


Commercial Refrigeration Load Shape Project

Forum Presentation

June 18, 2015

Thank You!

- NEEP Technical Committee
  - Elizabeth Titus
  - Danielle Wilson
  - Dave Jacobson
  - Steve Waite
- Sponsors

Agenda

- Study Objectives
- Technology Review
- Methods
- Results (Unit, Loadshapes, Aggregate)
- Key Lessons/Recommendations

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Study Objectives

Evaporator Fan Motor Retrofit	Evaporator Fan Motor Control	Door Heater Control

- Produce 8,760 savings loadshapes
- Determine annual kWh and kW savings
- Suggest TRM updates

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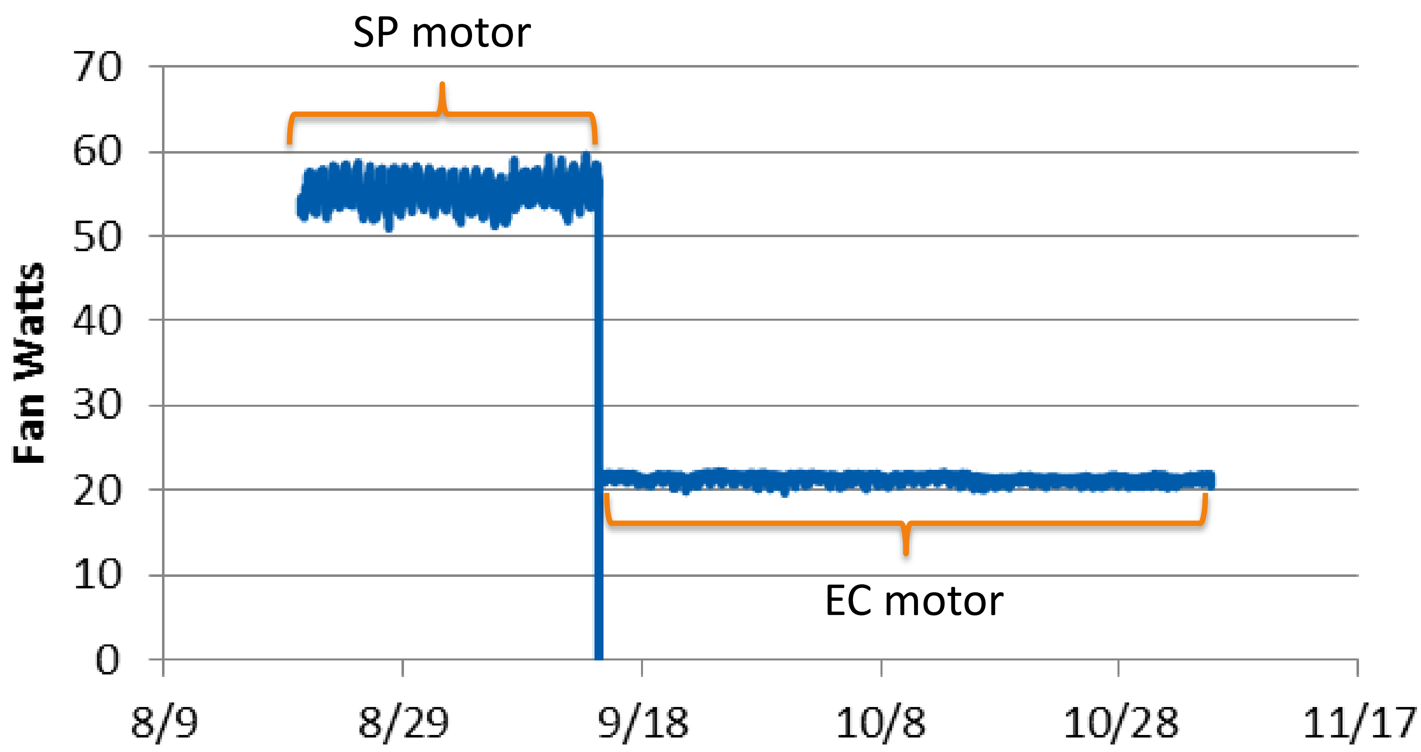
Evaporator Fan Motor Retrofit

Evaporator Fan Motor Retrofit



Evaporator Fan Motor Controls

Motor controller

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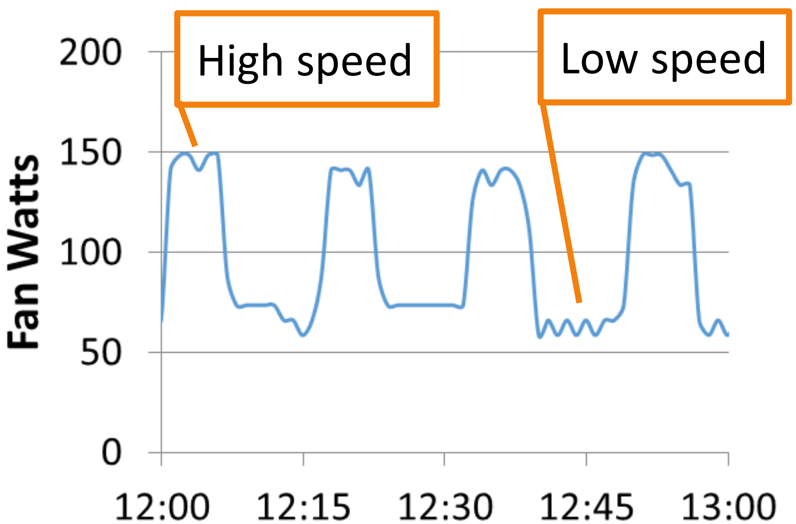
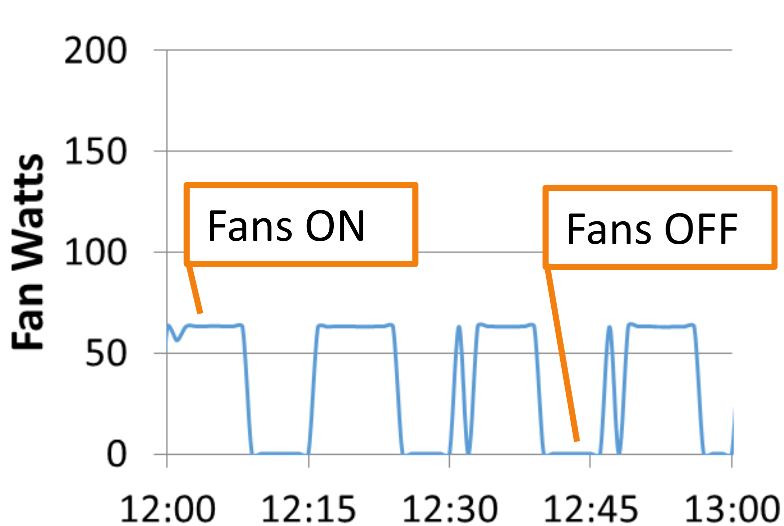
Evaporator Fan Motor Controls

Variable/Multi-Speed



On/Off



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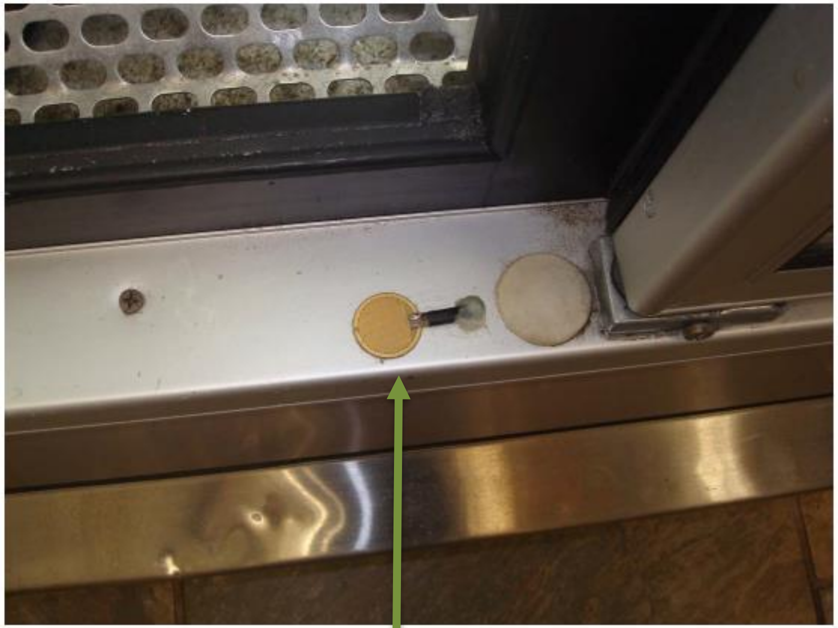
Door Heater Controls



