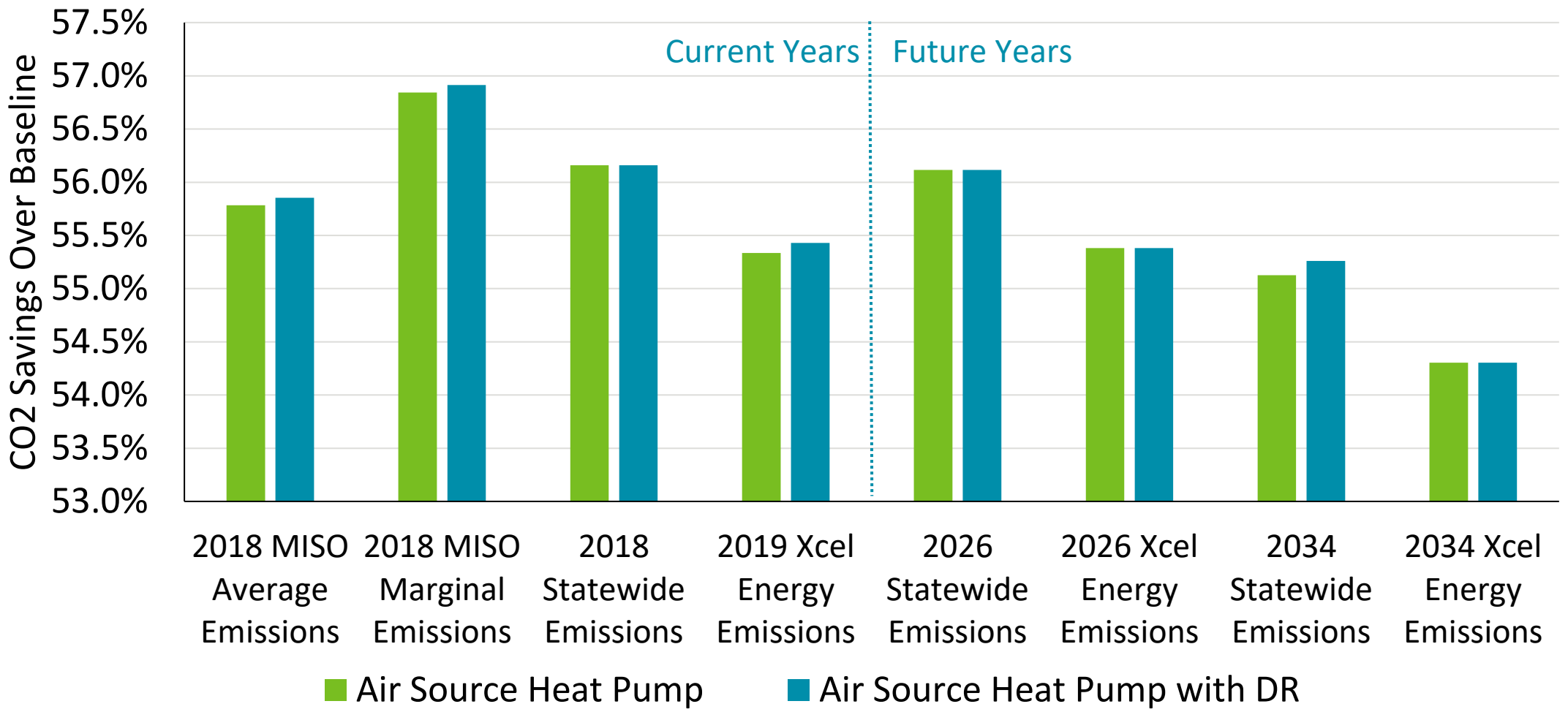
THREE MEASURES

MODELED THREE TIME PERIODS ····· MODELED THREE TERRITORIES

