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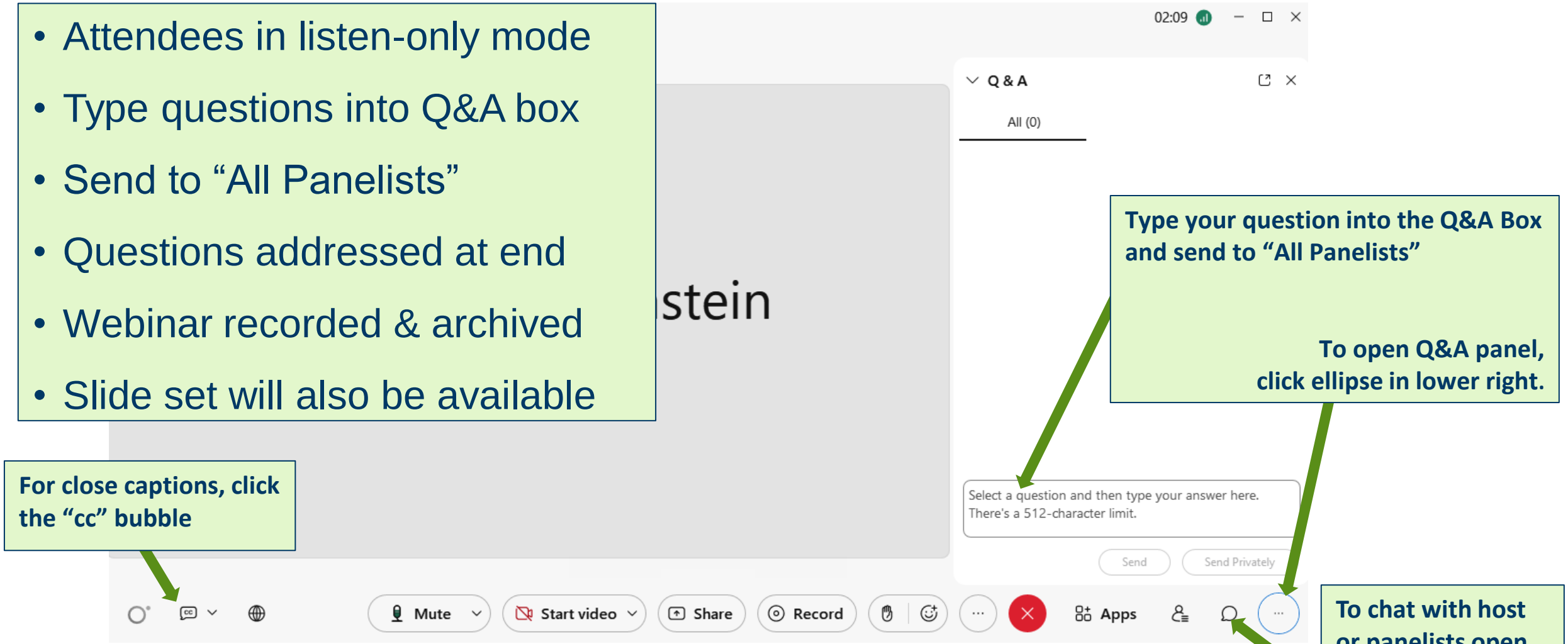
Conservation Applied Research & Development (CARD) Webinar

June 8, 2023

Overcoming the Market Barriers for Rooftop Unit (RTU) Retrofit Enhancement

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



Type your question into the Q&A Box and send to “All Panelists”

To open Q&A panel, click ellipse in lower right.

For close captions, click the “cc” bubble

To chat with host or panelists open chat panel

Introductions



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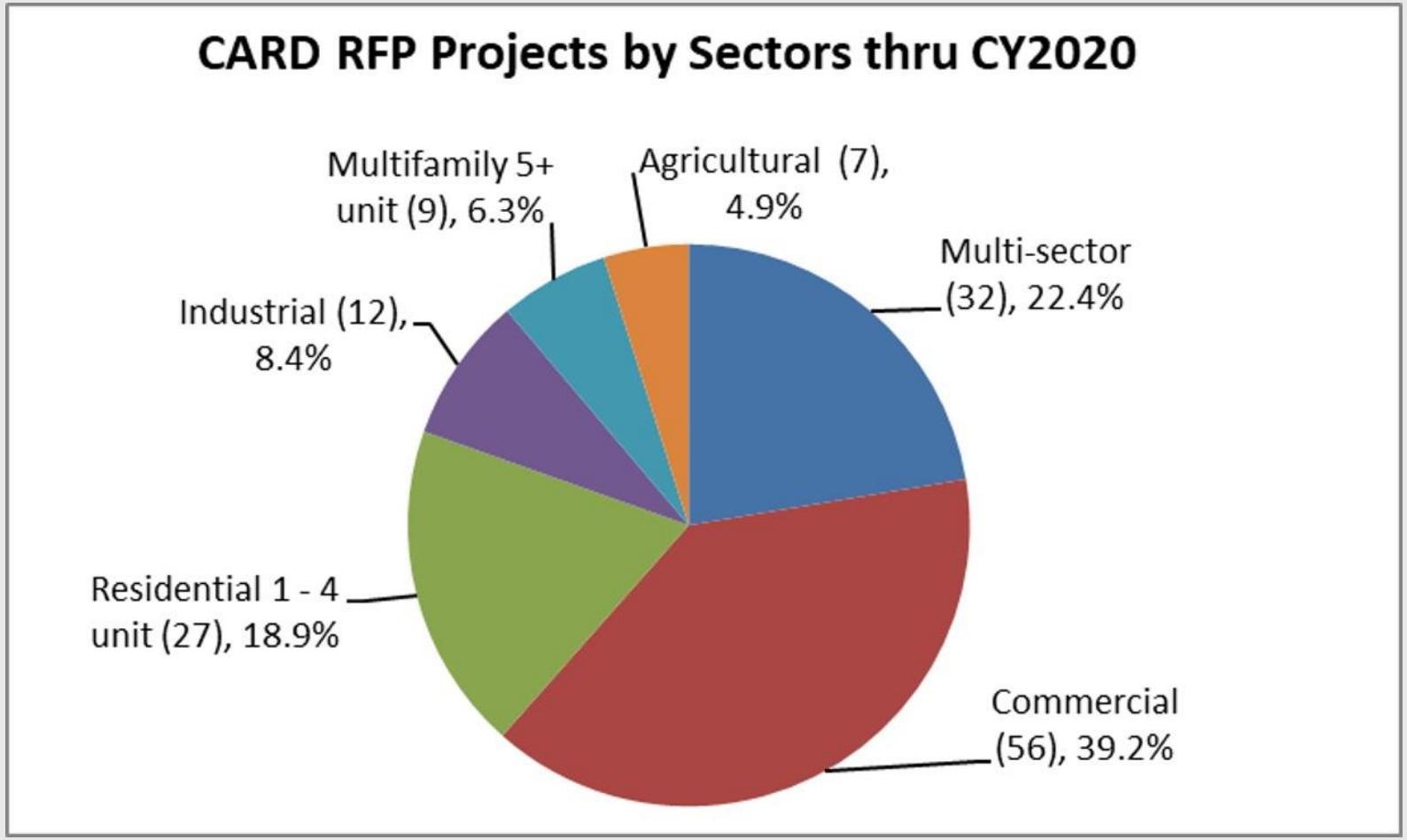
- **Purpose to help Minnesota utilities achieve energy savings goal by:**
  - ***Identifying new technologies or strategies to maximize energy savings;***
  - ***Improving effectiveness of energy conservation programs;***
  - ***Documenting CO_2 reductions from energy conservation programs.***

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 FY2020



RFP Summary

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

Overcoming the Market Barriers for RTU Retrofit Enhancements

Alex Haynor

Mason Miller

Center for Energy and Environment

Discover + Deploy

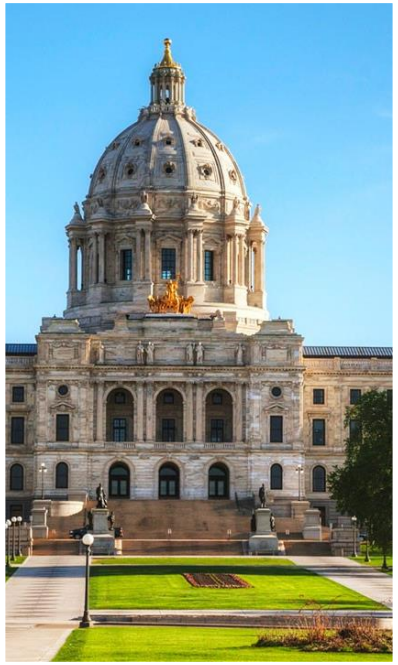
the most effective solutions for a healthy, low-carbon economy











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RTU Background and Potential

- **80%** of commercial buildings in Minnesota are served by RTUs
  - Approximately **20,700 buildings**
- There are ~154,000 RTUs serving Minnesota buildings
- Most existing RTUs are standard efficiency and have tremendous opportunity for upgrades

