COMMERCE DEPARTMENT

Welcome

Conservation Applied Research & Development (CARD) Webinar

October 19, 2021

The Low Down on High Performance Envelope Retrofits

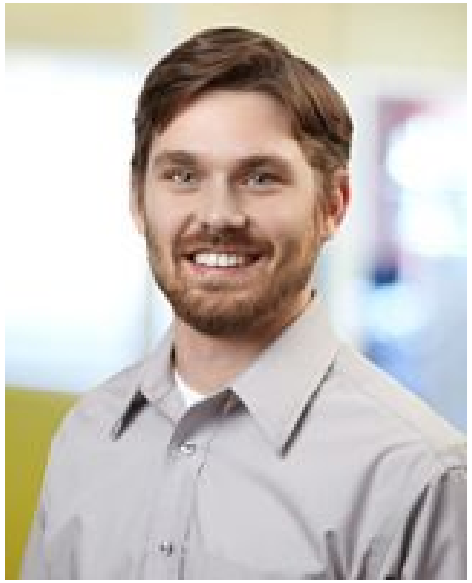
Energy Efficiency Opportunity Potential at Minnesota Water Utilities



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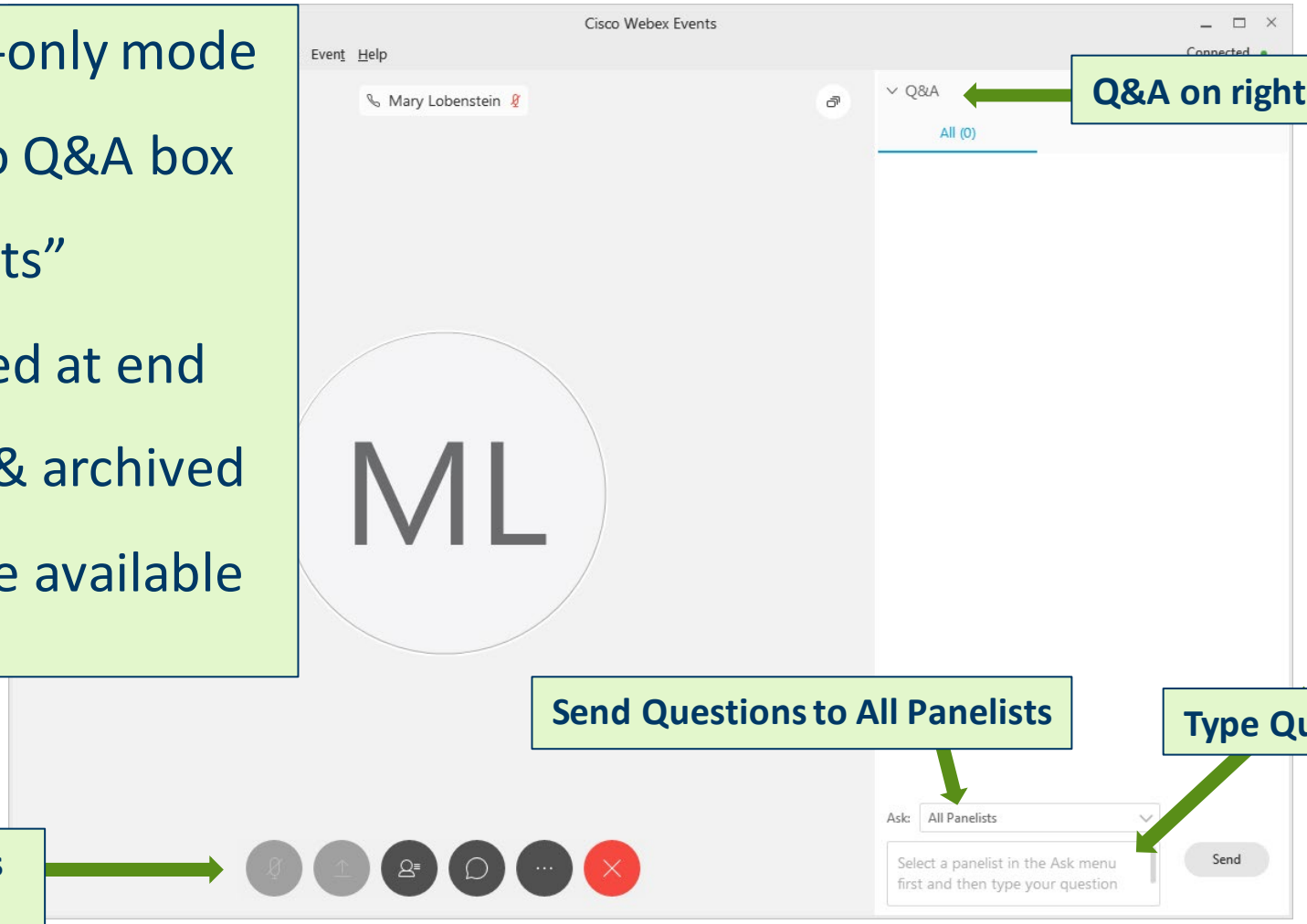
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Webinar Basics

- Attendees in listen-only mode
- Type questions into Q&A box
- Send to “All Panelists”
- Questions addressed at end
- Webinar recorded & archived
- Slide set will also be available



Q&A on right side of WebEx panel

Send Questions to All Panelists

Type Questions in Q&A box

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Minnesota Applied Research & Development Fund

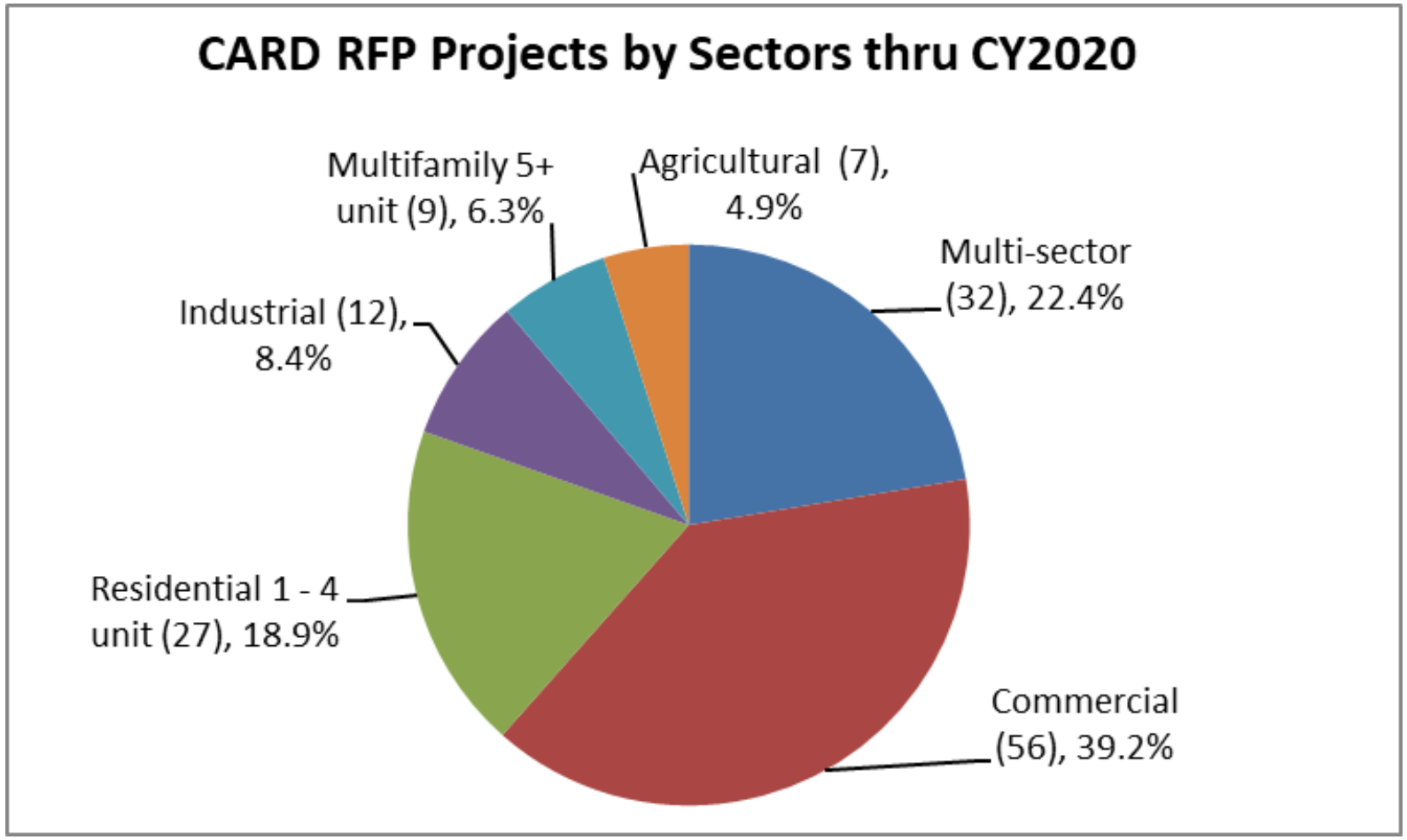
- **Purpose to help Minnesota utilities achieve 1.5% energy savings goal by:**
  - ***Identifying new technologies or strategies to maximize energy savings;***
  - ***Improving effectiveness of energy conservation programs;***
  - ***Documenting CO_2 reductions from energy conservation programs.***