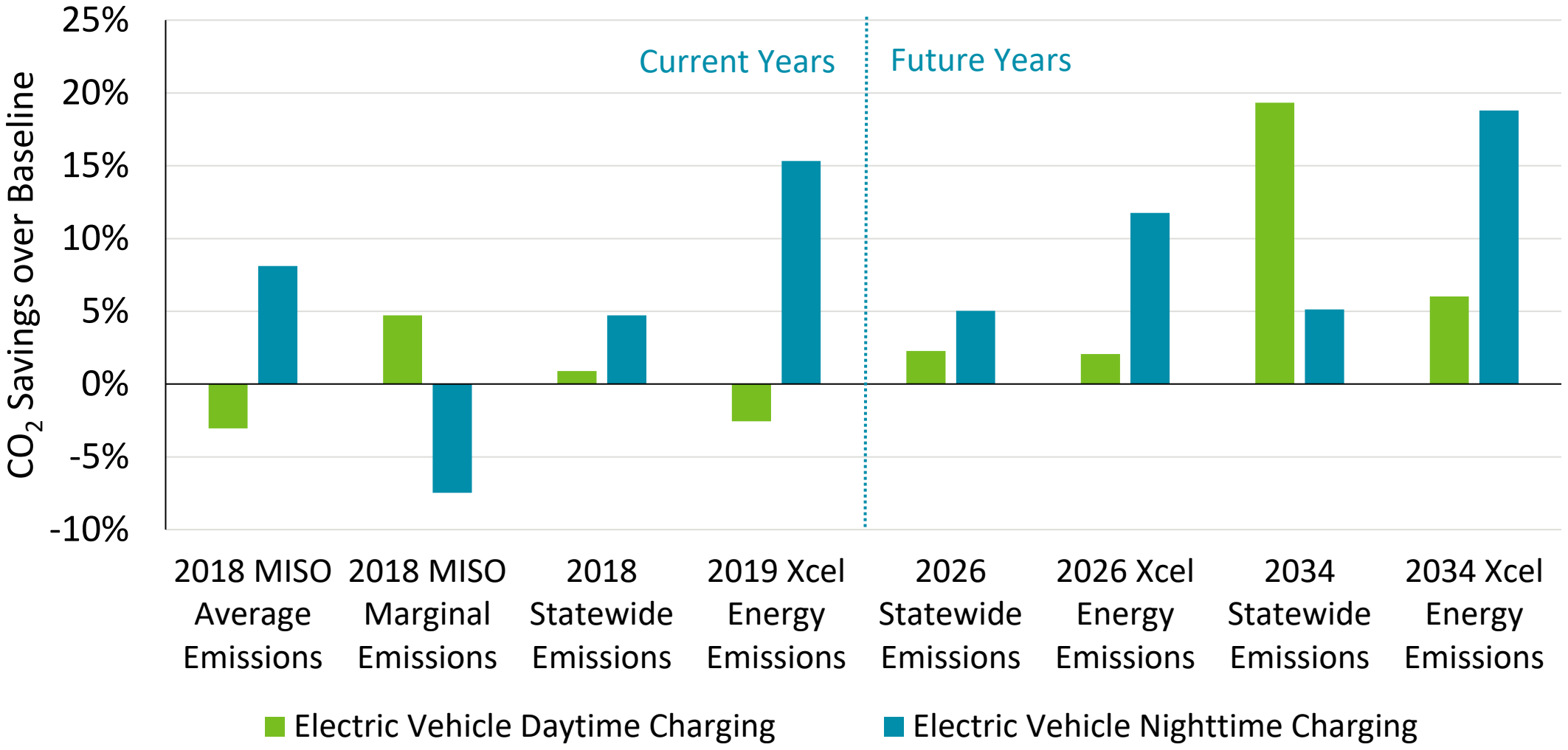
Annual emission factors across time and footprint