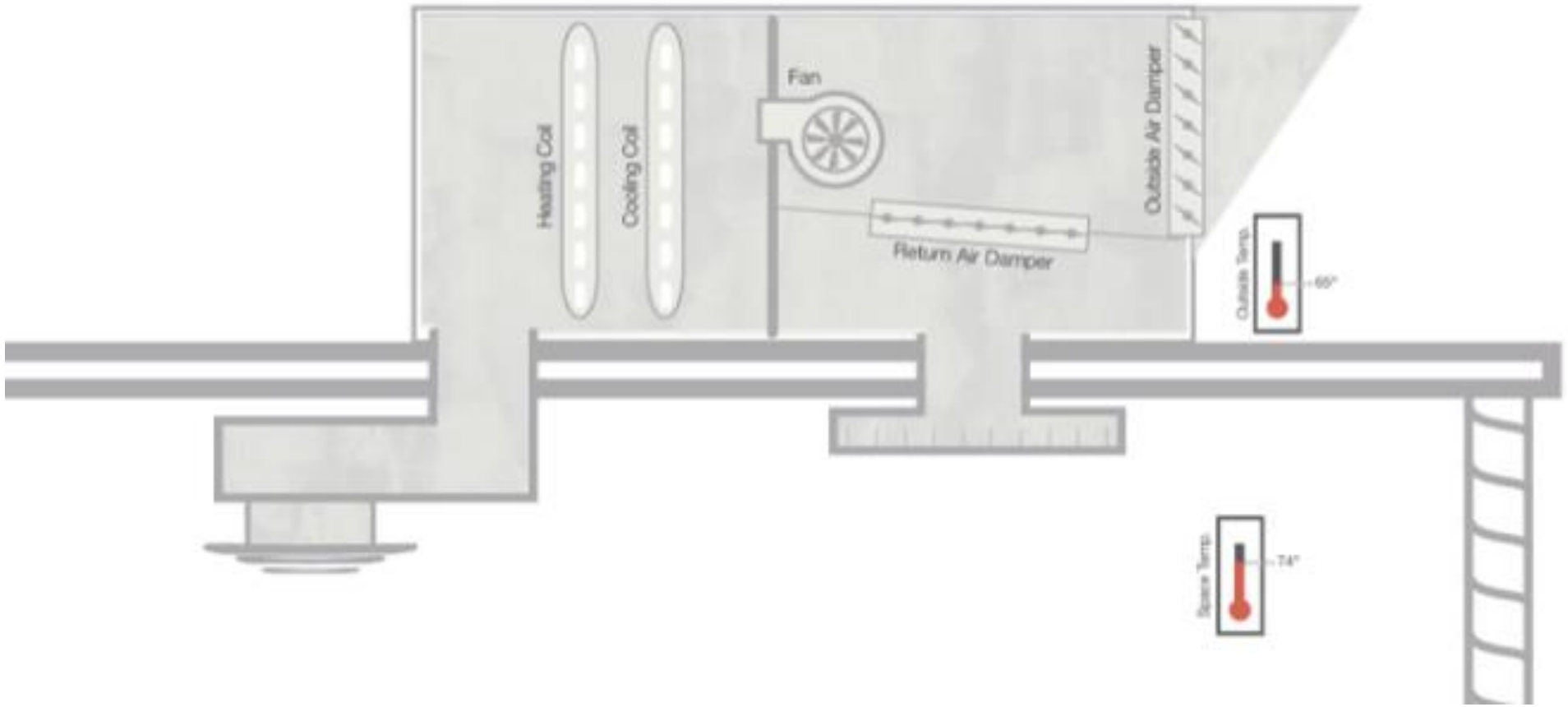
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What is an RTU?



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RTU Configuration



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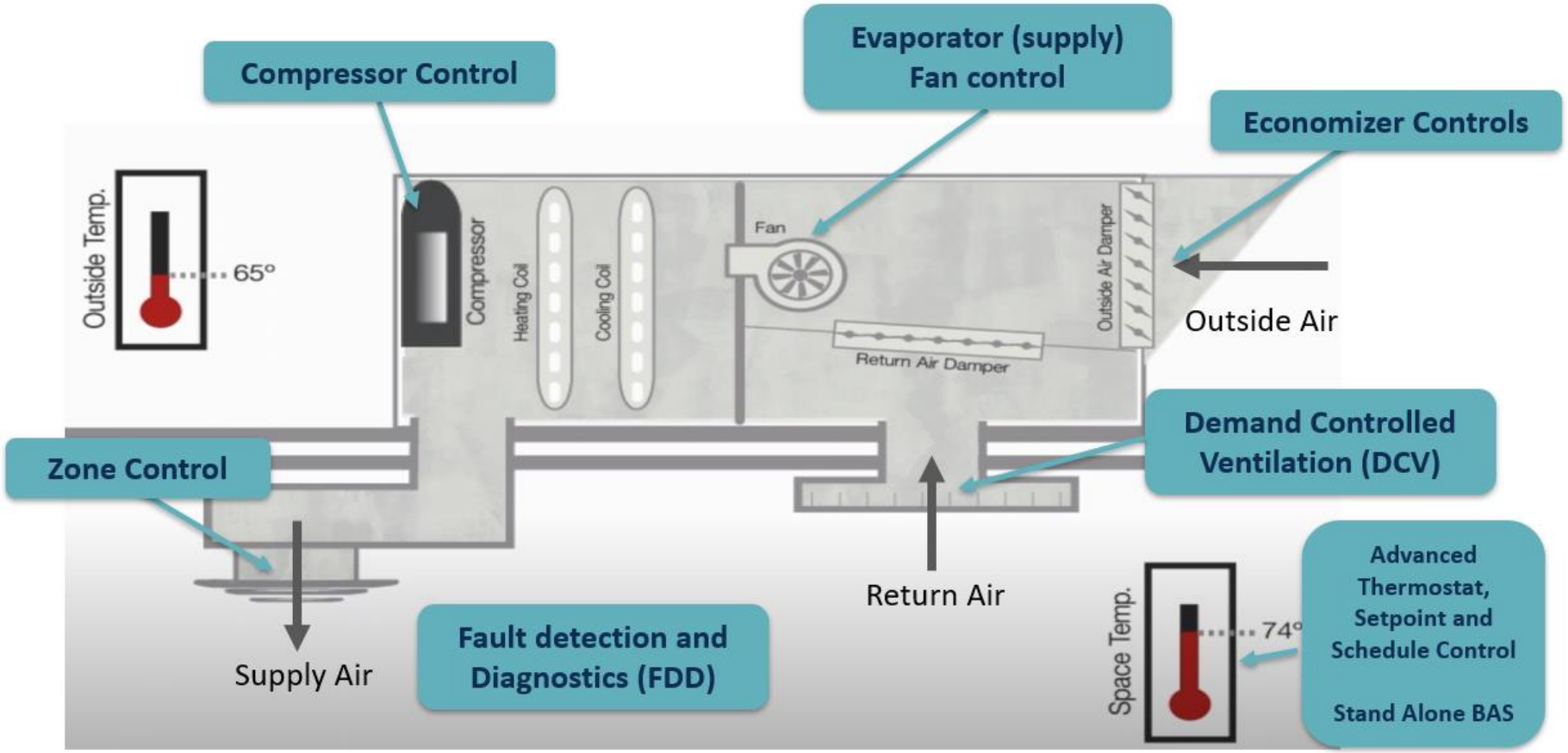
Project Overview

- Technology Assessment
- Stakeholder Interviews
- Field Measurements
- Energy Savings Calculations
- Summary and Recommendations

Technology Assessment

- Broad scan of the market to find available retrofit technologies for packaged RTUs
- Goal to find Minnesota-specific technologies
- A wide variety of technologies were assessed
  - Ideal application, including RTU size, configuration, space type
  - Current manufacturers
  - Prevalence in the current market
  - Control strategy employed
  - Ease of installation
  - Installed cost
  - Energy savings

RTU Retrofit Potential



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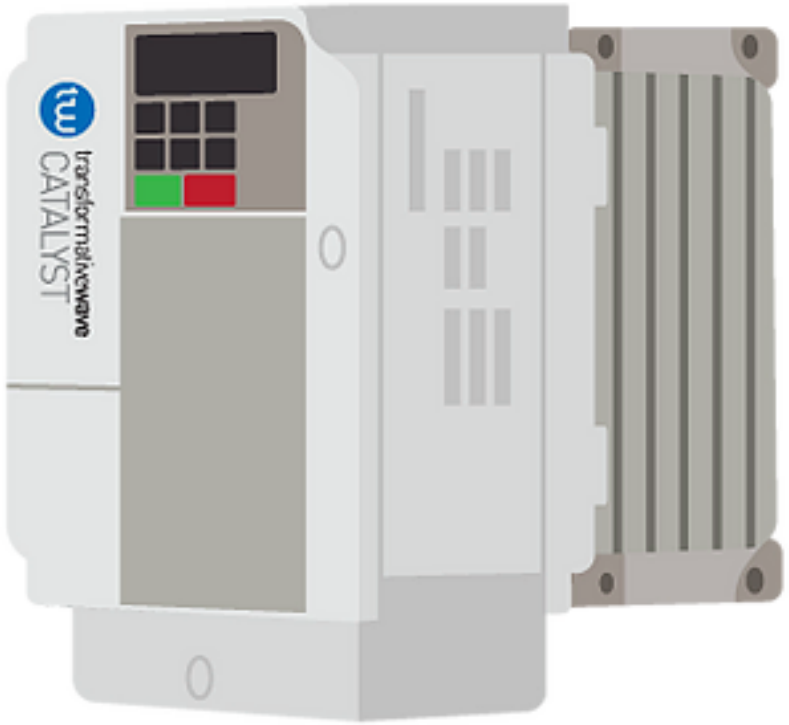
Technology Assessment