- **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**

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

State Capitol Image: Courtesy Minnesota Department of Administration

CARD RFP Spending by Sector thru FY2020



RFP Summary

- 12 Funding Cycles
- 513 proposals
- 143 projects funded
- $31.2 million in research

THE LOW DOWN ON HIGH PERFORMANCE ENVELOPE RETROFITS

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CEE: A mission driven energy efficiency organization

The Center for Energy and Environment promotes energy efficiency to strengthen the economy while improving the environment.

We provide practical energy solutions for homes, businesses, and communities.

WE STAND FOR

- ✓Collaboration
- ✓Community
- ✓Expertise
- ✓Integrity
- ✓Science
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Agenda

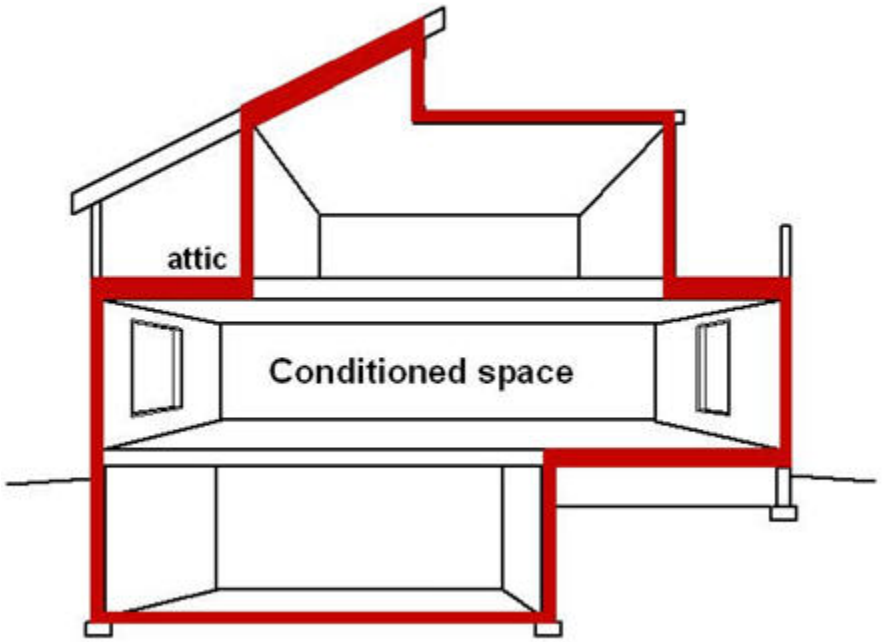
- Background: ***Building Envelopes & Space Heating in Minnesota***
- Objectives: ***What are we trying to do here?***
- Methods: ***How did we pursue this research?***
- Results: ***Barriers & Opportunities from Outreach***
  Minnesota's Existing Single Family Building Stock
  Weatherization
  High Performance Envelopes
  Cost Effectiveness
- Conclusion: ***Recommendations***
  Future Work

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The Building Envelope

- Collection of things that physically separate the conditioned space from unconditioned space

- For this project we break them into components
  - Attic / Ceiling
  - Walls
  - Doors & Windows
  - Rim joists
  - Above Grade Foundation
  - Below Grade Foundation
  - ~ Air Leakage (Infiltration)



https://silvermancpm.com/construction-term-of-the-week-building-envelope/

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Building Envelope Drives Space Heating Load

- Space heating is 60% - 80% of total energy use in a MN single family home
- ~67% of single-family homes use natural gas to meet this load
- Improving building envelope efficiency is the largest single natural gas savings opportunity
- More broadly, when other fuels are considered improving building envelope efficiency is equal to or greater than ***all other current residential energy efficiency measures combined***

Weatherization

- Conventional measures that improve building envelope efficiency are called weatherization
  - Sealing air leaks
  - Adding insulation (walls, attics, foundation)
  - Window upgrades and treatments
- Weatherization measures have a long and successful program history in MN and nationally
- Weatherization cost effectively brings buildings to minimum standard
- Generally limited to 15% - 20% savings on average

Beyond Weatherization

- Deep Energy Retrofit
  - High performance retrofit targeted ~50%+ total energy savings
  - Encompass all building systems, typically anchored by envelope improvements
  - Complex and invasive projects typically driven by comfort and environmental motivations
- Building Code:

	Windows	Ceiling	Walls	Basement	Leakage
<1990	~1.7	~26	~7.8	~4.7	~1.16
Current	3.125	49	20, 13+5ci	15	0.66
Next	3.33	60	20+5ci, 13+10ci, 0+20ci	15ci, 19, 13+5ci	0.66

- High Performance Envelope
  - Conventional weatherization measures + continuous exterior insulation (CEI) and window upgrades: ***Target 50%+ improvement***

How do we move beyond weatherization

- **Why?**
  - Diminishing returns on EE alternatives? Required for future CIP savings?
  - More emphasis on reaching climate targets?
  - Energy burdens? Infrastructure investments? Workforce developments?

Objectives

- What are the Opportunities & Barriers of moving beyond weatherization?

- What does it take to make ***high-performance*** envelopes?
  - Natural gas savings, project costs, and cost effectiveness as a function of variables that define existing building stock

Methods

Outreach Methodology

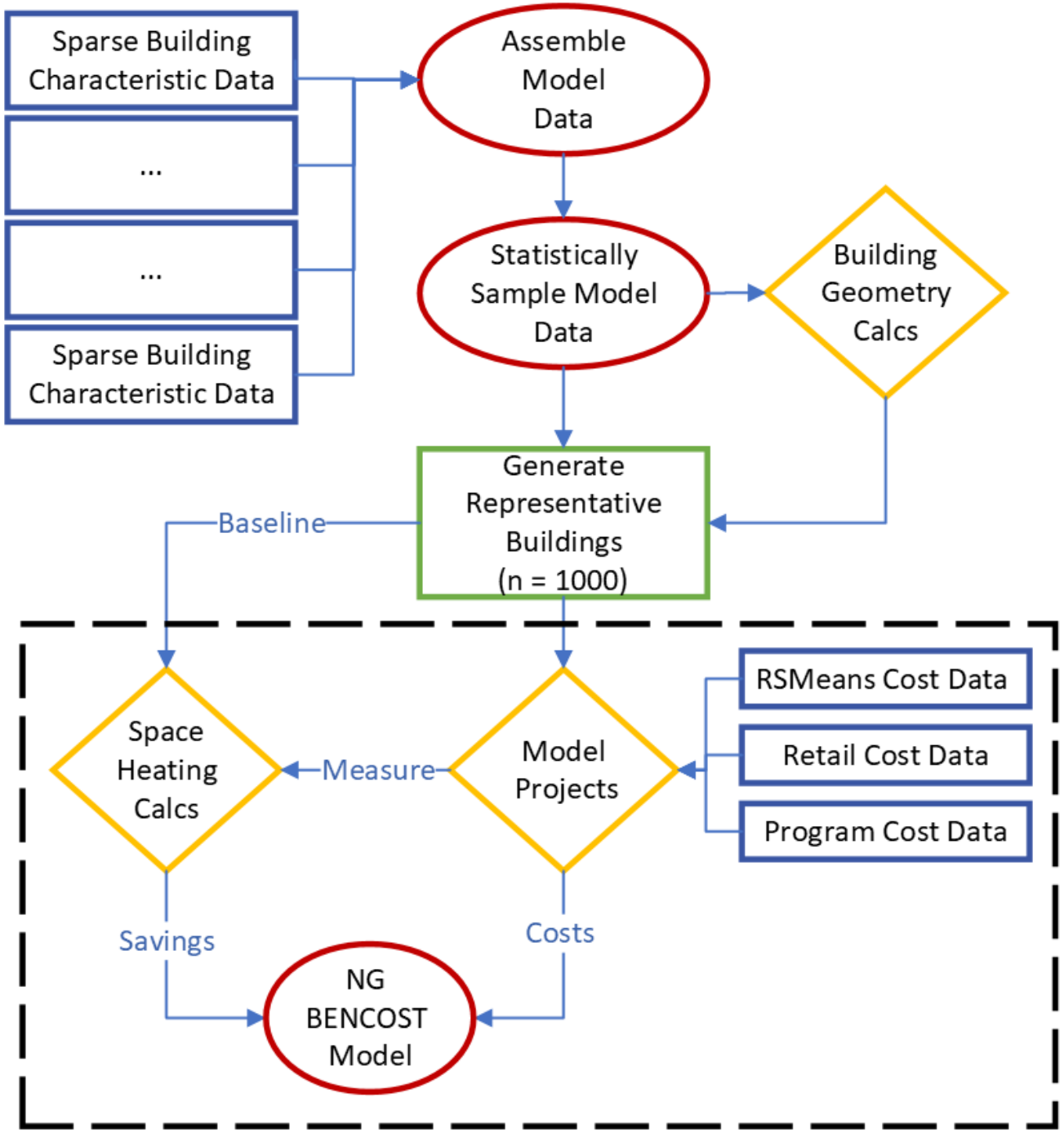
- Comprised of two aspects
  - Identify opportunities and barriers
  - Quantify potential savings, costs and market opportunities
- Compiled lists of stakeholders a part of this market
  - Contractors (General and Energy)
  - Architects and Engineers
  - Advocacy groups
  - Realtors and Appraisers
  - Supply Chains
- Attendance at local webinars and seminars