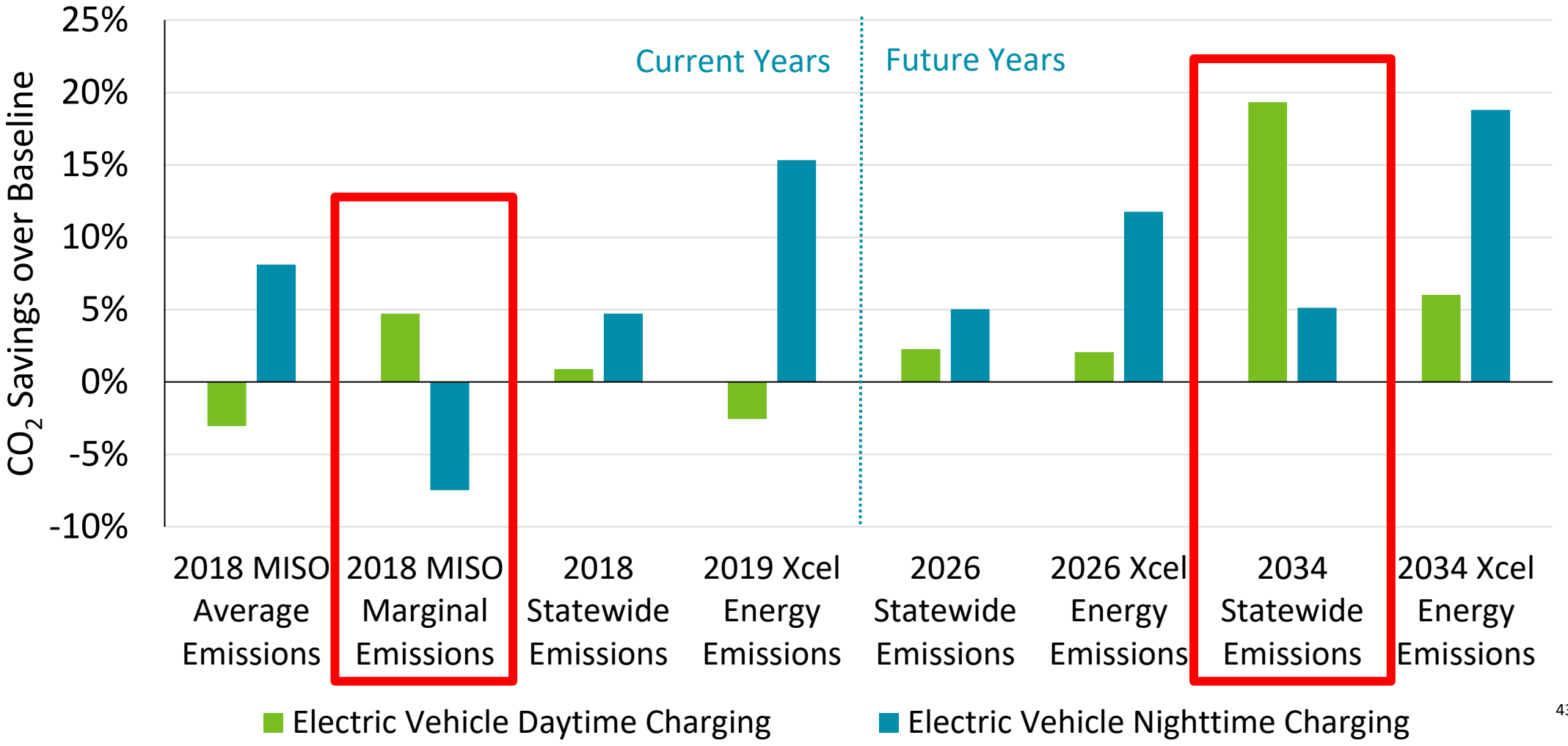
Air source heat pumps: Percent emissions savings over baseline