	Manufacturer									
	Prostar Energy Solutions	Bes-Tech	75F	NexRev	Enerfit	Prostar Energy Solutions	Swarm Logic	Turntide	Honeywell	Belimo
	Controller									
	Catalyst w/ eIQ	Digi-RTU	Dynamic Airflow Balancing/ Outdoor Air	DrivePak ARC	Enerfit	Catalyst	Swarm Logic	Switched Reluctance Motor	JADE Economizer	ZIP Economizer
Main Features										
Evaporator Fan Control	X	X		X	X	X		X	X	X
Demand Controlled Ventilation (DCV)	X	X	X	X	X	X			X	X
Advanced Economizer Controls	X	X	X	X	X	X			X	X
Fault Detection and Diagnostics (FDD)	X	X	X	X	X		X		X	X
Compressor Control		X								
Additional Features										
Advanced Thermostat Control	X	X	X					X		
Setpoint and Schedule Control	X	X	X					X		
Demand Response Capability	X	X					X			
Web User Interface	X	X	X				X	X		
BAS Integration	X	X			X	X	X	X		X
Stand Alone BAS	X	X	X							
Zone Control			X							
Multi Unit Coordination	X						X			
Claimed Savings	25-50%	60%	25-40%	25-50%	50%	25-50%	15-30%	60-70%	30%	40%
Claimed Payback Period	2 years	2-4 years	2-5 years	1.5-2 years	3 years	2 years	1 year	1-4 years	Varies	Varies
Ideal Application	Large fan motor, fan on config	Large RTU (>10 tons)	Large RTU serving multiple space types	Large fan motor, fan on config	Large fan motor, fan on config	Large fan motor, fan on config	High peak demand. Many RTUs servings single open space	Large fan motor, fan on config	Nonfunctioning Economizer, above 5 tons	Nonfunctioning Economizer, above 5 tons
Price	$$$$	$$$$	$$$$	$$$$	$$$	$$	$$	$	$	$

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Transformative Wave (Now Prostar Energy Solutions) – Catalyst

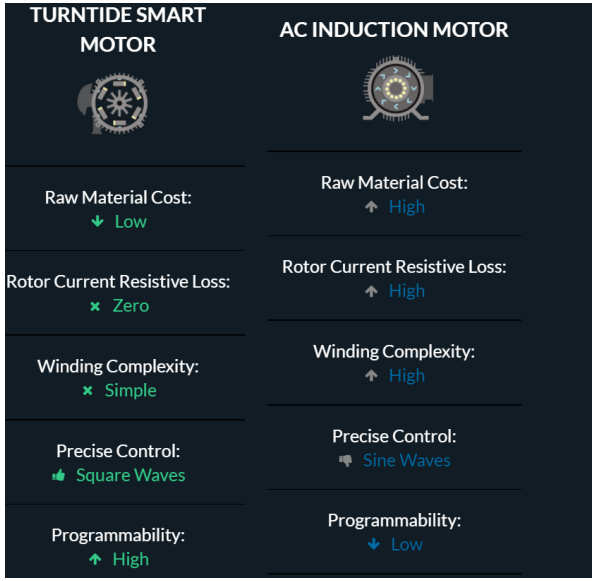
- Studied by CEE in 2013
  Advanced Rooftop Control Pilot
- Catalyst Controller
  - Catalyst Lite – VFD
  - Catalyst – VFD, economizer controls, DCV
  - Catalyst with EiQ – Adds remote setpoint and schedule control, along with real-time RTU operational data

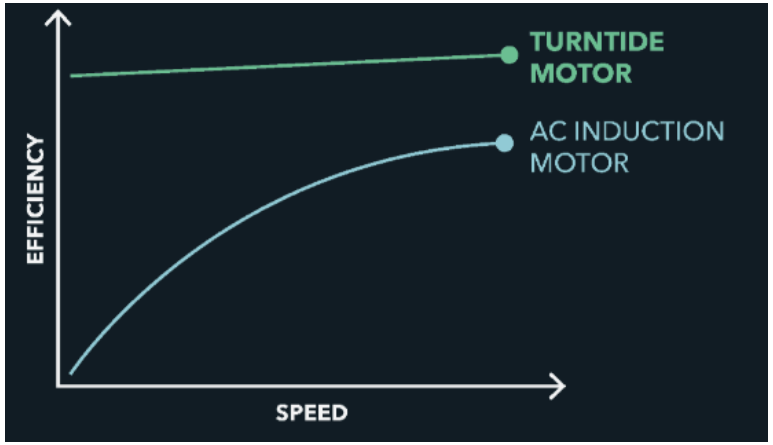


https://prostarenergy.com/solutions/hvacr-solutions/

Turntide – Smart SRM

- Switched Reluctance Motor (SRM) technology would replace induction motor for evaporator fan
- Cloud-connected and software-powered
- Variable speed by design
- Composed of a motor, motor controller, gateway and the cloud



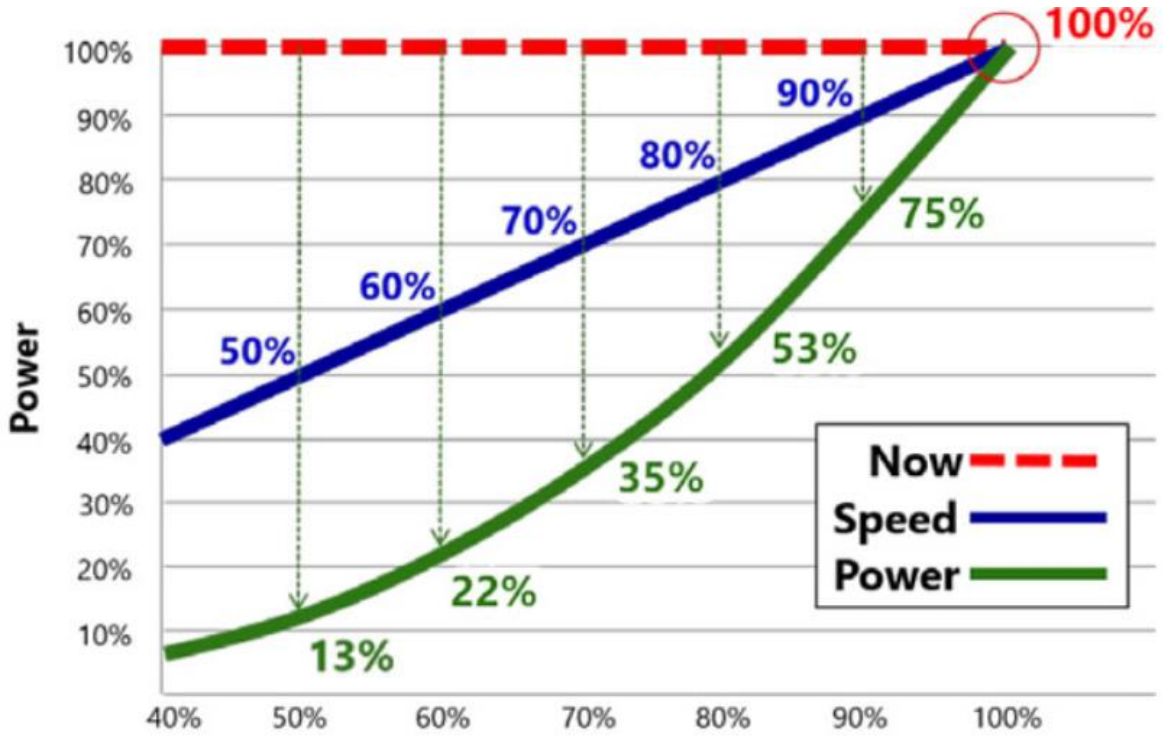


https://turntide.com/technology/motors/

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NexRev – DrivePak

- Evaporator fan control with VFD
  - Matches fan speed to airflow requirements for cooling, heating, and ventilation
- Controls intercept heating and cooling signals with set fan speeds configured to each RTU
- ARC package adds economizer optimization, DCV, and fault detection



https://www.nexrev.com/solutions

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Honeywell – JADE Economizer

- Economizer controls device
- Can be integrated with Honeywell's building and HVAC controls package, includes:
  - VFD
  - Two-way communicating thermostat
  - CO2 sensor
  - BAS



https://buildings.honeywell.com/us/en/products/by-category/building-management/field-devices/economizers-and-ventilation-controls/jade-w7220-economizer-logic-module

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Belimo – ZIP Economizer

- Uses local zip code to recognize climate zone to set high limit change-over temperature
- Allows for various plug-in sensors for DCV and BAS integration
  - Enthalpy, dry bulb
  - CO2
  - RAT, SAT, MAT, OAT



https://www.belimo.com/us/shop/en_US/Systems/Economizer/ECON-ZIP-SELF/p?code=ECON-ZIP-SELF

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Controls

	Manufacturers					
	Pelican Wireless systems	Johnson Controls	Honeywell	Nest	Ecobee	Trane
	Thermostats/Controls					
Features	TS200 Series	Verasys System	LCBS Commercial Economizing Thermostat	Nest Thermostat, Nest Learning Thermostat	EMS Si	Pivot
Can be Integrated With	• Zone Controller • PEARL Economizer • Temperature, humidity, and CO2 sensors	• Smart building Hub • Constant Volume Controller • Smart Equipment Controllers	• SmartVFD • LGW1000 Gateway	•Nest temperature sensor	• Additional Temperature Sensors	•Tracer Ensemble Cloud
Remote Monitoring	X	X	X	X	X	X
Realtime Alerts	X	X	X	X	X	X
Multi Unit Control	X	X	X	X	X	X
Standalone BAS	X	X				
Historical Detailed Data	X	X	X	X	X	X
Group Scheduling and Setpoint Control	X	X			X	X
Optimal Start		X	X	X	X	X

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Utility Program Review

- Representatives from five utilities in Minnesota and six national utilities were interviewed.
- Each hour-long interview was conducted to gather information regarding their RTU and RTU retrofit offerings.
- National utilities were chosen to represent all areas of the country.