Model Overview

- Capture variations in real building characteristics and performance data

- Generate representative buildings
  - Calculate space heating loads
  - Estimate envelope projects
  - Cost effectiveness testing

Variable
Building age (decade)
Building size (total sq ft)
Building type (e.g., one-story, split-level)
Cladding type (siding material)
Window area/ratio (sq ft)
Attic geometry
Attic insulation R-value
Wall insulation R-value
Air leakage
Window type/details



Results

Lack of Awareness

- Interviewed stakeholders were asked familiarity with either Deep Energy Retrofits, Passive House Retrofits or High-Performance Building Envelope Retrofits
  - 68% claimed familiarity
  - 52-58% could either define or supply examples
- ~50% of participants were unaware of these projects
  - 18% admitted no knowledge
  - 12% did not answer

Lack of Interest

- Amongst builders and contractors in particular
- Stakeholders expressed frustration builders/contractors' unwillingness to
  - Learn new methods
  - Learn about energy efficiency
  - Participate in innovative projects or technology

Cost Effectiveness

- 55% of stakeholders reported this barrier
  - Speaking for Clients/Customers
  - Contractors and builders question it's cost effectiveness
- Significant payback periods
- Clients prefer aesthetic remodels over efficiency
- Lack of rebate incentives

Opportunities

- When asked if Deep Energy Retrofits are an opportunity or barrier, stakeholders claimed opportunity but oftentimes, provided only barriers.
  - 59% viewed as opportunity
  - 14% viewed as barrier
  - 27% viewed as both
- Opportunities are endless
  - Lower incremental cost when paired with existing maintenance projects
  - Aesthetic payoffs – coupling high performance envelope with new exterior
  - Home equity potentials
  - Other non-energy benefits including comfort, home equity improvements, resilience, more flexible loads (DR responsiveness), lower HVAC investments

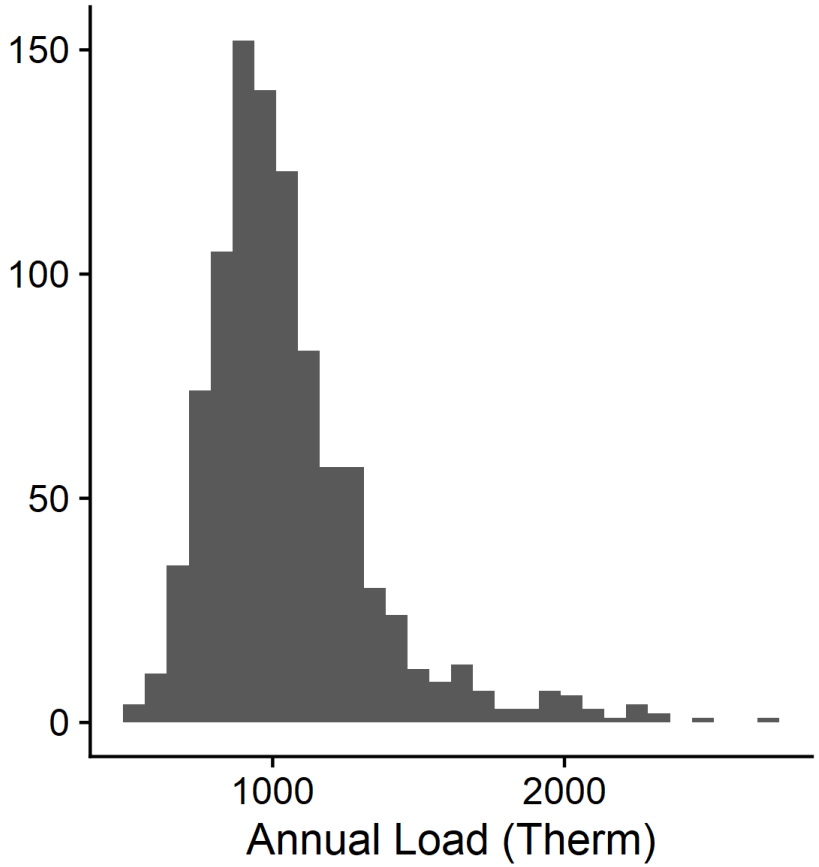
Bottom Line

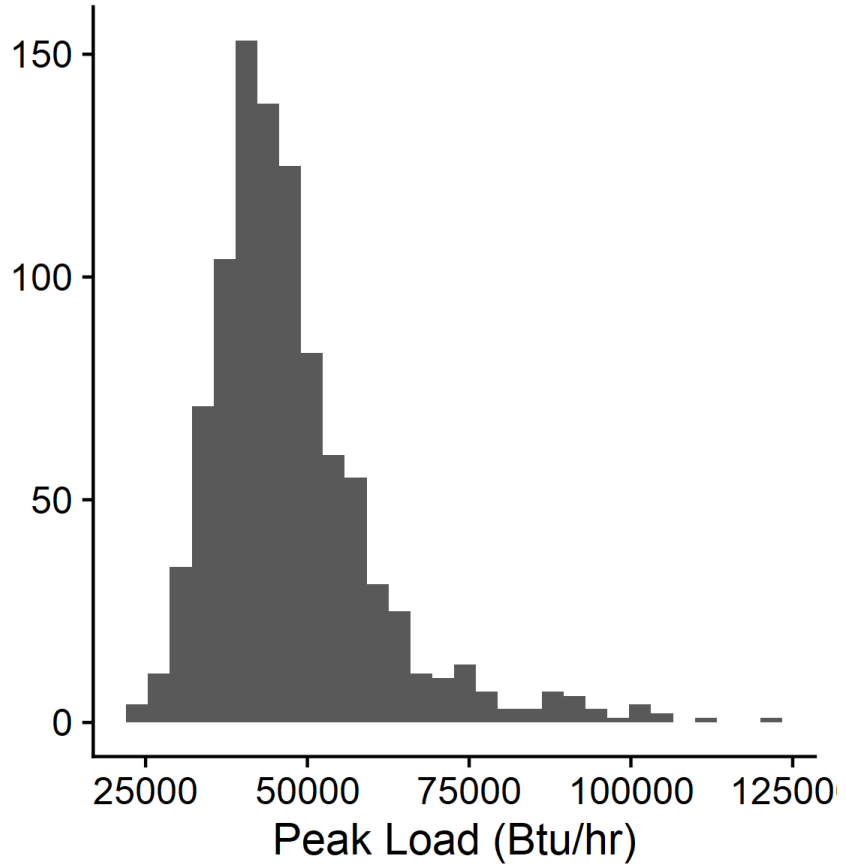
- Strong and long-standing market barriers and attractive alternative efficiency measures have historically relegated high-performance retrofits to niche status