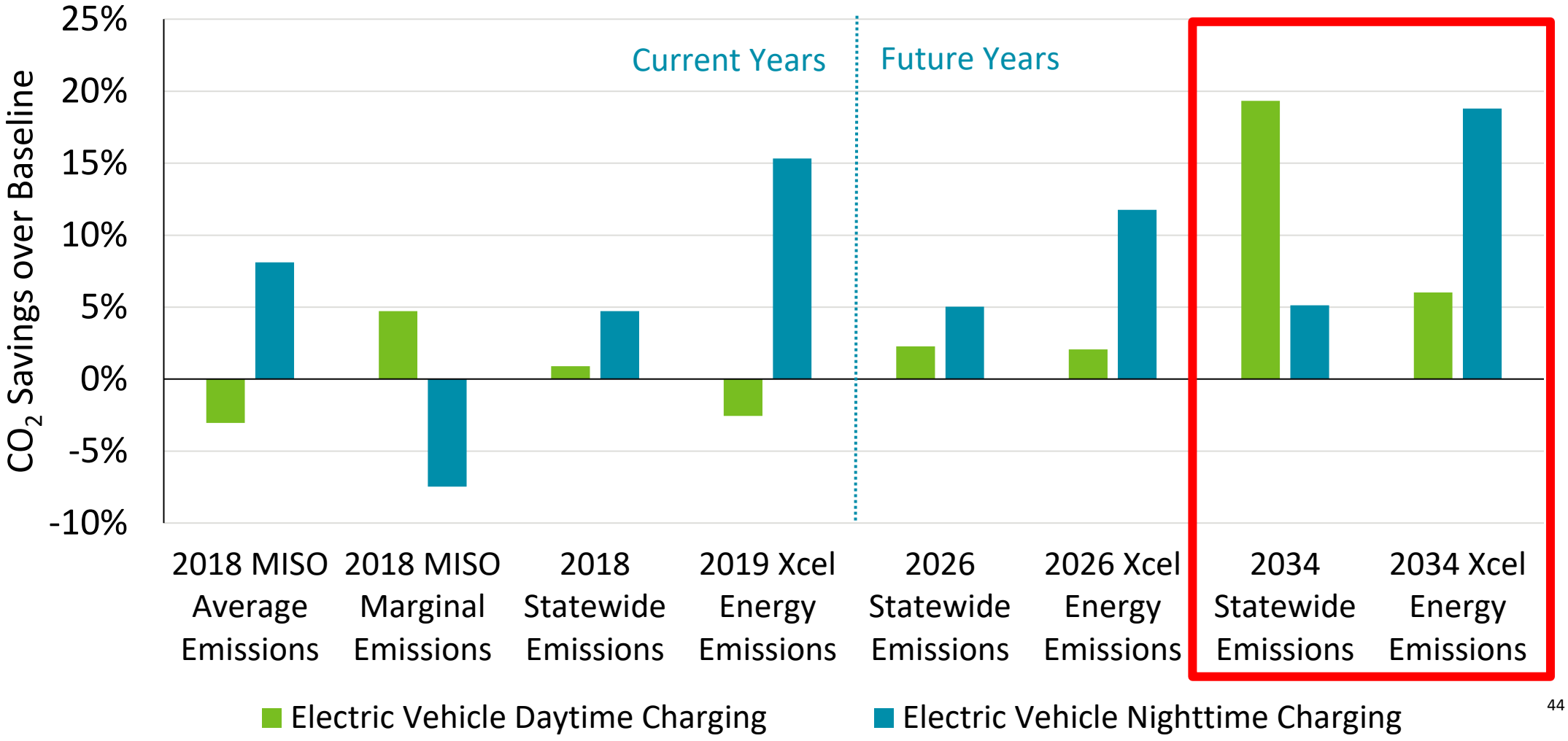
Electric vehicles: Percent emissions savings over baseline



Electric vehicles: Percent emissions savings over baseline



Electric vehicles: Percent emissions savings over baseline



Key Takeaways

- Absolute carbon savings can as much as double depending on which **grid region** is used to analyze emissions.
- For measures with energy efficiency benefits, **optimization based on prices versus average emissions** does not lead to significant changes in average emissions savings in the current Minnesota grid.


Recommendations

Program Recommendations, part 1

1. Continue to pursue **load shifting measures that can save energy** in CIP portfolios.

2. Bundle **cost-effective load shifting measures** with other measures in CIP portfolios.

3. Consider **future rate designs** that incentivize customers to shift energy when system is near capacity.

Program Recommendations, part 2

4 Apply a **utility-specific grid region** to calculate emissions benefits where available.

5 Further investigate measures **that shift load to nighttime hours** absent any energy savings benefits.

6 Explore **additional measures** that may offer similar load shifting benefits.

Future Research Recommendations

1. For future demand side management potential studies, **expand consideration of measure benefits to include cost savings and carbon benefits** associated with load shifting.

2. Perform additional **field research on load shifting measures** to generate a more robust database of empirical load shapes.

3. Conduct additional research to **improve marginal emissions, energy costs, and capacity cost forecasts..**

Thank you!



Questions?