Heater control

Door moisture sensor

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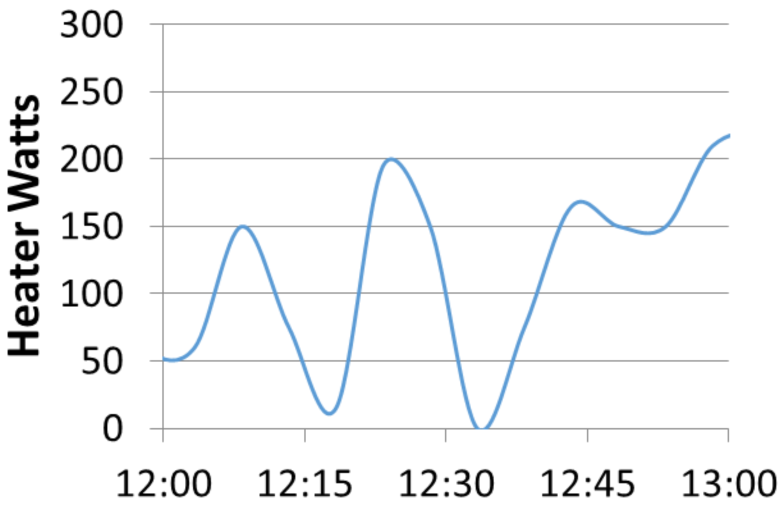
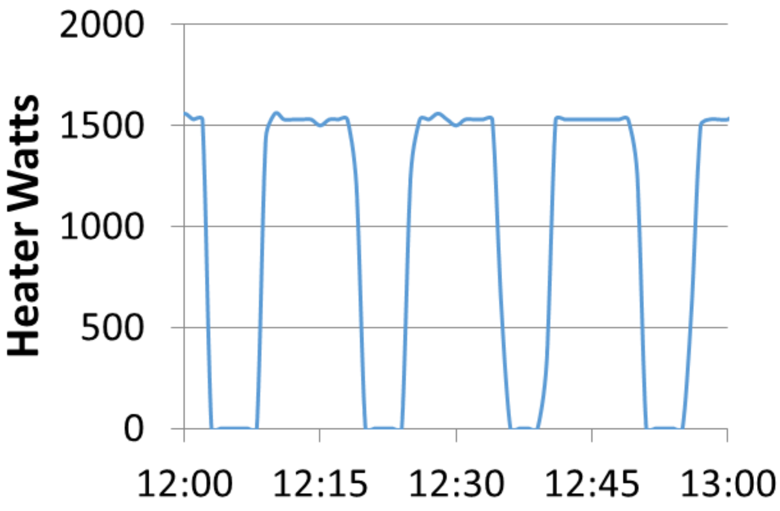
Door Heater Controls

Micropulsing



On/Off



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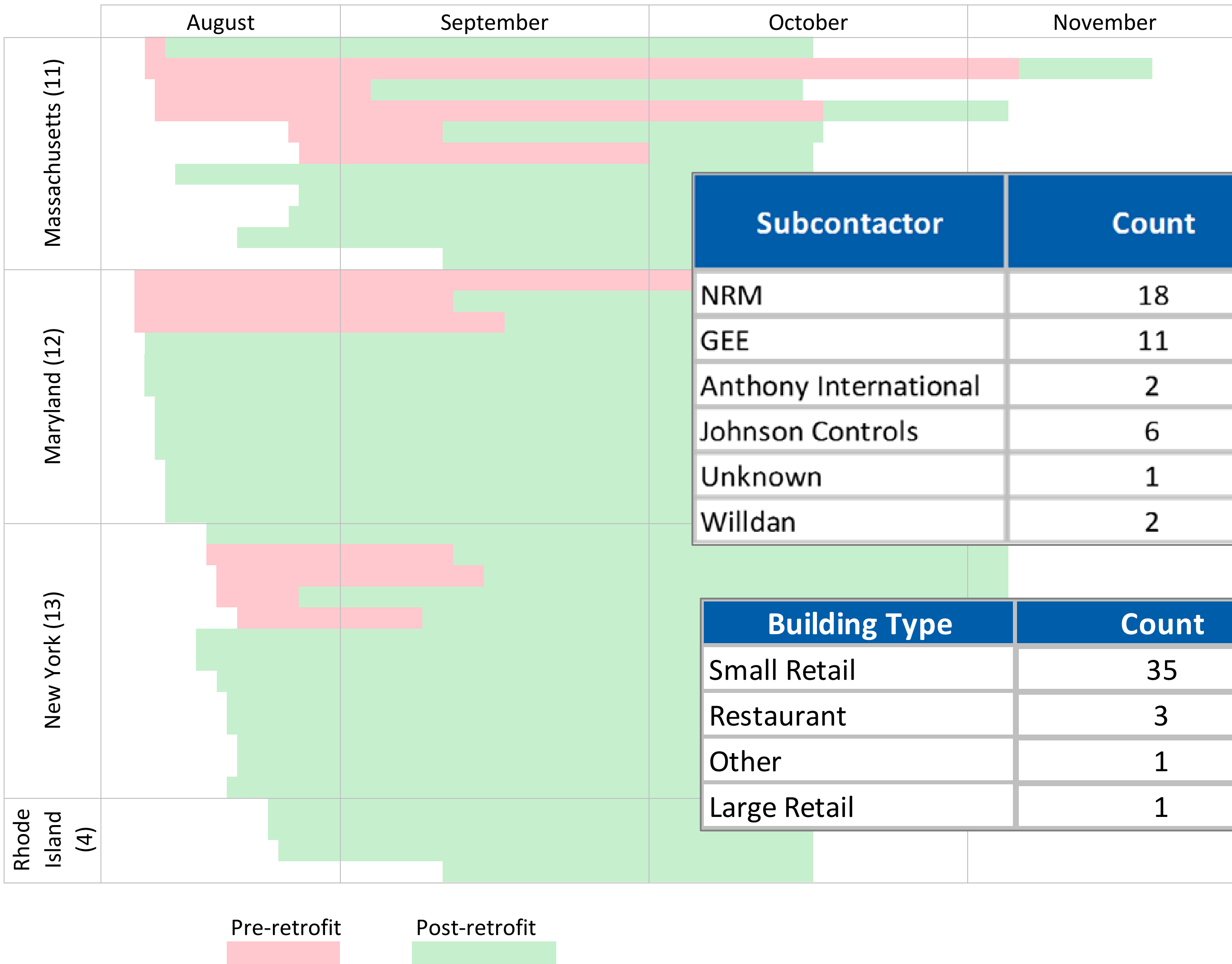
Primary Data Collection



Subcontactor	Count
NRM	18
GEE	11
Anthony International	2
Johnson Controls	6
Unknown	1
Willdan	2