Minnesota Utilities

Measure Name	Xcel Energy	Otter Tail Power	Minnesota Power	Minnesota Energy Resources	CenterPoint Energy	Great River Energy	Southern Minnesota Municipal Power Agency
Direct Expansion Units	X					X	X
Variable Frequency Drive or Adjustable Speed Drive	X	X				X	X
Economizer	X					X	
Demand Control Ventilation	X			X	X	X	
Controls						X	
Motors	X	X				X	X
Custom	X	X	X	X	X	X	X

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National Utilities

Program Type	Mass Save	ComEd	Southern California Edison	NJBPU	Efficiency Works Colorado	BPA
Direct Install	X			X		
RTU Tune-Up	X	X				
Early Retirement		X				
Midstream	X	X	X	X	X	X

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Bonneville Power Administration (BPA)

Full ARC Retrofit

Manufacturer	Model	Product Website
Bes-Tech	Digi-RTU	http://www.bes-tech.net/digi-rtu/
Honeywell	LCBS with SmartVFD and LGW1000 Gateway	https://buildingcontrols.honeywell.com/Building-Automation-Systems/LCBS-Connect
Pelican	Pelican solution that includes: • Pelican TS200 or TS250 Thermostat, • Pelican zone controller Z8 or Z24, or PEARL Economizer, • Pelican Extended Range Wireless Gateway, and	http://www.pelicanwireless.com/
Transformative Wave	CATALYST with eIQ	http://transformativewave.com/
Unity Energy Solutions	Unity solution that includes: • USC Site Controller, • SMT400 Thermostat or M-172 PLC Controller, and •Site Support Package Subscription	http://www.unityenergysolutionsgroup.com/unity/

ARC-Lite Retrofit

Manufacturer	Model	Product Website
Bes-Tech	Digi-RTU	http://www.bes-tech.net/digi-rtu/
Honeywell	LCBS with SmartVFD	https://buildingcontrols.honeywell.com/Building-Automation-Systems/LCBS-Connect
Lennox	ARC -with DCV	http://www.lennoxcommercial.com/products/
NexRev	DrivePak	http://www.nexrev.com/products/drivepak/
Pelican	Pelican solution that includes: • Pelican TS200 or TS250 Thermostat, • Pelican PEARL Economizer, • Pelican Extended Range Wireless Gateway, and	http://www.pelicanwireless.com/
Trane	ARC -with DCV	http://www.trane.com/
Transformative Wave	CATALYST Lite	http://transformativewave.com/
Unity Energy Solutions	Unity solution that includes: • USC Site Controller and • SMT400 Thermostat or M-172 PLC Controller	http://www.unityenergysolutionsgroup.com/unity/

https://www.bpa.gov/-/media/Aep/energy-efficiency/document-library/advanced-rooftop-unit-control-qualified-products-list.pdf

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Stakeholder Interviews

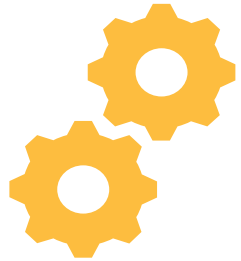
- In-depth interviews were conducted with key industry professionals to determine market barriers
  - 5 mechanical contractors
  - 5 manufacturers
  - 2 building owners
  - 2 distributors

Interview Takeaways



Mechanical contractors

- Expressed concerns about cost, payback and lack of prescriptive rebates
- High-efficiency RTUs (cooling) are generally recommended at time of replacement when rebates offset incremental cost
- Custom rebates tend to steer contractors away from recommending efficiency upgrade equipment



Retrofit manufacturers

- Contractor engagement and involvement is crucial for retrofit implementation
- To combat lack of contractor engagement, manufacturers have had success reaching directly to customers.
- National accounts (such as chains) can lead to implementation across many RTUs and buildings

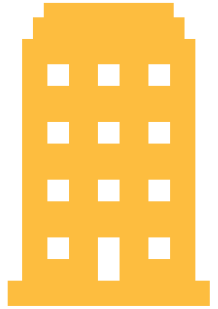
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Interview Takeaways cont.



Distributors

- High-efficiency RTUs are becoming more popular as replacement as incentives mostly offset the incremental cost
- Many new RTUs come standard with a staged evaporator fan



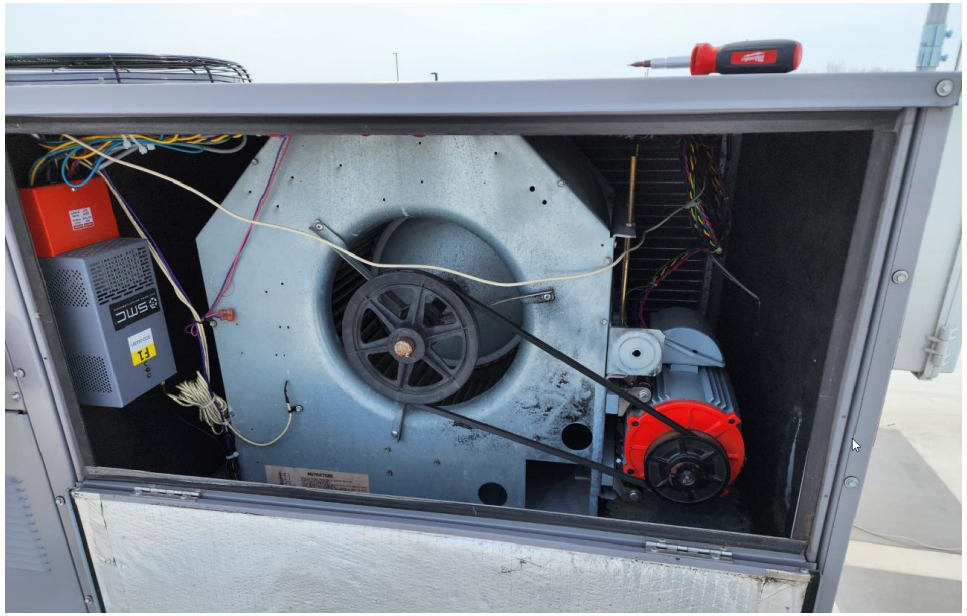
Building owners

- Payback period is the biggest factor for building owners when considering investing in RTU retrofits
- Owners are unaware of available packages for retrofit
- System failure and callbacks are a concern with new and unfamiliar technologies.

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Field Measurements

- 8 field sites were monitored with a variety of RTU retrofit packages to determine energy savings potential





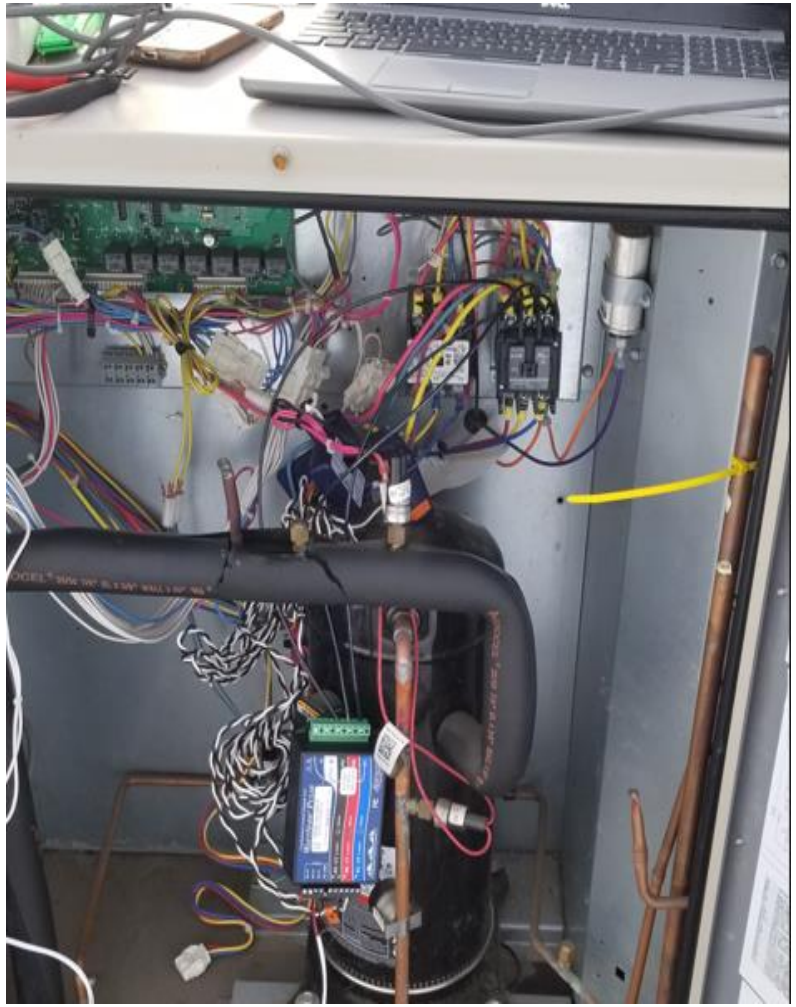
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Field Sites and Technologies

Site	Number of RTUs	Retrofit Technology	Technology
1	6	Catalyst	Evaporator fan VFD
2	2	Turntide SRM	Switched reluctance motor (evaporator fan)
3	4	Turntide SRM	Switched reluctance motor (evaporator fan)
4	5	Honeywell JADE	Advanced economizer controls
5	4	Belimo ZIP	Advanced economizer controls
6	3	DrivePak	Evaporator fan VFD
7	17	DrivePak	Evaporator fan VFD
8	2	Turntide SRM	Switched reluctance motor (evaporator fan)