- However due to their rare status, perceptions of cost effectiveness are not likely based on real data and outcomes
  - Born out in literature which suggests high variability in cost effectiveness outcomes and a relatively cost-neutral outcome on average

- Modeling focuses on the perceptions of cost effectiveness
  - What are the costs and anticipated outcomes of weatherization and high-performance envelope retrofit measures and how do they vary across the building stock

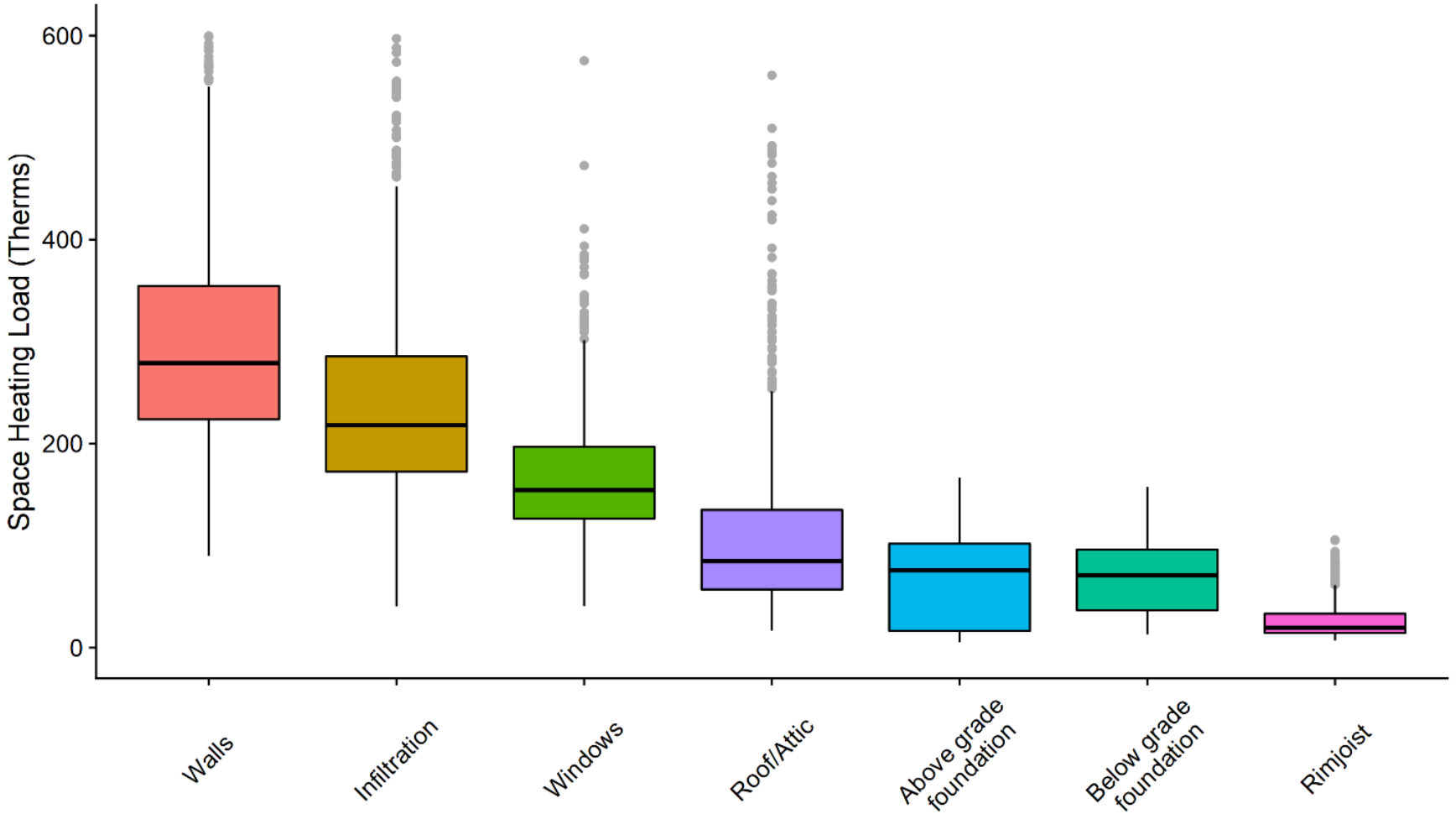
Existing Loads on <1990 single family homes





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Space Heating Load by Envelope Component