Building Type	Count
Small Retail	35
Restaurant	3
Other	1
Large Retail	1

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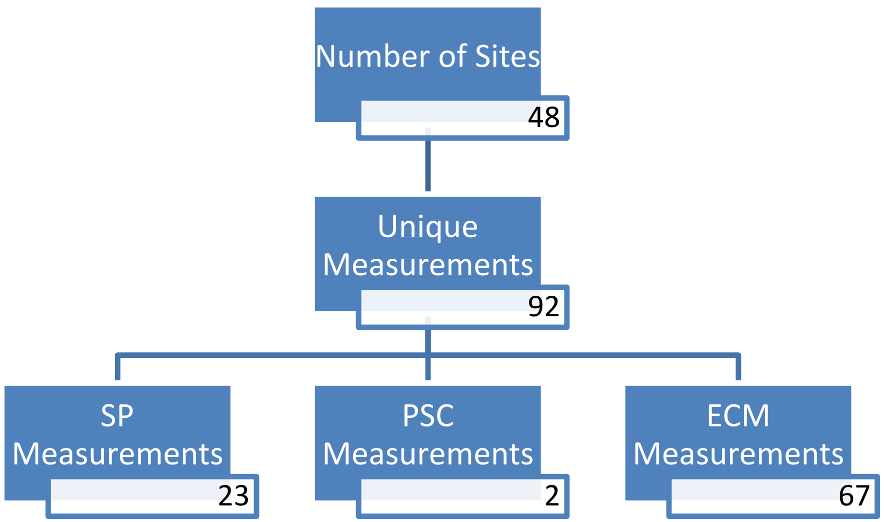
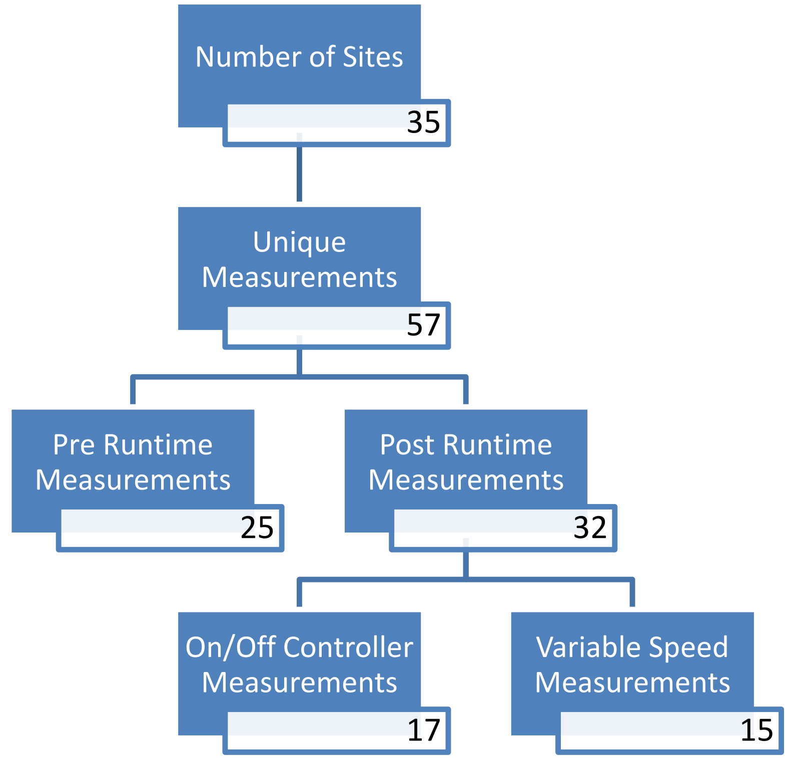
Final Sample– Evaporator Fan Motors

EC Motor Retrofit Power Measurements



Motor Controller Runtime Measurements



On/Off Controllers: MA, RI, MD

Variable Speed Controllers: NY, MD

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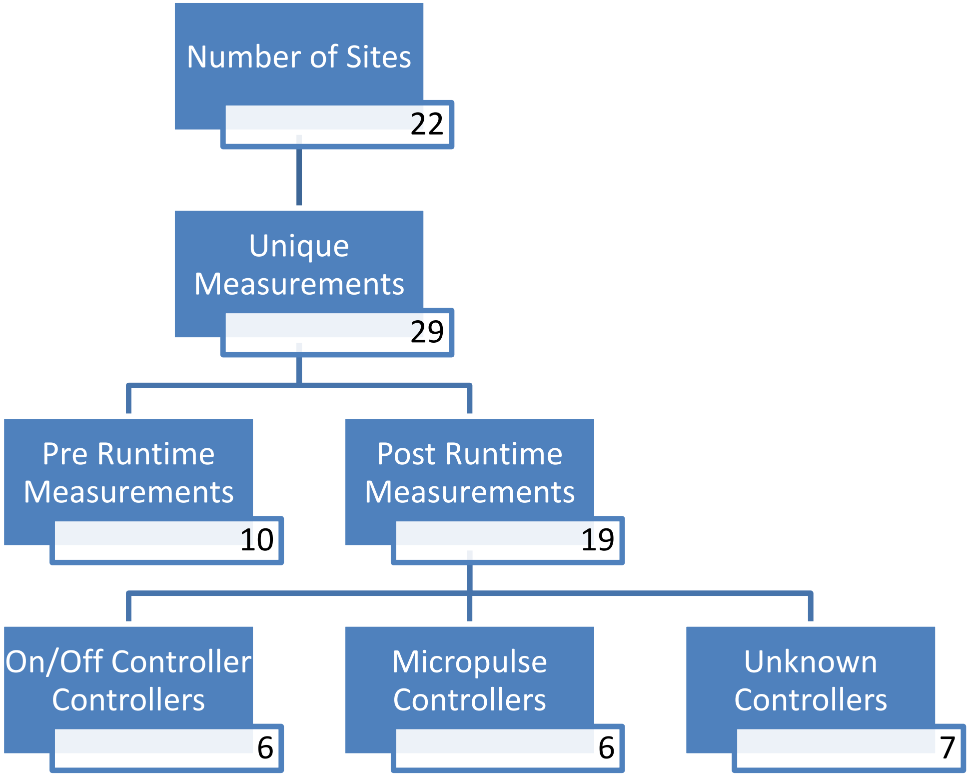
Final Sample – Door Heater Controls

ASDH Runtime Measurements



On/Off Controllers: NY, MD
Micropulse Controllers: MA, RI, MD

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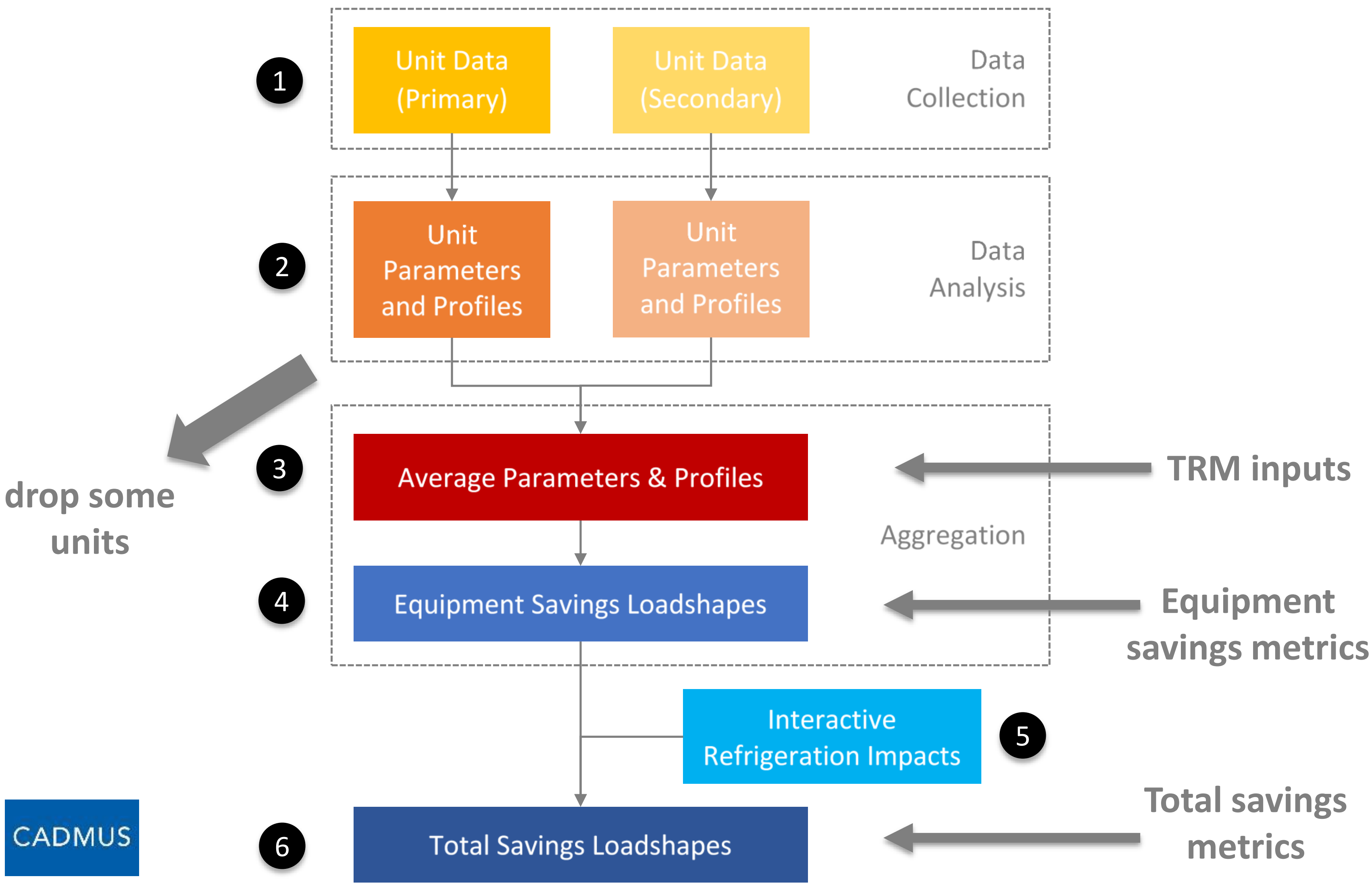
Method