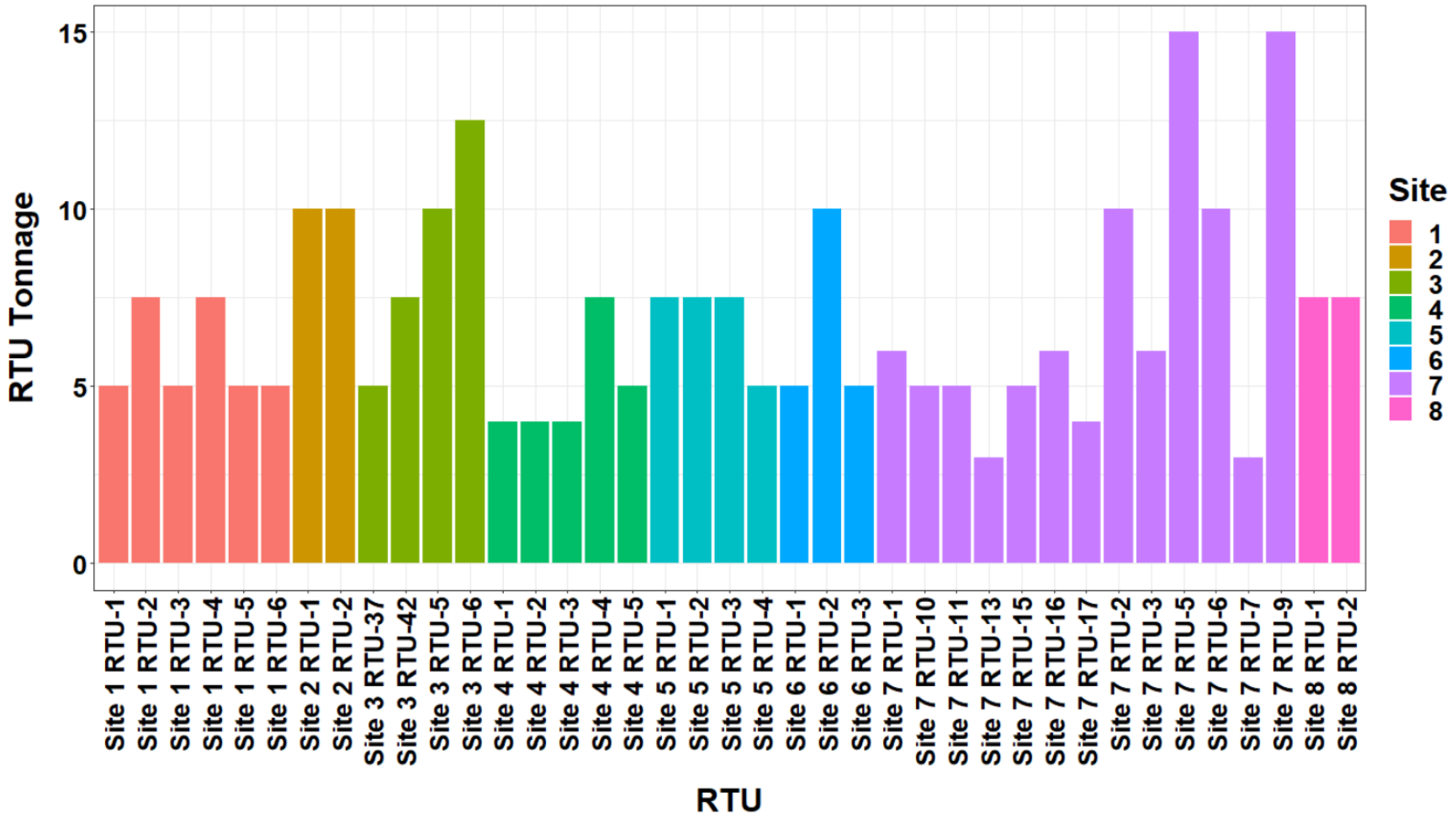
Monitoring Approach

- All field sites were monitored with a pre and post test period
- Monitoring period length varied based on the package measured
- Power measurements were taken at each field site to determine overall energy consumption of the RTU
- Other measured parameters include:
    - Gas signal on/off
    - Cooling call signal (economizer packages)
    - Space temperature and relative humidity



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RTU Size

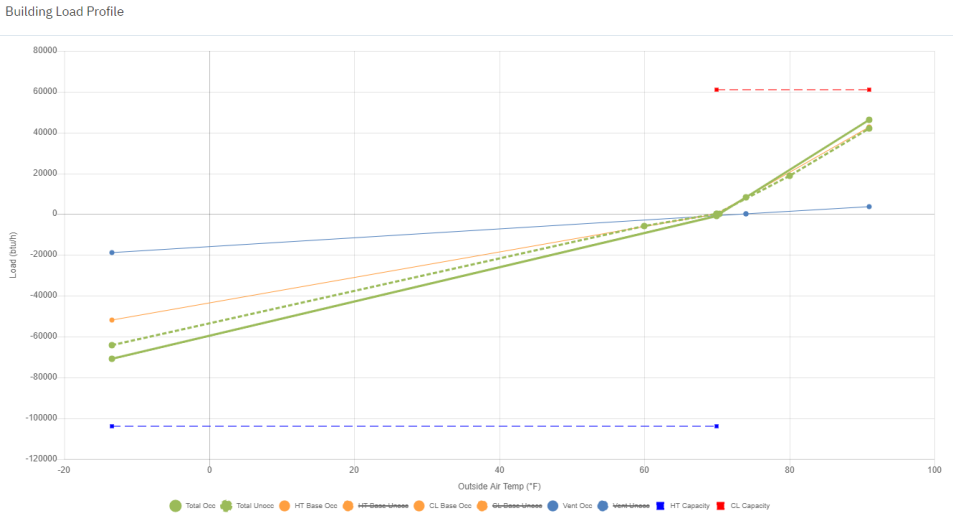


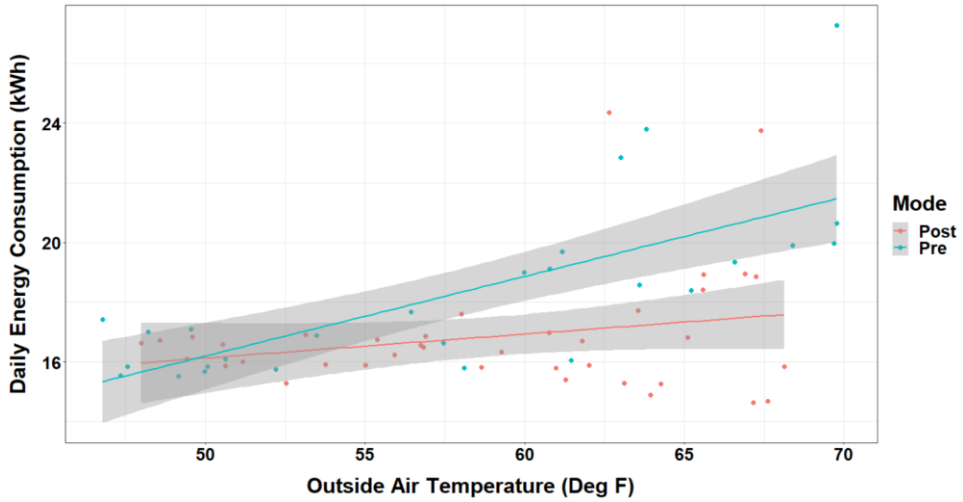
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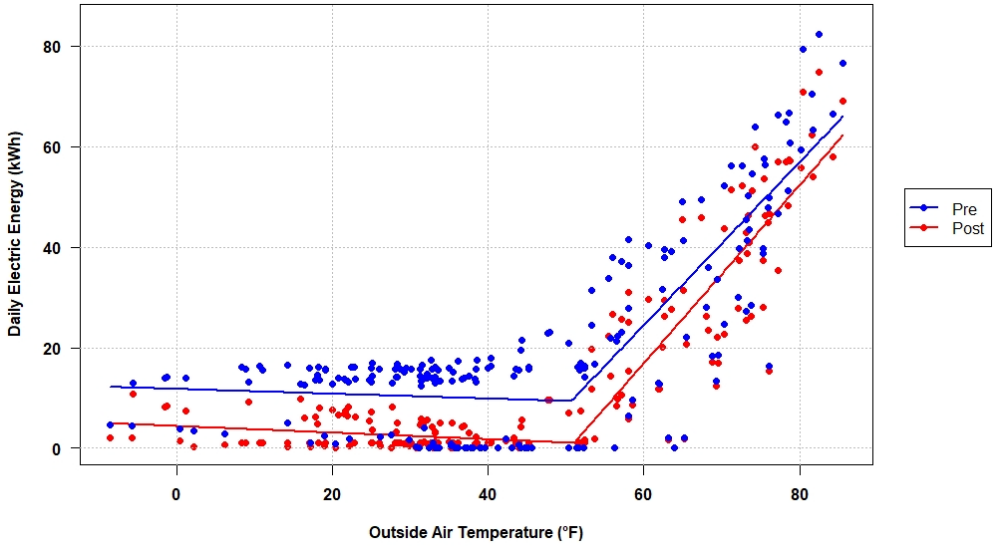
Analysis Approach

- **Variable speed evaporator fan calculations**
  - Approach 1 – Measured field data was used to create annual performance models at hourly intervals using a calculation tool for RTUs
    - Catalyst
    - Turntide
  - Approach 2 – A year's worth of previously measured field data (power values) was used to model pre and post VFD retrofit
    - DrivePak
- **Advanced economizer packages**
  - Data was collected during shoulder seasons (spring and fall) to determine energy savings from free cooling
    - Honeywell JADE
    - Belimo ZIP

Analysis Approach cont.