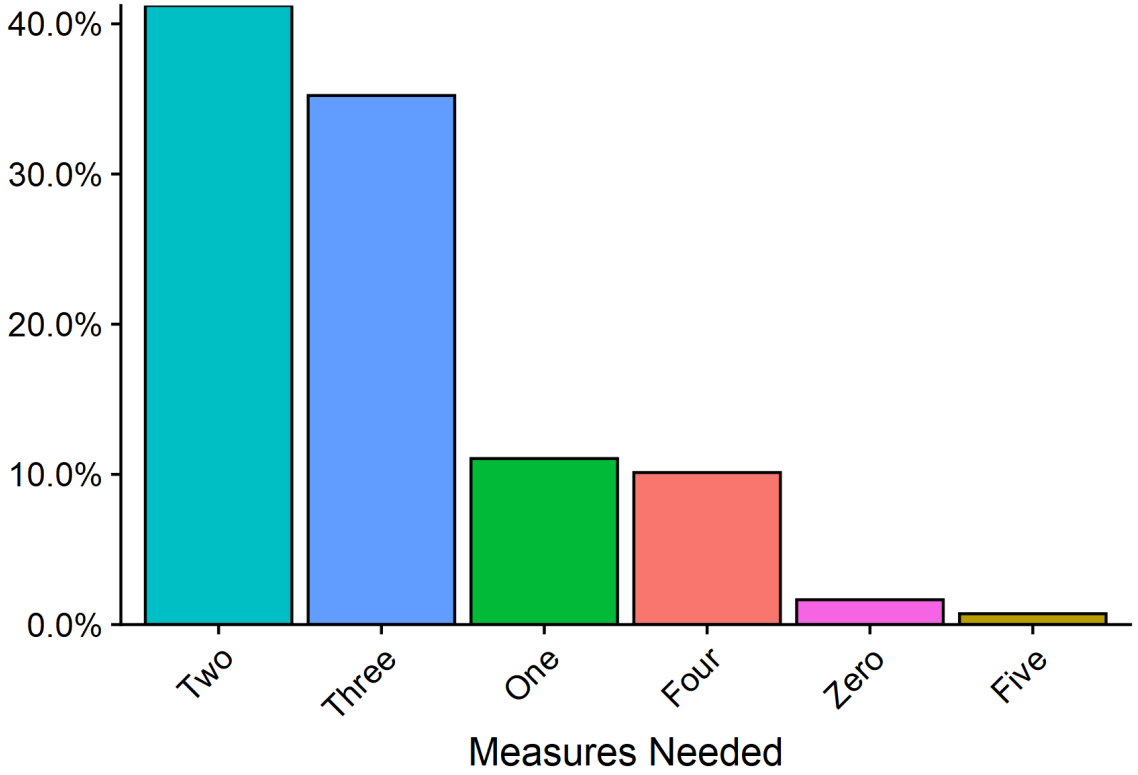


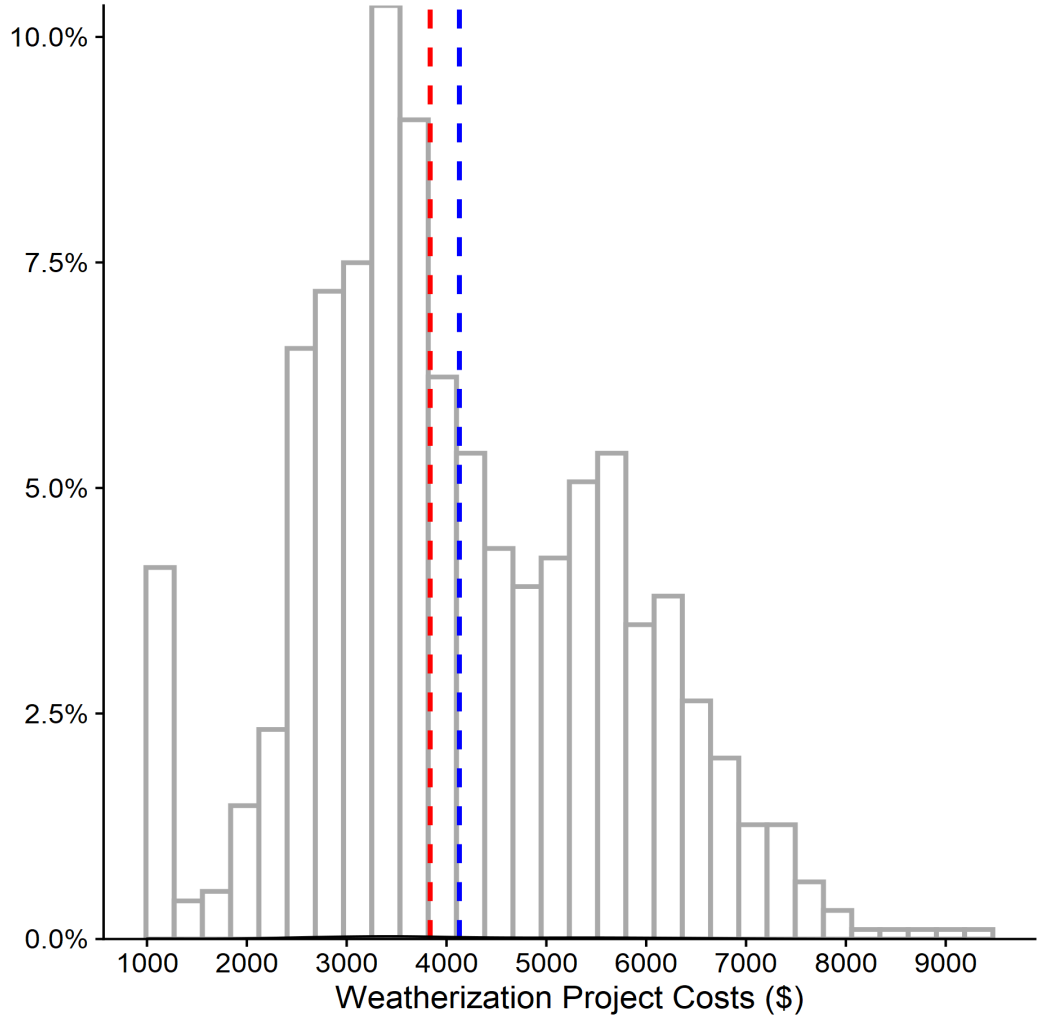
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Weatherize the Existing Building Stock

- Weatherize all the buildings to higher levels than current programs
  - Air sealing
  - Attic insulation
  - Wall insulation
  - Rim joist insulation
  - Continuous exhaust ventilation where required
- Costs from program data
  - Regression models for measures on size & building type
- Savings estimated from expected leakage reductions & added insulation values