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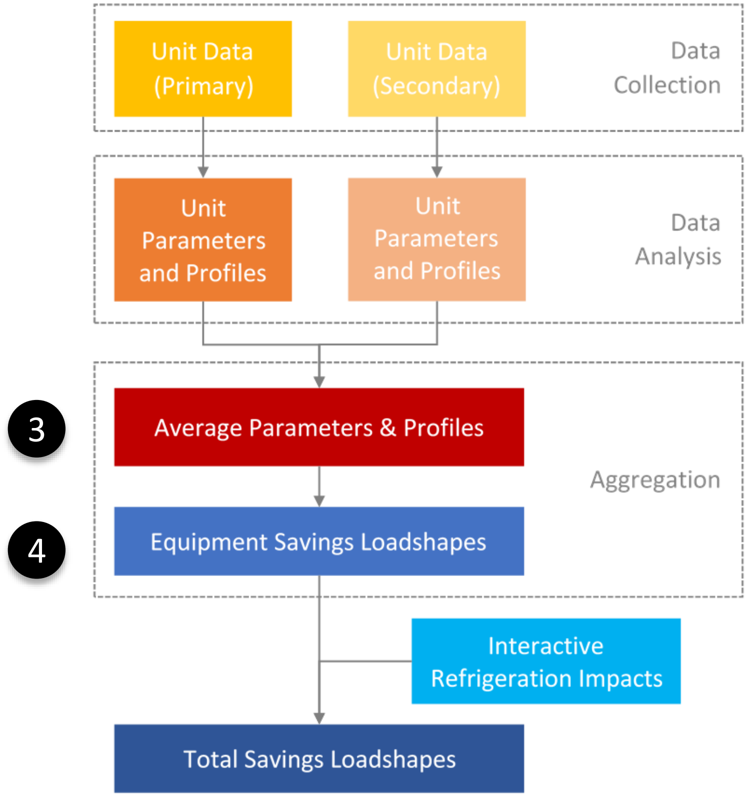
Aggregation

3 Combine unit data to calculate average parameters and profiles (all units are evenly weighted)

4 Combine average parameters and profiles to calculate hourly savings loadshapes



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Any questions before we jump into results?

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Results

- Sumary
- For each technology:
  - Unit Level Results
    - Performance
    - Key findings
  - Aggregate Results
    - Compare to current TRM estimates
    - Final savings estimates
  - Discussion

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Summary of Results

- All three measures provide reliable energy and demand savings
- Easy to install and unobtrusive
- Appropriate for large and small commercial refrigeration

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Evaporator Fan Motor Retrofit

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Evaporator Fan Motor Retrofit Formula

Constant = 1,192 W/hp

User Input

$$\Delta W_{ECM} = \left(\frac{W_{PRE} - W_{POST}}{W_{POST}}\right) \times \left(\frac{W}{hp}\right)_{ECM} \times hp_{ECM}$$

Parameter	Description	Source	Meter Sample (Circuits)	Value
$\frac{W_{PRE} - W_{POST}}{W_{POST}}$	% change in power relative to post wattage	Pre/post metering only	9 primary 0 secondary	1.57
$\left(\frac{W}{hp}\right)_{ECM}$	Post power normalized by horsepower	Pre/post and post-only metering	42 primary 24 secondary	759 W/hp

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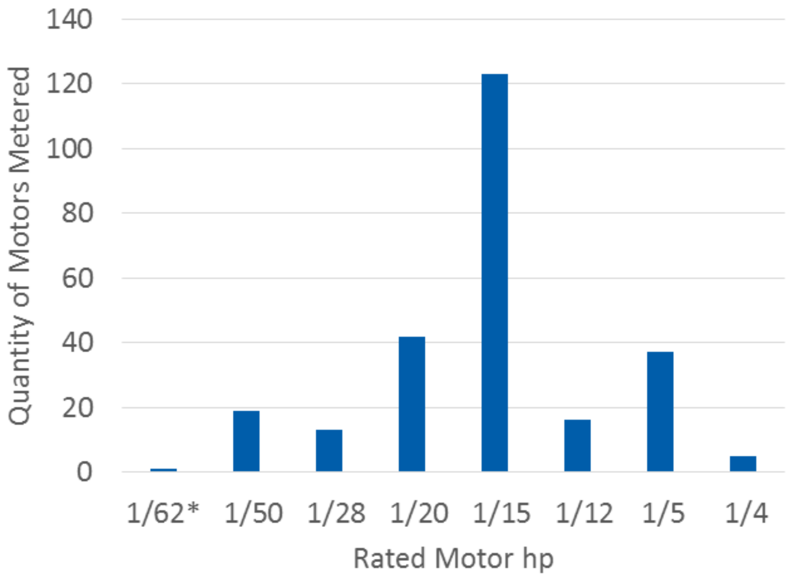
Evaporator Fan Motor Retrofit
Motor Power

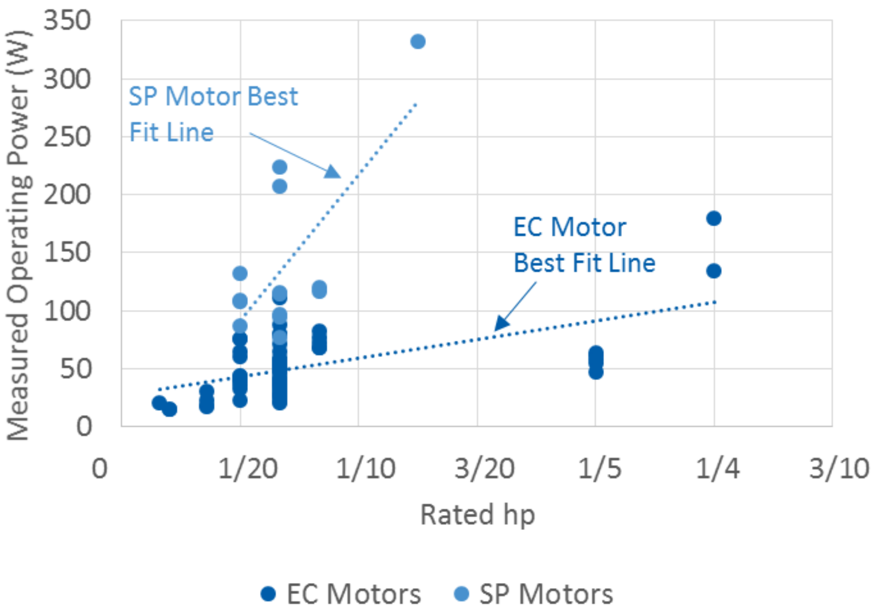
Number of Motors Metered



* Motors rated below 1/50-hp are reported in Watts; value is equivalent hp.