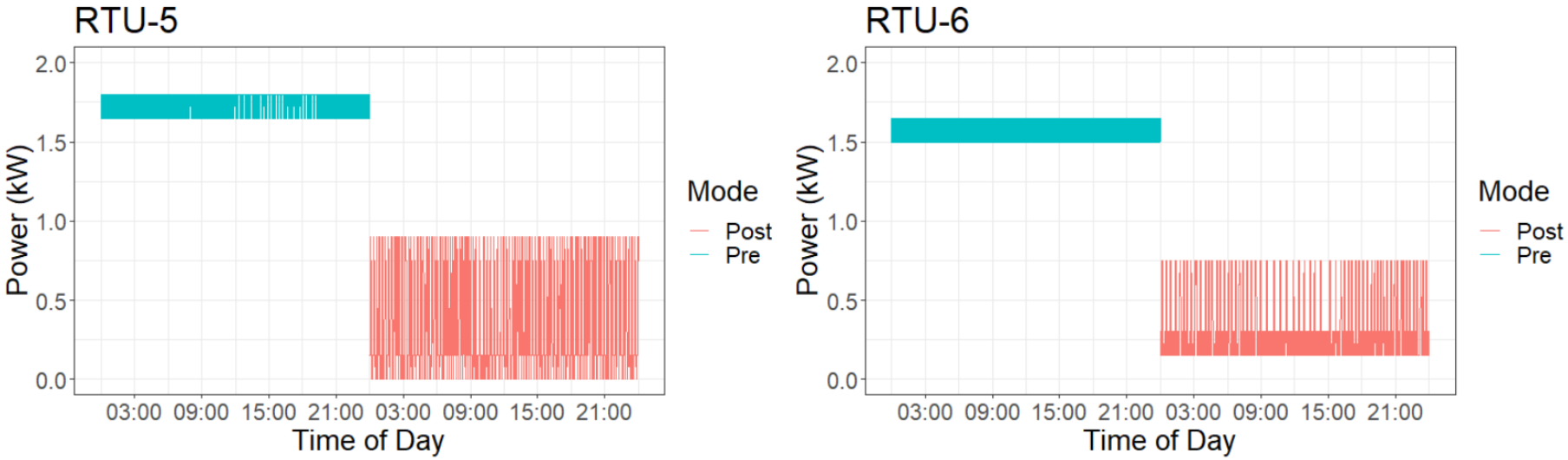


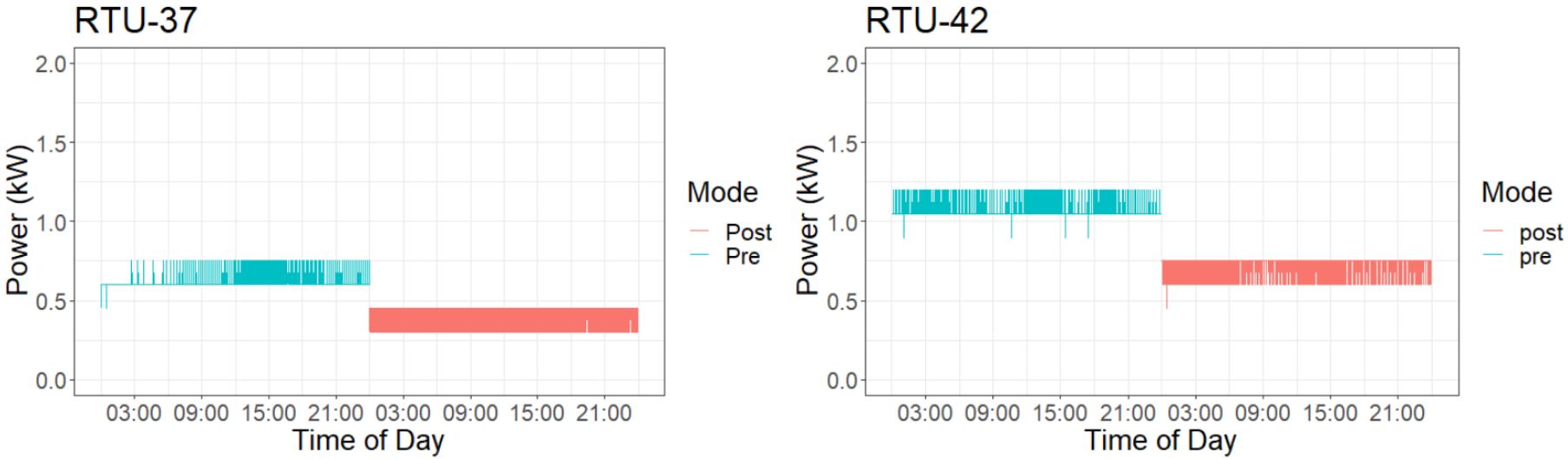




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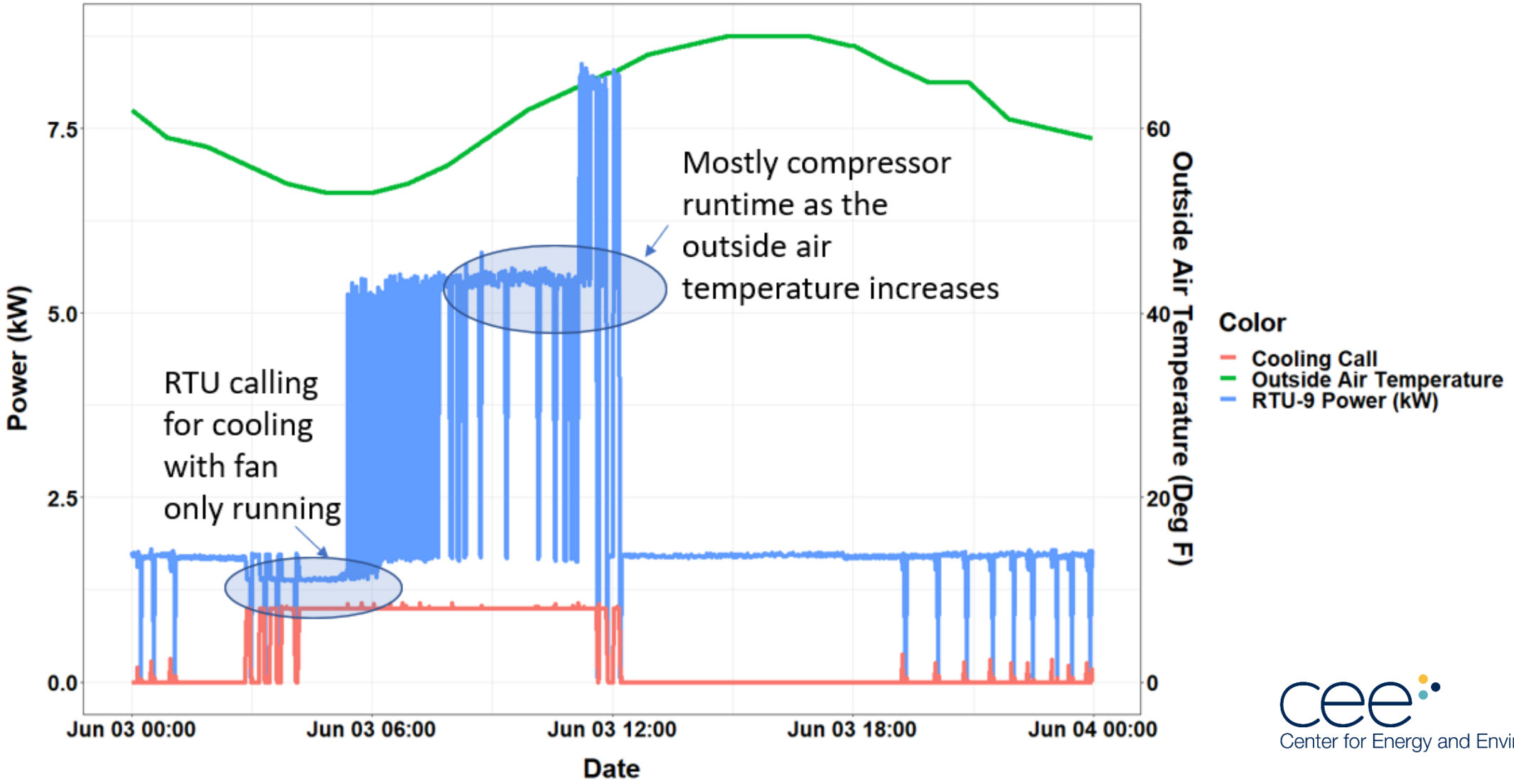
SRM Operation