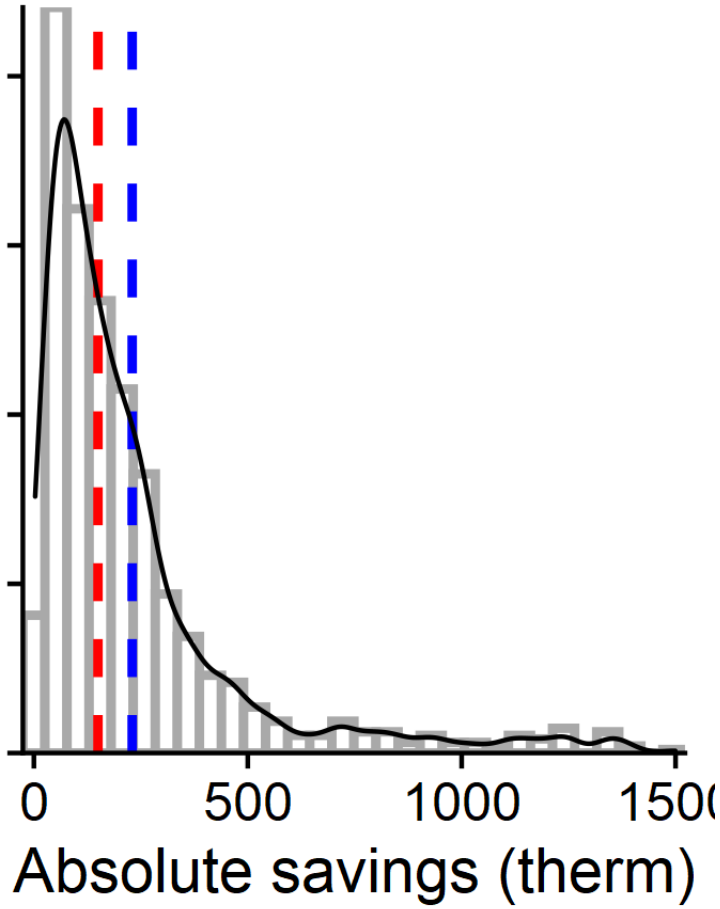
Weatherization Costs

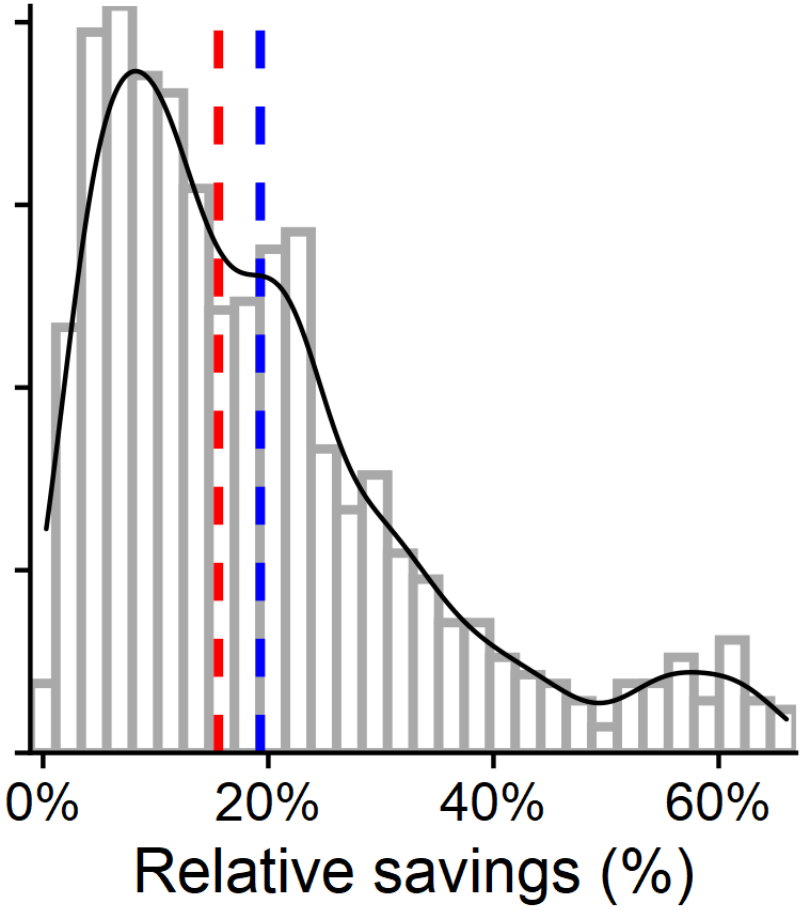




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Weatherization Savings

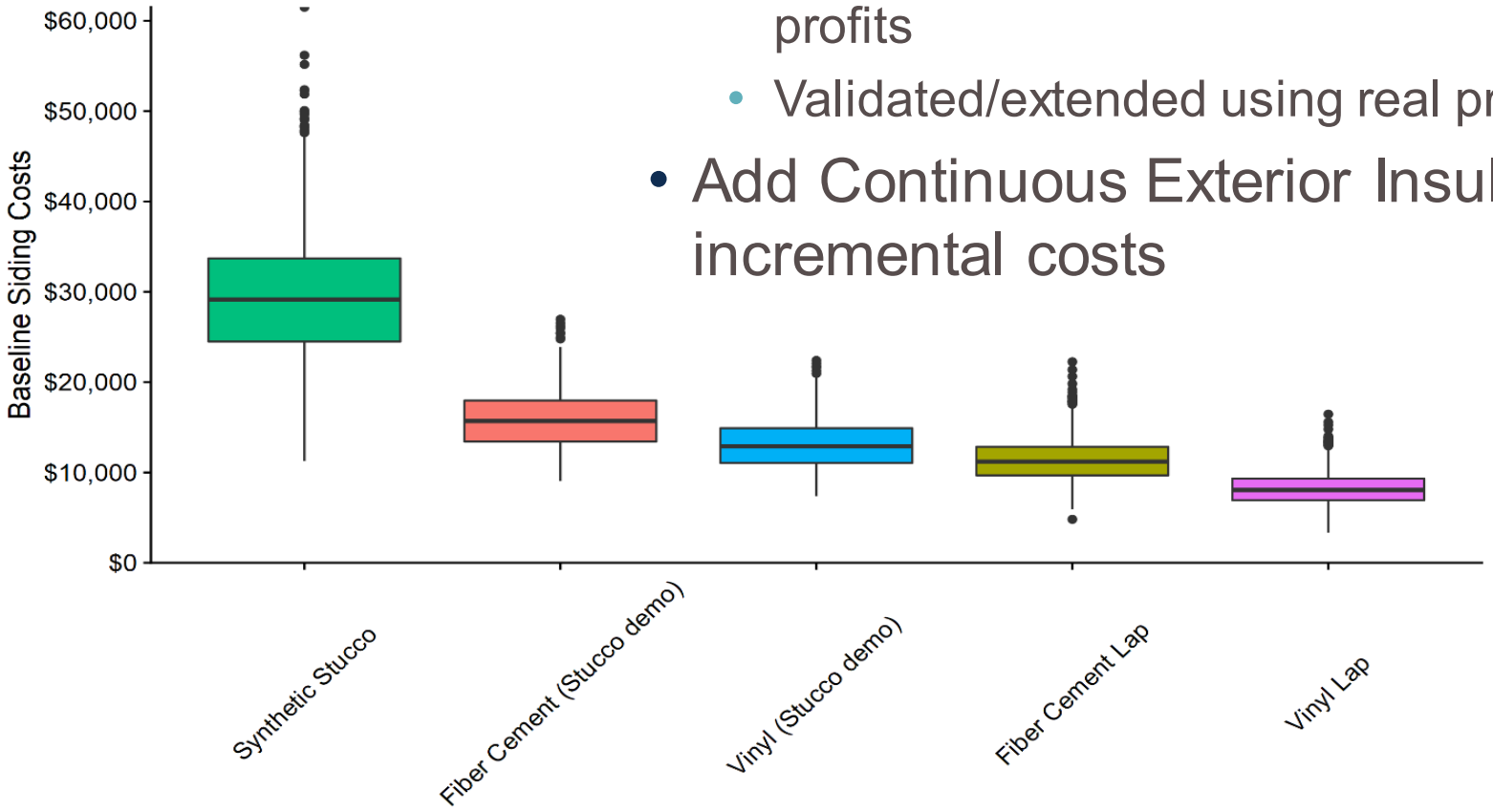




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Recladding (Siding) jobs as Efficiency Opportunities

- Several baseline recladding projects considered
  - Estimated project costs using RSMeans 2020 data
  - Built in materials, equipment rental, labor, permit estimates, and profits
  - Validated/extended using real project bids and retail costs
- Add Continuous Exterior Insulation (CEI) to lower the incremental costs



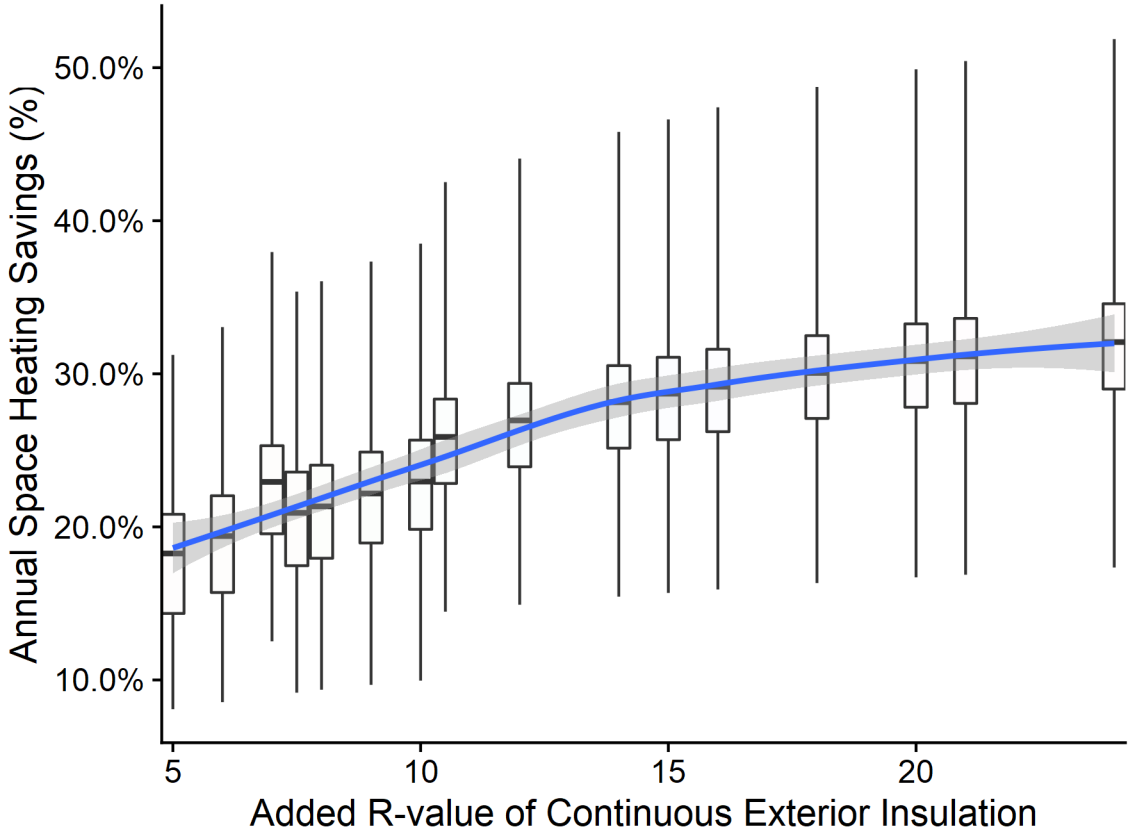
Continuous Exterior Insulation

- Investigated several insulation products and 32 different CEI assemblies
- Each with different performance characteristics and cost functions
  - Labor & material costs depend on building characteristics
- Adding insulation thickness decreases insulation costs, but adds ancillary costs
  - Windows, flashing, sill build-outs
  - Wall penetrations
  - Non-insulated build-outs

Type	R-value per inch	Thickness (in.)
EPS	4	1.5, 2, 3, 4, 6
XPS	5	1, 1.5, 2, 3, 4
EIFS - XPS	5	1.5, 2, 3, 4
PIR (POLYISO)	6	1, 1.5, 2, 3
SIP - EPS	4	3.5, 5.5
Closed Cell Spray foam (CC)	7	1, 1.5, 2, 3
Mineral wool (MWOOL)	4	1.5, 2, 3, 4
Wood fiber (WFIBER)	4	1.5, 2, 3, 4