Average Motor hp = 1/12

Measured Motor Power



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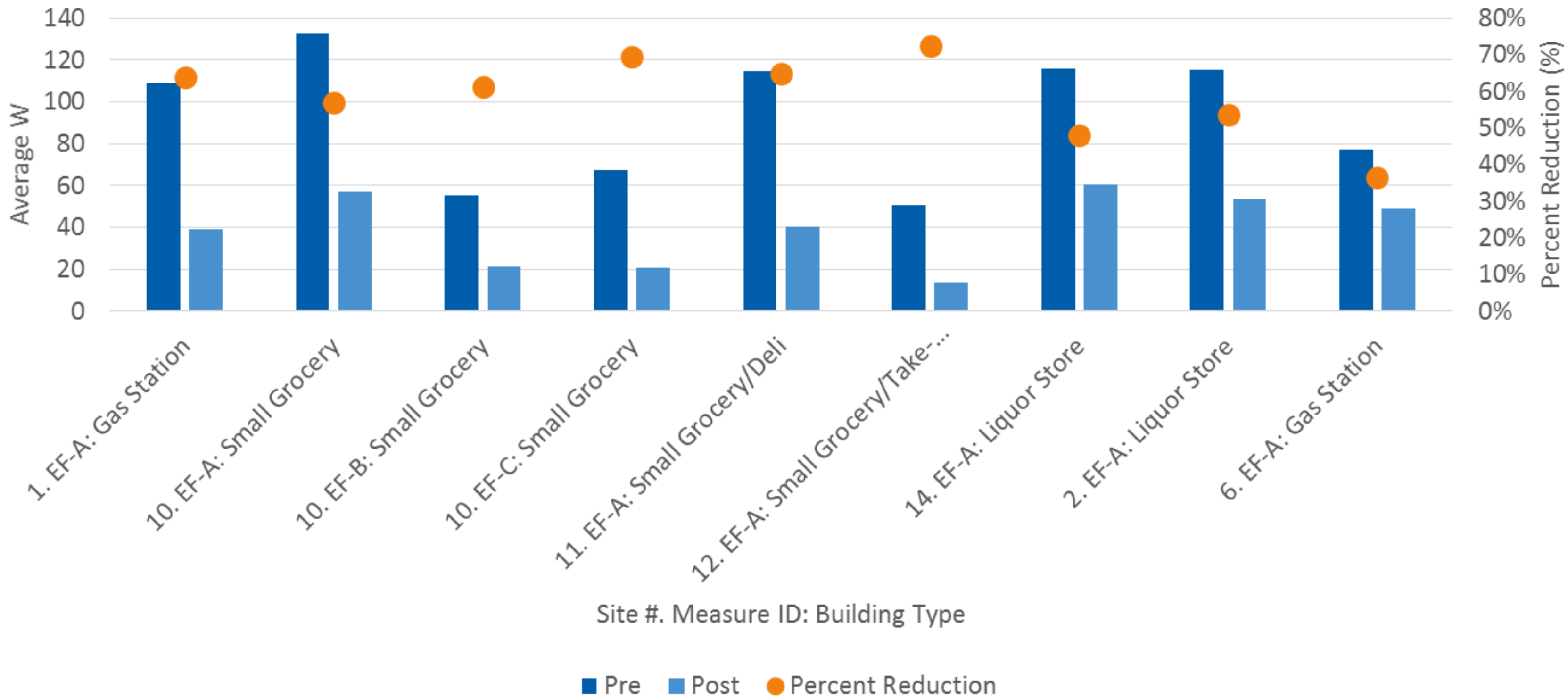
Evaporator Fan Motor Retrofit
Power Reduction



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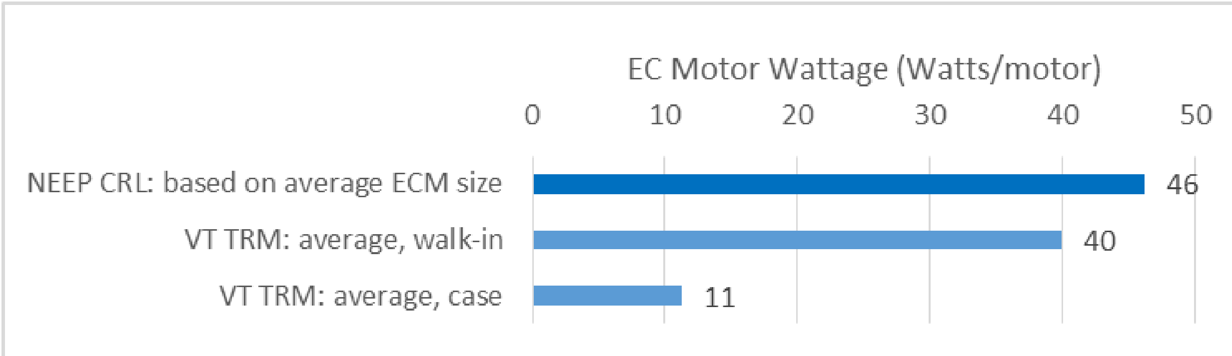
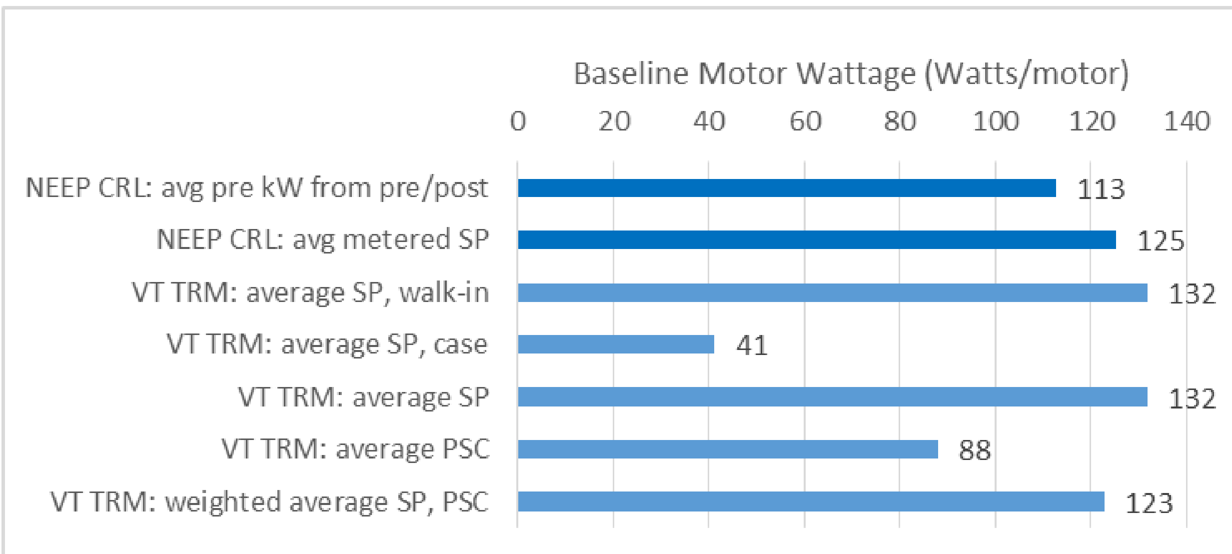
Evaporator Fan Motor Retrofit

Motor Power – TRM Comparison





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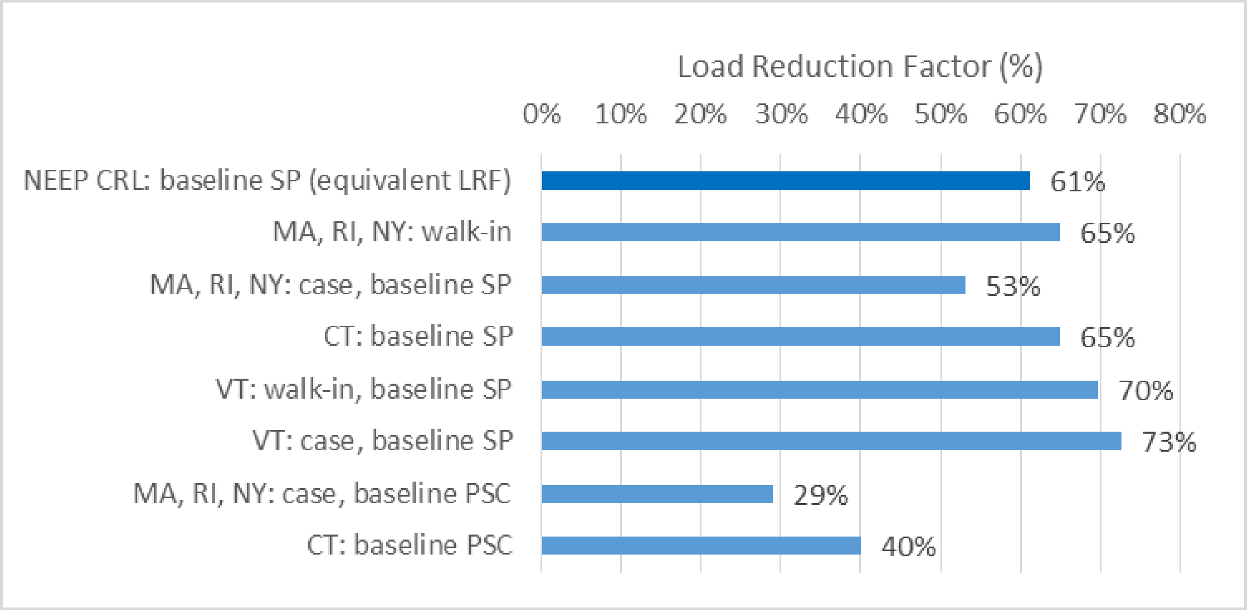
Note: Not all TRMs use each parameter; in some cases, we use TRM information to calculate parameters for comparison