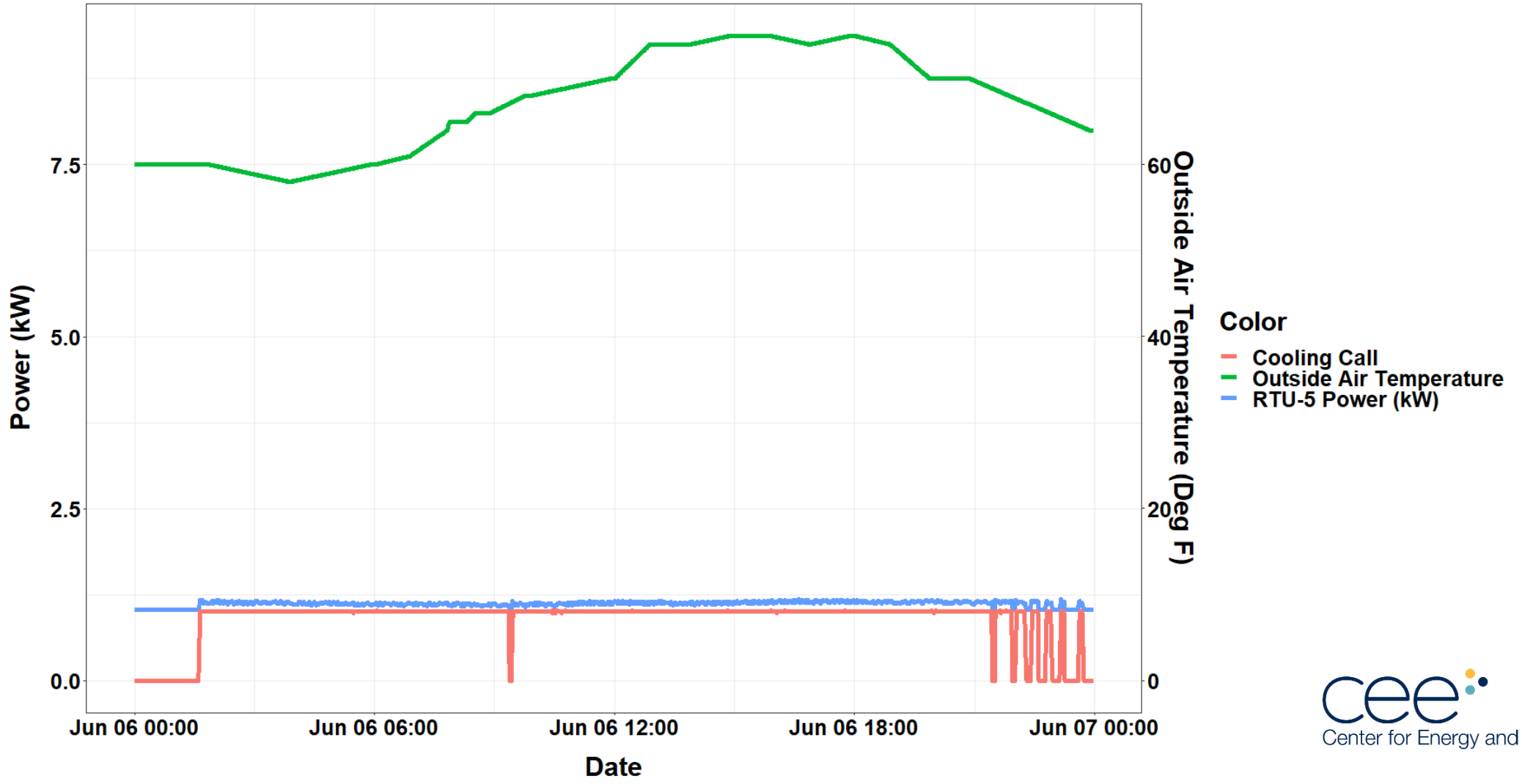
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Advanced Economizer Operation



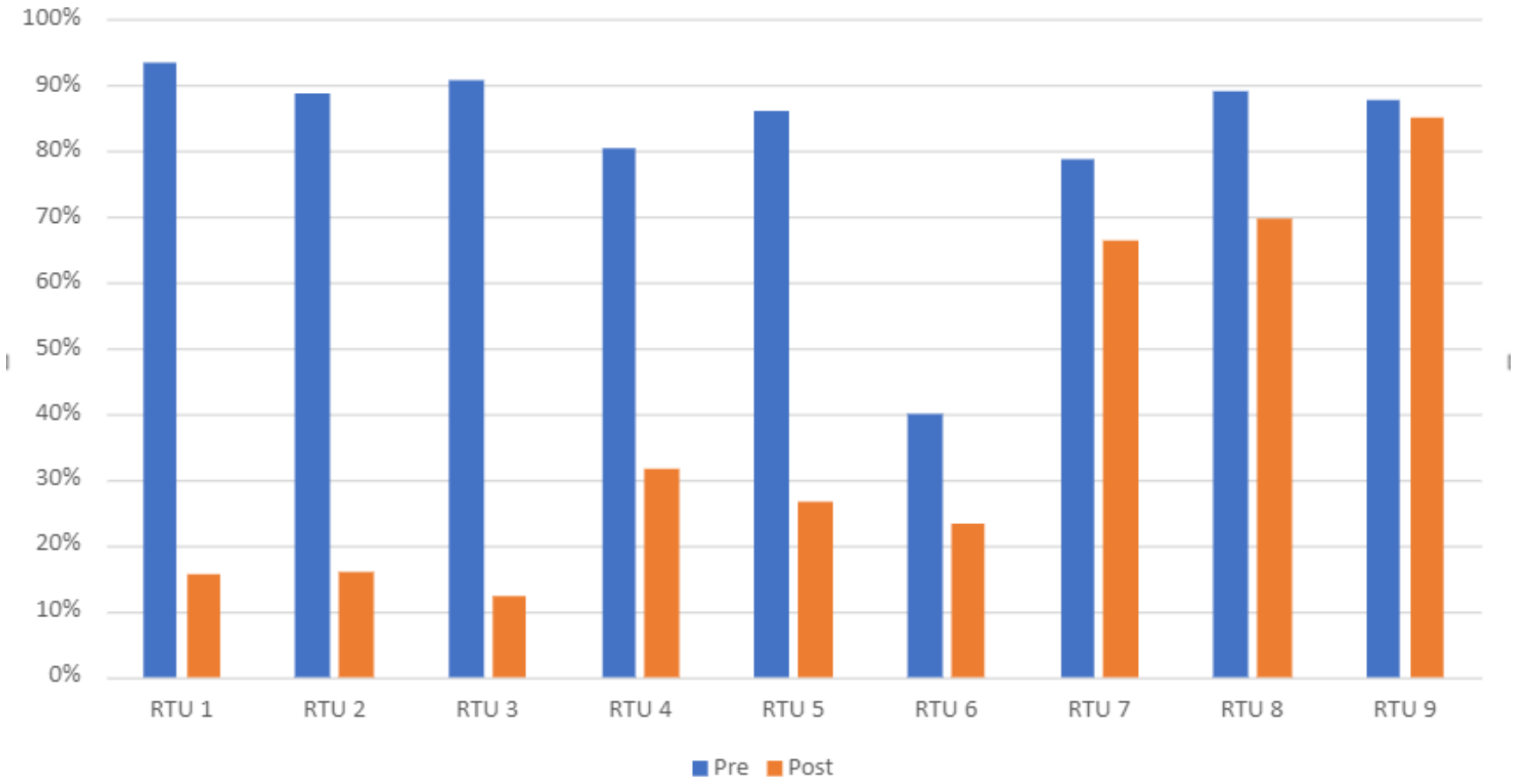
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Advanced Economizer Operation cont.



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Advanced Economizer Compressor Runtime Reduction