Continuous Exterior Insulation Savings

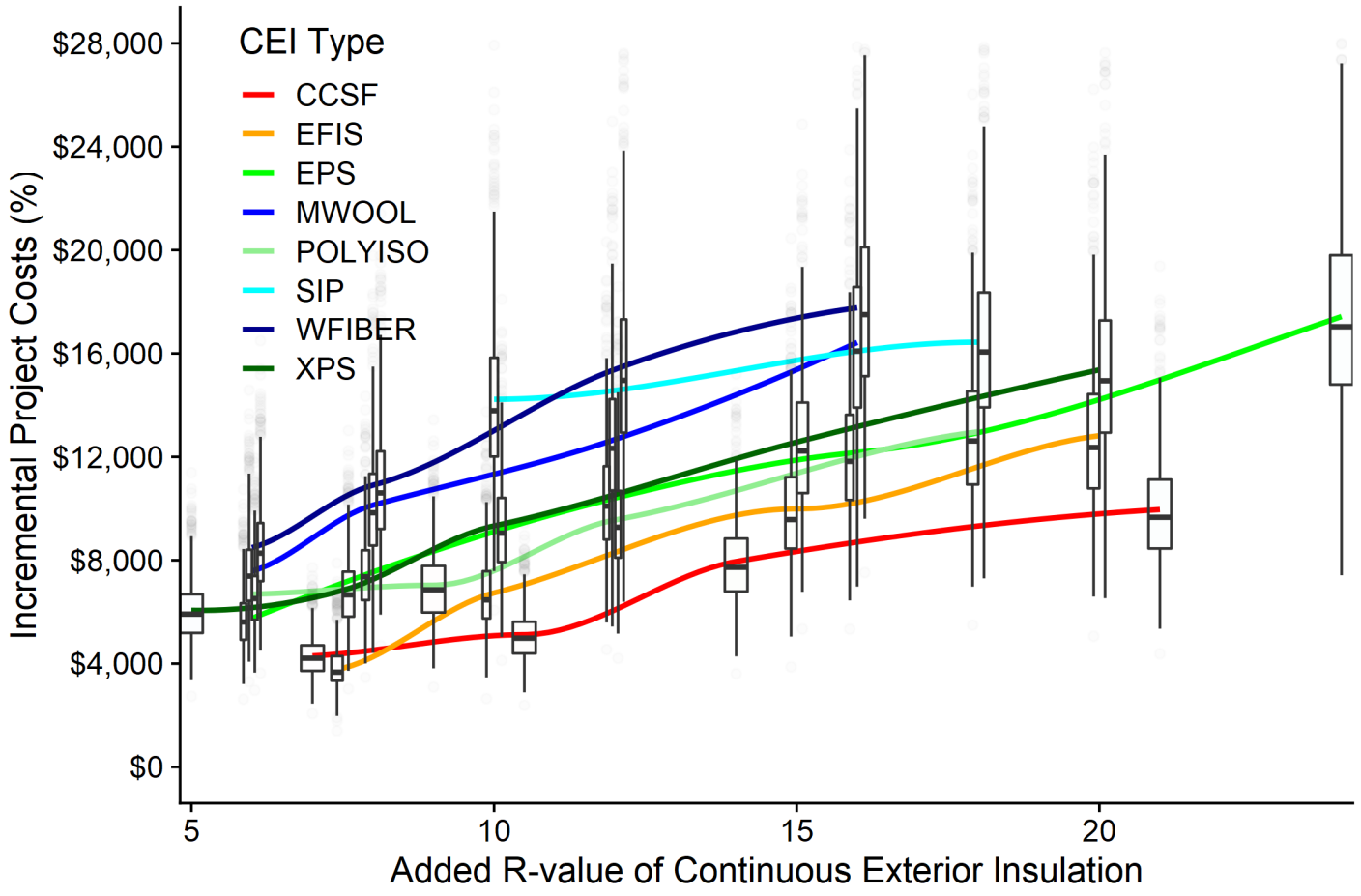
- 32 CEI assemblies (~16 different R-values)
- Savings a function of added-R-value
- For any given project, savings vary extensively across the modeled buildings
- Median savings of ~18% to 32%
- Diminishing returns around R-12



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Continuous Exterior Insulation Costs

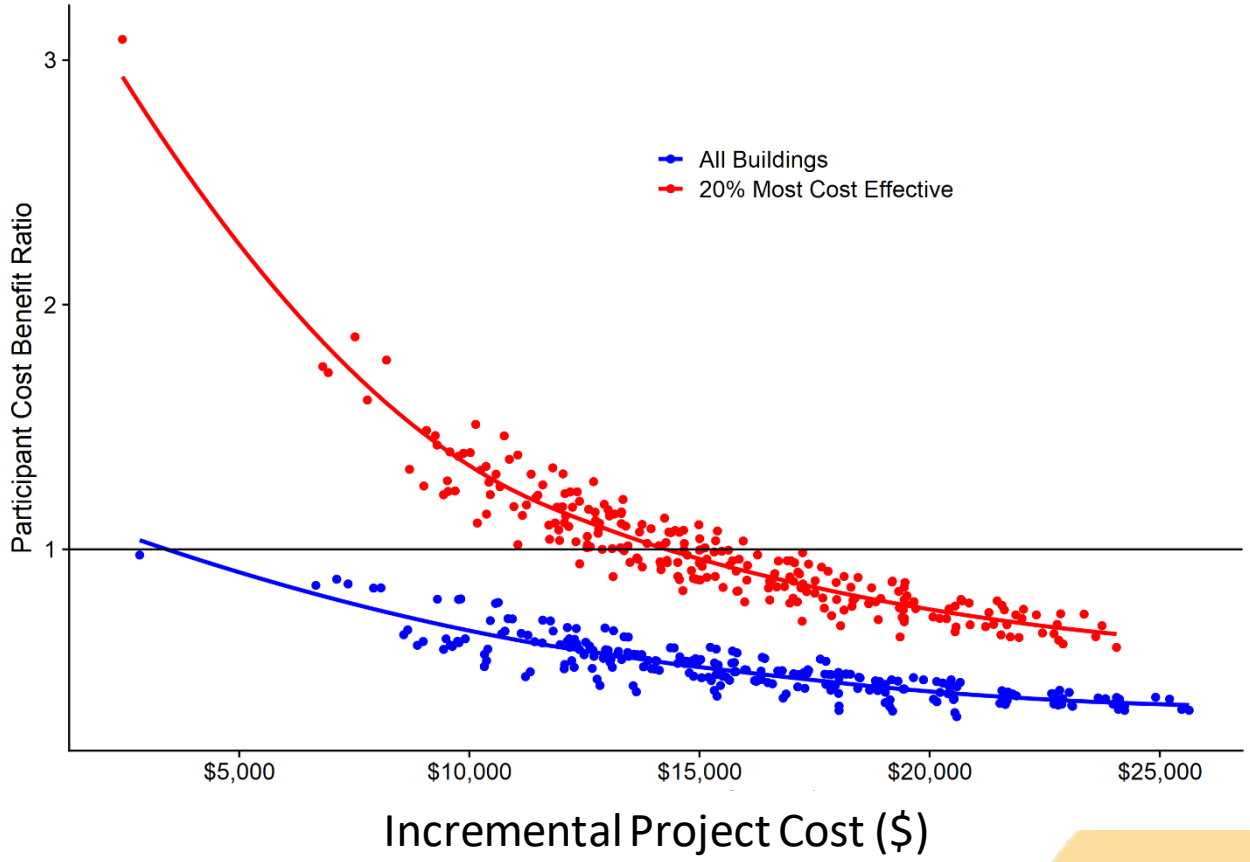
- CEI median costs range ~$4,000 to $17,000
- Within each project type, costs range 2 – 4x across building stock
- High-cost
  - SIP, Mineral Wool, Wood Fiber
- Medium-cost
  - Rigid foams
- Low-cost
  - Spray foam, EFIS



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Median Cost Effectiveness Results