Evaporator Fan Motor Retrofit
Power Reduction – TRM Comparison



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Note: Not all TRMs use each parameter; in some cases, we use TRM information to calculate parameters for comparison

Evaporator Fan Motor Retrofit
Aggregation Decisions

- One site where retrofit took place, but not part of utility program
  - Included in analysis
- Two sites where PSC as baseline
  - Removed from analysis

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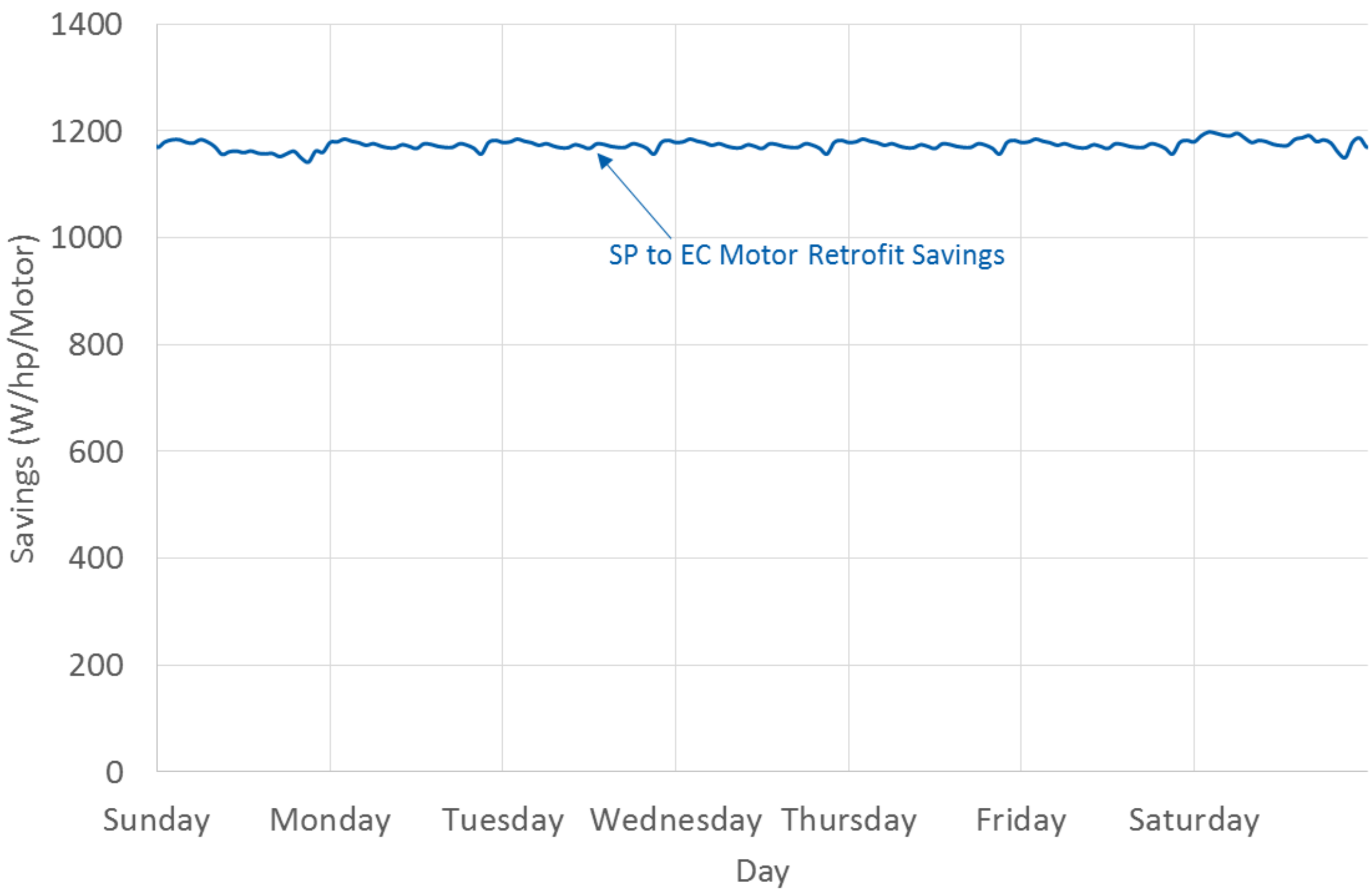
Evaporator Fan Motor Retrofit Equipment Savings Loadshape



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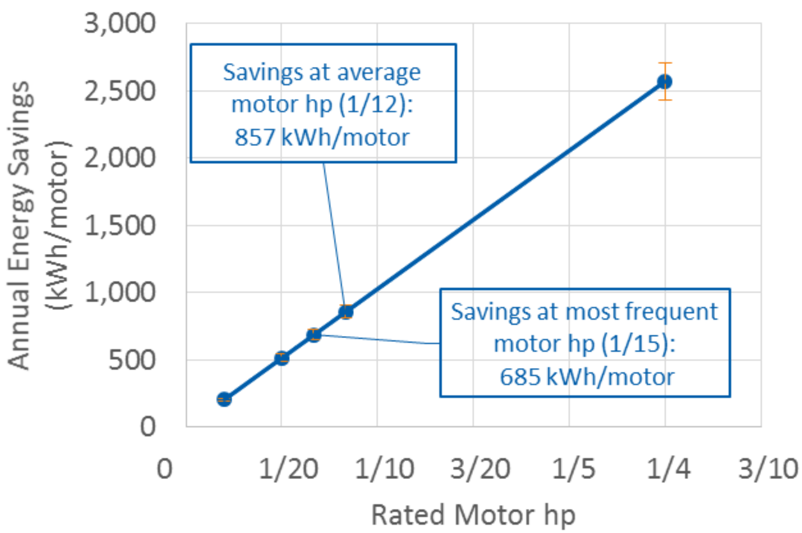
Evaporator Fan Motor Retrofit
Equipment Savings Metrics

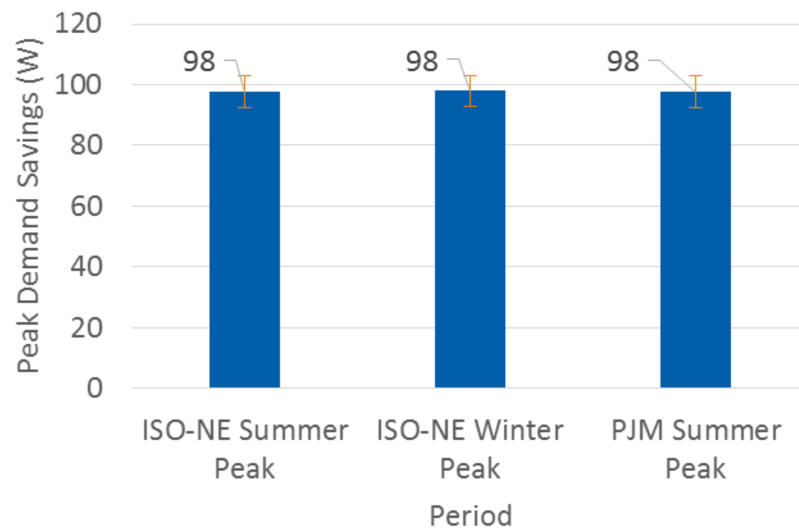
Annual Energy Savings



*Error bars indicate relative precision at 90% confidence interval

Measure	Annual Total Energy Savings	
	RP @ 90%	RP @ 80%
EC Motor Retrofit	5.3%	4.1%