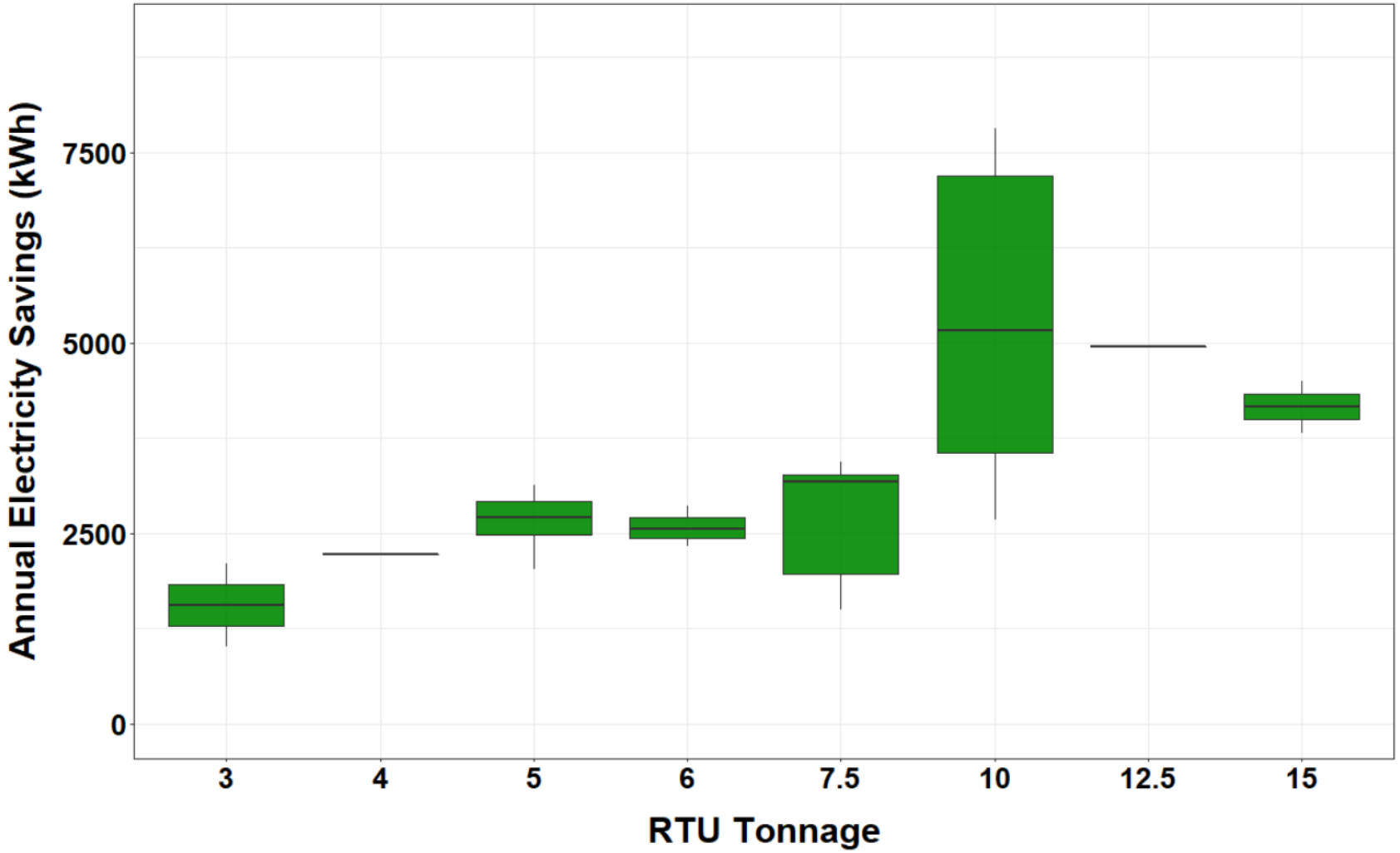


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Savings

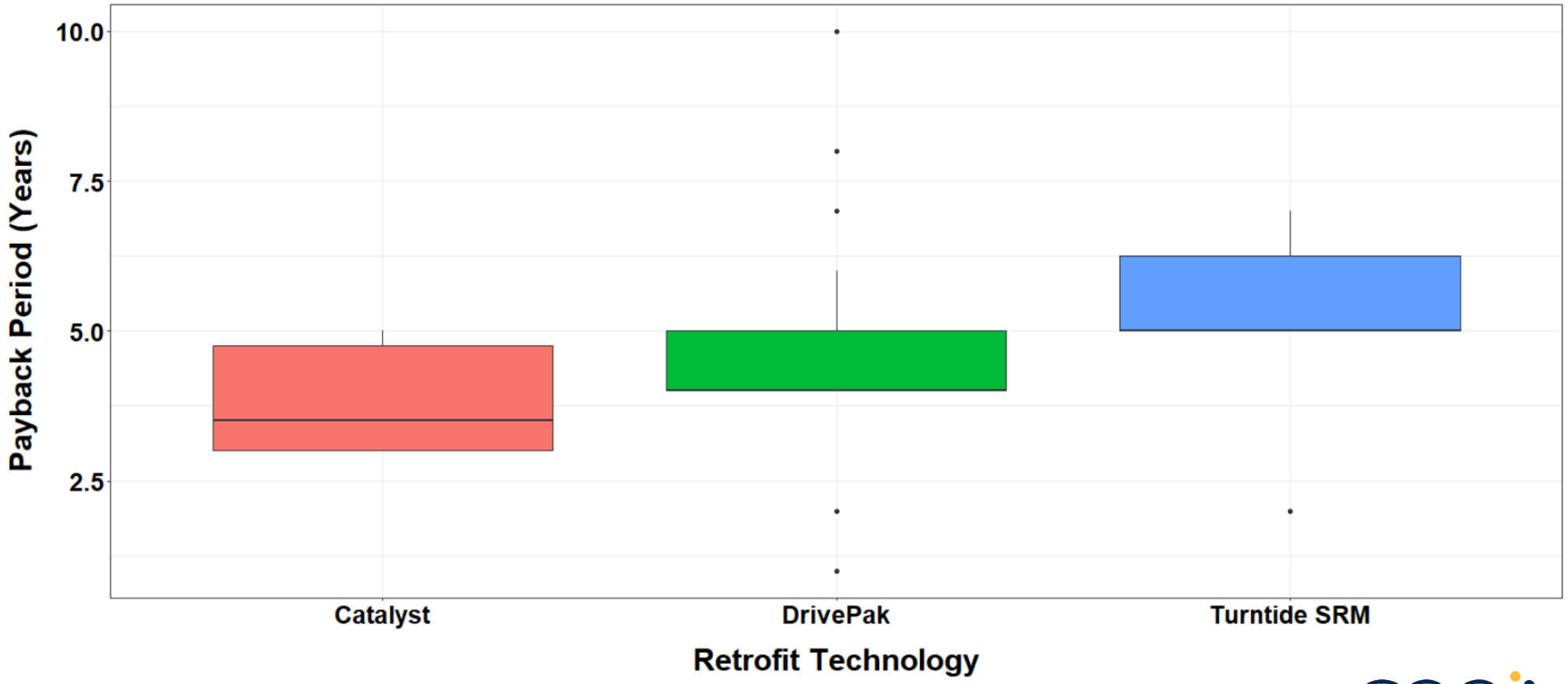
Technology	Retrofit Technology	Average RTU Size (Tons)	Average RTU Annual Electricity Savings %	Average RTU Annual Electricity Savings (kWh)
Catalyst	Evaporator VFD	6	36%	2,702
Turntide	Evaporator SRM	9	33%	3,556
DrivePak	Evaporator VFD	7	43%	3,592
Honeywell Jade	Advanced Economizer	5	0%	(5)
Belimo ZIP	Advanced Economizer	7	3%	140

Savings by Size – Variable Speed Evaporator Fan



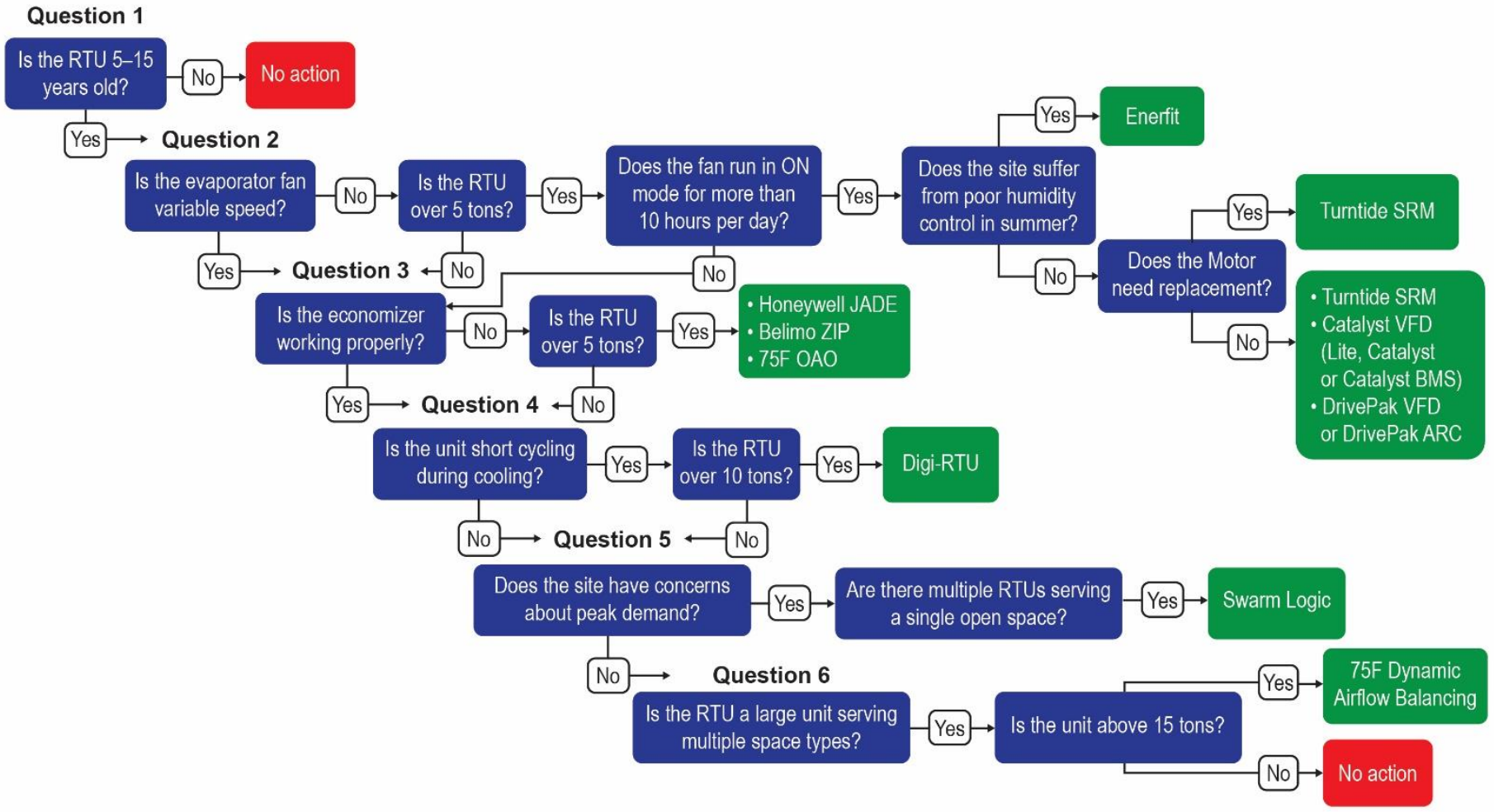
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Payback



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Decision Tree



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Summary of Market Barriers

- RTUs are replaced only when they fail
  - Contractors and building decision makers act quickly to replace RTU
- Custom rebates
- RTU runtime and associated savings are highly variable
- Contractor engagement has been difficult
- Leased buildings vs. owner-occupied
- New standards incorporate energy savings measures
  - Staged evaporator fan
  - More robust economizer control and FDD

Recommendations

- Contractor engagement
- Utility and manufacturer customer engagement
  - Newsletters, communication, etc.
  - Engage customers before the end of the RTU's useful life
- Prescriptive rebates where possible
- Simplify the custom rebate process
- Possible $/ton incentive on specific packages
  - Tiered approach
- TRM measures

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Thank You!

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Questions?

Overcoming the Market Barriers for Rooftop Unit (RTU) Retrofit Enhancement

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Send us your questions using the Q&A panel

CARD Project Result Dissemination

- Reports, webinars, fact Sheets, guidelines & tools available online under “Resources”
- Final webinar recording and report available in a couple months
- Website is currently under construction

https://mn.gov/commerce/energy/industry-government/cip/applied-research-development/



Let us know how we did today!

Your Feedback Matters

Thanks for Participating!

Upcoming CARD Webinars:

- **July 20, 2023: Center for Energy and Environment – How Smart Do Intelligent Buildings Need to Be?**

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

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