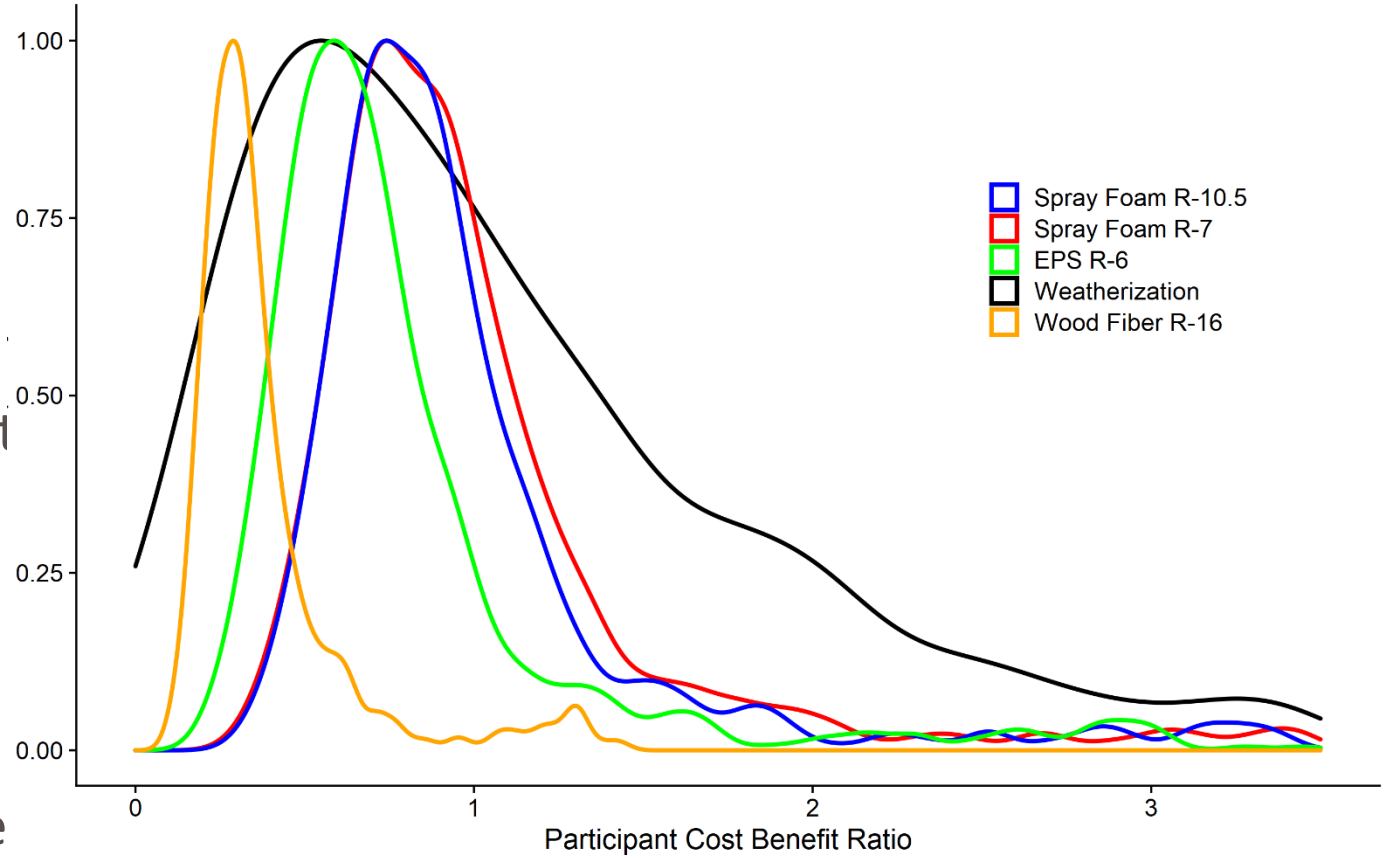
- 465 project types representing weatherization, CEI, and window combos
- Weatherization is about cost effective
- All other projects less than one
- However most projects under $16,000 have hundreds of thousands of cost effective opportunities



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Cost Effectiveness of Specific Project Types

- Weatherization has a long tail
  - Many highly cost effective projects
- Cost effectiveness narrows post-weatherization
- 1” to 1.5” spray foam offers highest cost effectiveness
- 1.5” EPS the most cost effective rigid foams
- 4” wood fiber is least cost effective CEI studied



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What Leads to Cost Effectiveness?

- Cost effectiveness varies substantially across the building stock
  - Average approach to estimating savings and costs misses these opportunities
  - Statistical approach enables the discovery of cost-effective projects

- What do cost effective projects have in common?
  - Geometrically simple buildings
  - 30% smaller & 10% higher window area
  - Little-to-no wall insulation & leakier than overall building stock
  - Larger relative space heating loads

A few Quick Notes about Windows

- Three types of window upgrades were also studied as component of each CEI measure and siding project
- Windows rarely improve cost effectiveness, but sometimes they don't hurt it too much
- Windows look somewhat more attractive when their cost-to-value ratio is considered

Conclusions

Project Conclusions

- Weatherization should be expanded, both the standards and implementation
- High-performance envelope packages can bring existing building stock up-to and beyond current code-minimum performance levels
  - R-9 to R-12 with windows or energy recovery likely needed for 50% median savings across building stock
- Cost effectiveness is a barrier, but somewhat exaggerated
  - 100,000+ cost effective opportunities in the state of Minnesota
  - Significant flexibility across in measure combinations to obtain these savings
- Largest opportunity for natural gas savings, if not residential energy efficiency overall
- Merits more attention than received both at research and implementation ends

Recommendations

- Lower cost pressures
  - Permit fees, sales tax, and property taxes significantly impact ROI
- BENCOST adaptations to reflect full suite of benefits
  - Enable true lifetime of insulation and windows
  - Enable extensive NEBs, which may exceed energy efficiency benefits by +200-500%
- Accelerate market transformation efforts
  - Engage contractors, the key stakeholders
  - Raise consumer awareness
  - Pilot projects on low hanging fruit
- Continued R&D: Lots on horizon including products, processes that will impact cost, project timelines, and invasiveness

Future Work

- Project optimization according to existing building characteristics
  - Is rainscreen cladding necessary?
- Explore cost synergies between recladding, weatherization, CEI, and window upgrades
- Incorporate cooling savings, HVAC downsizing, additional DR, and other NEB savings
- Cost effectiveness for electric and propane heated homes
- Consider the necessity for enabling/accelerating beneficial electrification

THANK *you*

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Questions?

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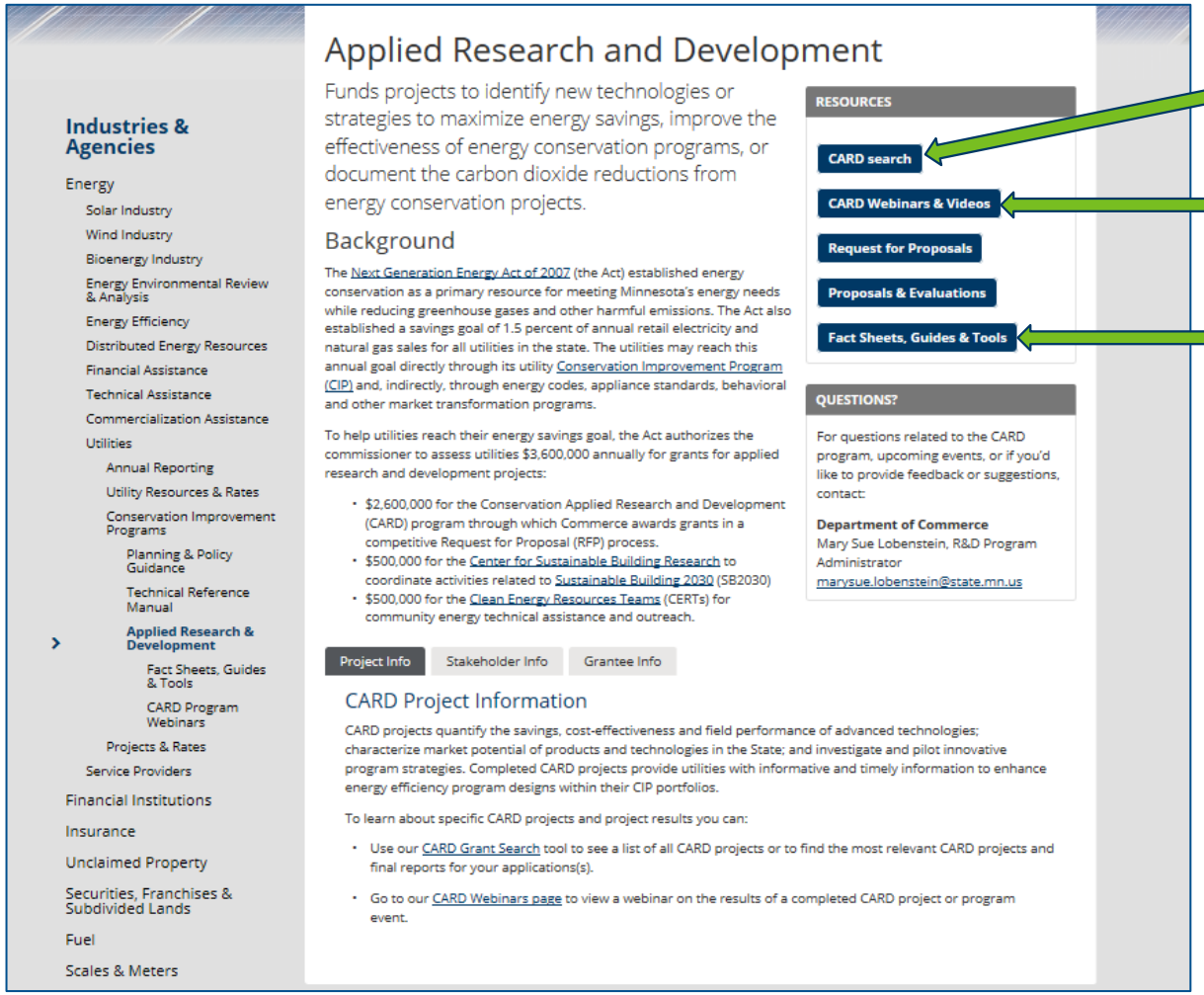
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Webinar Recording & Final Report available in couple months

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

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