Peak Demand Savings (at hp = 1/12)



*Error bars indicate relative precision at 90% confidence interval

Measure	ISO-NE Peak Demand Savings	
	RP @ 90%	RP @ 80%
EC Motor Retrofit	5.3%	4.1%

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Evaporator Fan Motor Control

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Evaporator Fan Motor Control

Formula

Constant — User Input

$$\frac{\Delta W}{motor_{ECM}} = \left(\frac{W}{hp}\right)_{ECM} \times (\%ON_{PRE} - \%ON_{POST}) \times hp_{ECM}$$

$$\frac{\Delta W}{motor_{SP}} = \left(\frac{W}{hp}\right)_{SP} \times (\%ON_{PRE} - \%ON_{POST}) \times hp_{SP}$$

Parameter	Description	Source	Meter Sample (Circuits)	Value
$\left(\frac{W}{hp}\right)_{ECM}$	Post-retrofit power normalized by hp	Post and Pre/Post	42 primary 24 secondary	759 W/hp
$\left(\frac{W}{hp}\right)_{SP}$	Pre-retrofit power normalized by hp	Pre and Pre/Post	13 primary 5 secondary	2,088 W/hp

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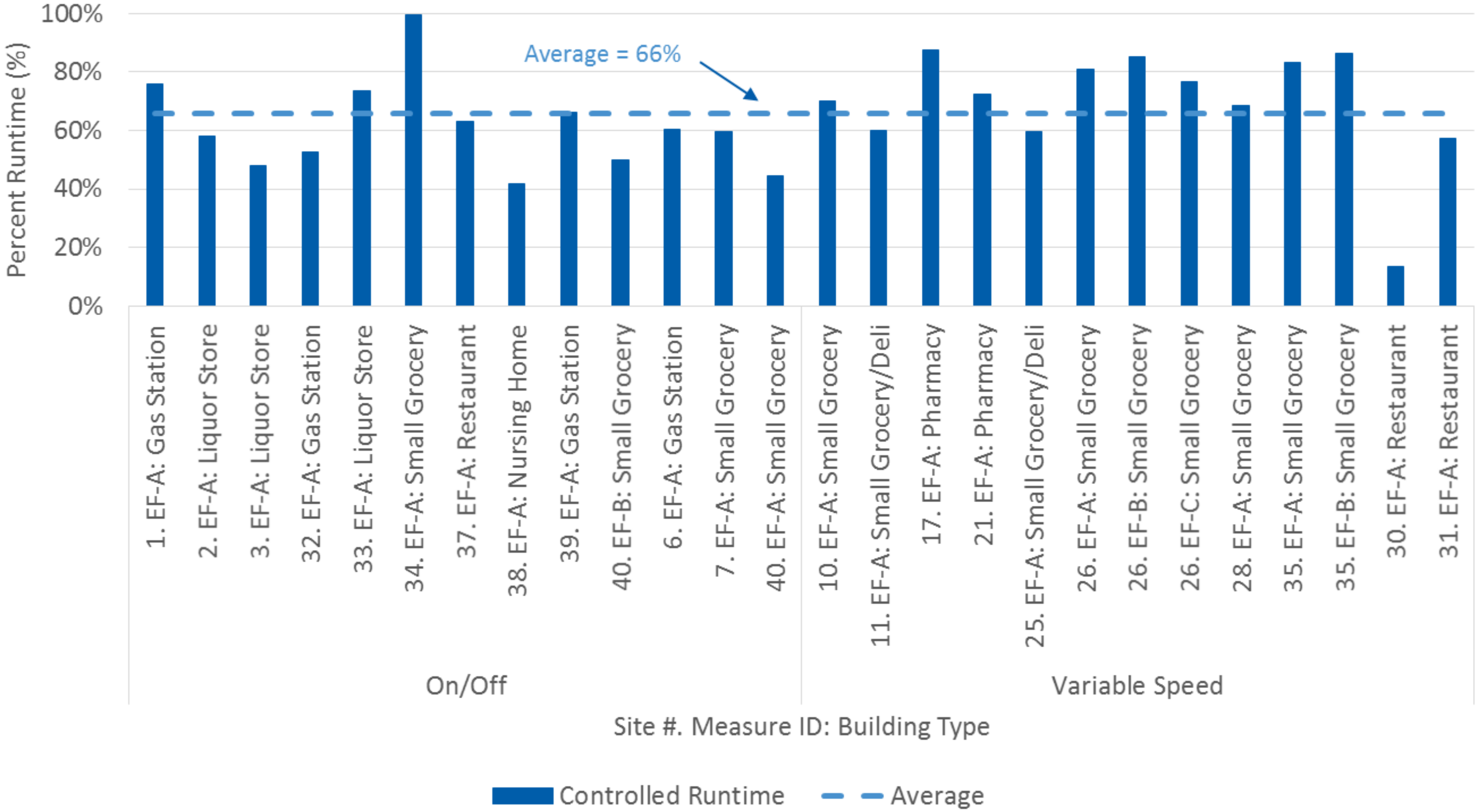
Evaporator Fan Motor Control

%Runtime



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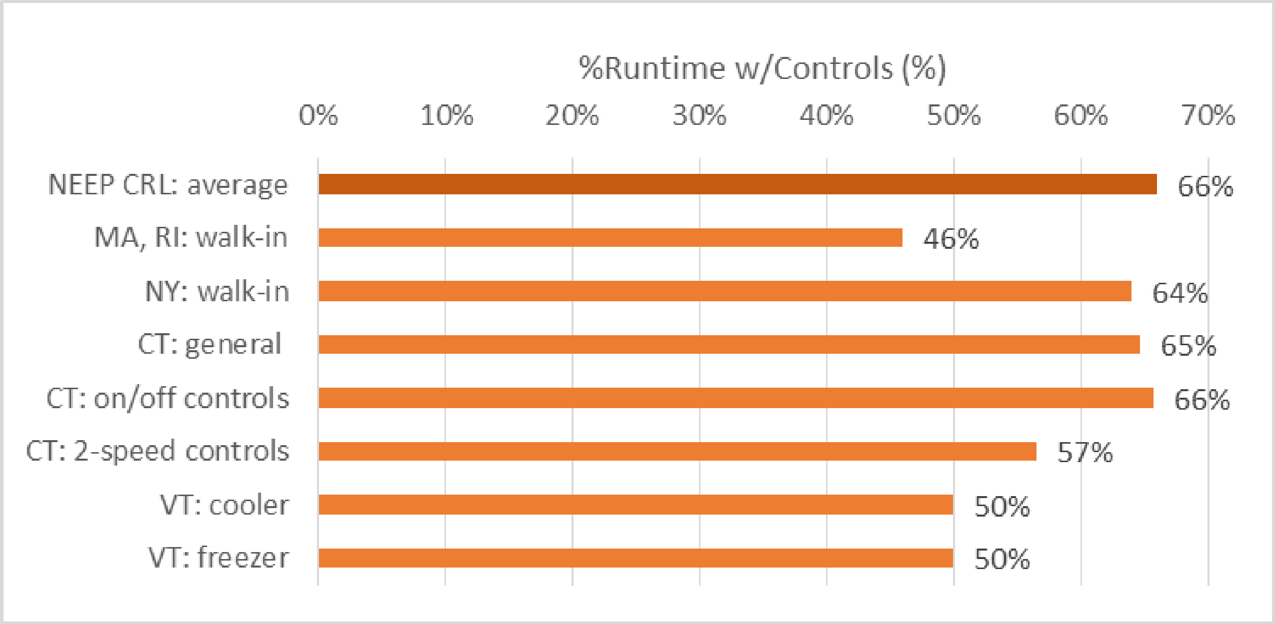
Evaporator Fan Motor Control

%Runtime – TRM Comparison



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Note: Not all TRMs use each parameter; in some cases, we use TRM information to calculate parameters for comparison