Load shifting: market potential for carbon and energy savings



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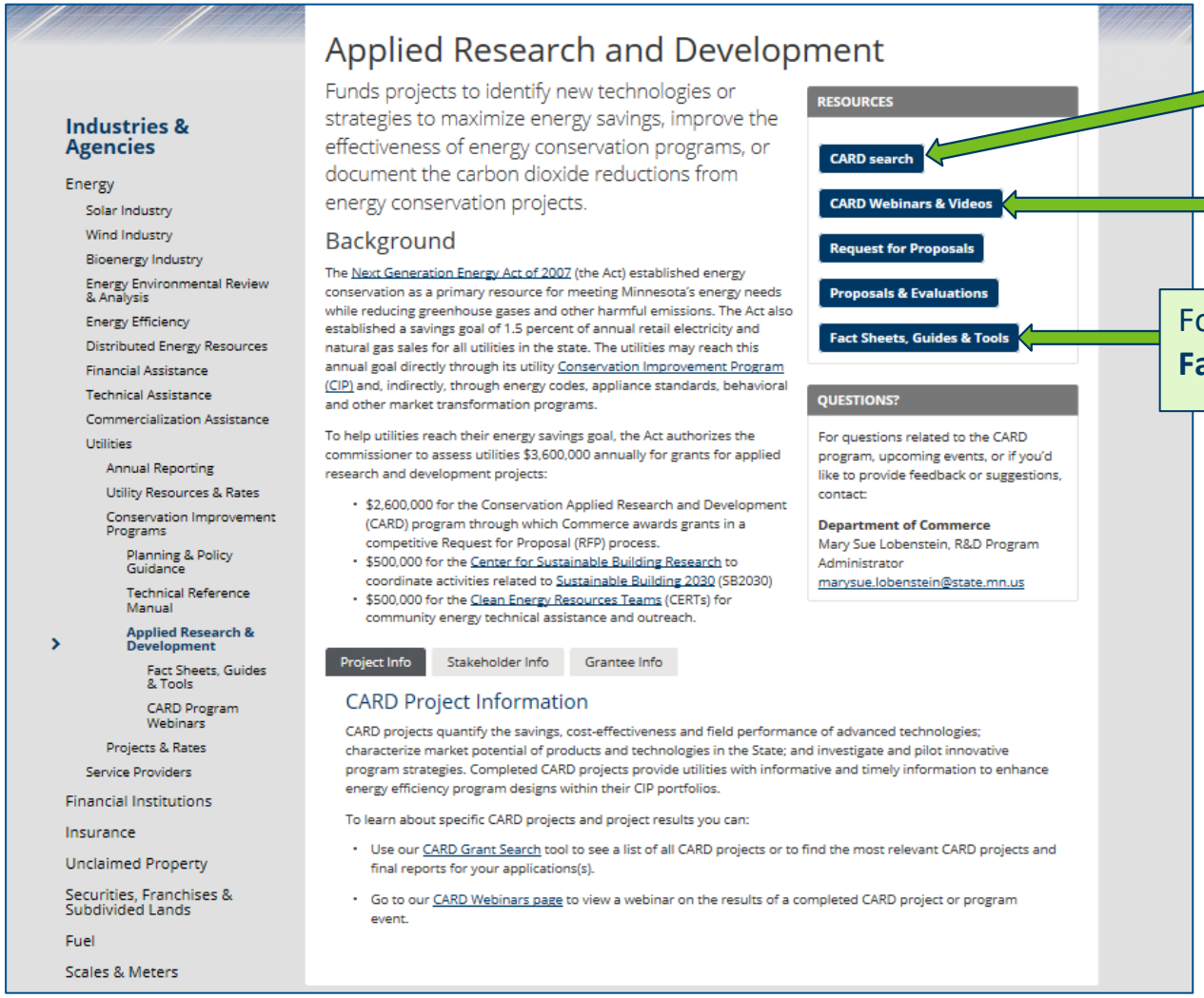
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Send us your questions using Q&A box

CARD Project Resources



For **Reports** use **CARD Search** Quick Link

For **Webinars** use **CARD Webinars & Videos** Quick Link

For **Other** research documents use **CARD Fact Sheets, Guidelines & Tools** Quick Link

Webinar Recording & Final Report
available in couple months

R&D Web Page (https://mn.gov/commerce/industries/energy/utilities/cip/applied-research-development/)

Thanks for Participating!

Upcoming CARD Webinars:

- **December 4 (New Date)** – Reconsidering MN Cooling Loads (Center for Energy and Environment)
- **December 10 (Tentative)** – C&I Refrigeration Market Assessment (Center for Energy and Environment)
- **December 16** – Codes and Standards Roadmap (2050 Partners)

Commerce Division of Energy Resources e-mail list sign-up

If you have questions or feedback on the CARD program contact:
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How Did We Do?



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