Evaporator Fan Motor Control

Aggregation Decisions

- One site had SP motor with controls as baseline
  - Used wattage on uncontrolled motor as baseline
- One site installed controls on SP motor as part of program
  - Used runtime as post-retrofit condition
- Two sites where controls were disconnected
  - Included in analysis
- One site where technician advised against installing controls – were never installed
  - Used pre data only

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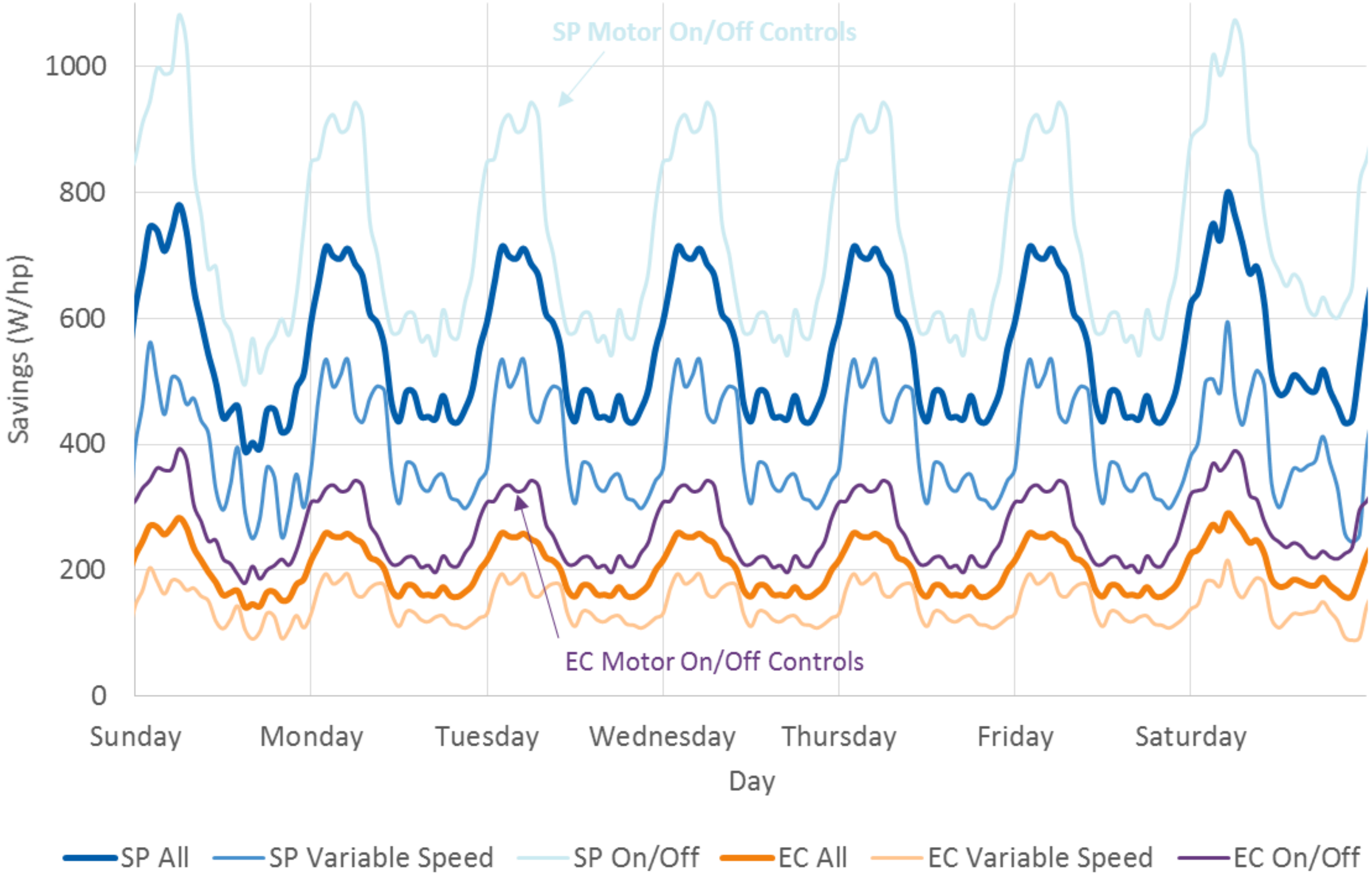
Evaporator Fan Motor Control

Equipment Savings Loadshape



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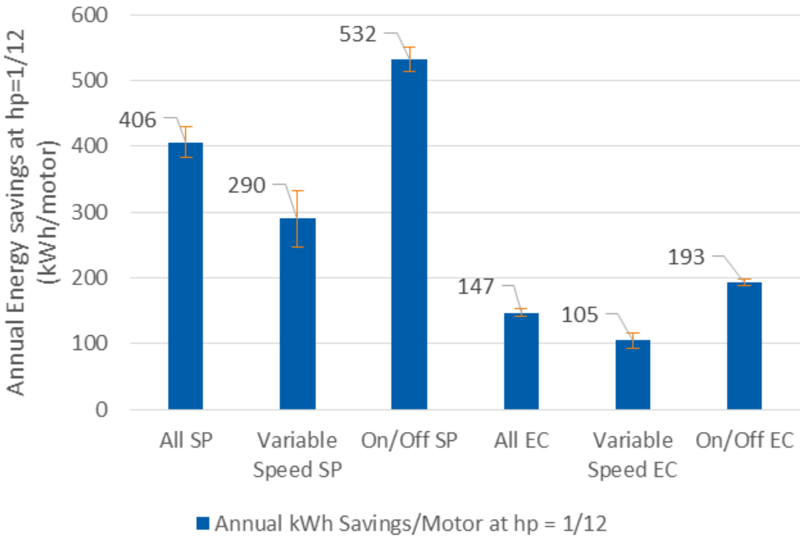
Evaporator Fan Motor Control

Equipment Savings Metrics

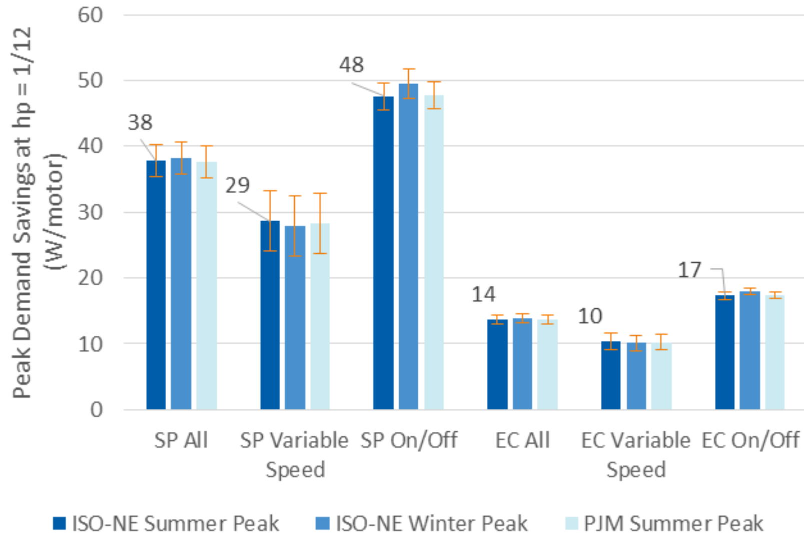
Annual Energy Savings (at hp = 1/12)



*Error bars indicate relative precision at 90% confidence interval

Control Type	Annual Total Energy Savings	
	RP @ 90%	RP @ 80%
All SP	5.6%	4.4%

Peak Demand Savings (at hp = 1/12)



*Error bars indicate relative precision at 90% confidence interval

Control Type	ISO-NE Peak Summer Demand Savings	
	RP @ 90%	RP @ 80%
All SP	6.4%	5.0%

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Door Heater Control

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Door Heater Controls

Formula

Constant — User Input

$$\Delta W = \frac{Watt}{door}_{BASE} \times (\%ON_{PRE} - \%ON_{POST}) \times N_{doors}$$

Parameter	Description	Source	Meter Sample (Circuits)	Average Value
$\frac{Watt}{door}_{BASE}$	Operating power per door	Pre, Post, and Pre/Post	21 primary 6 secondary	130 Watts/door

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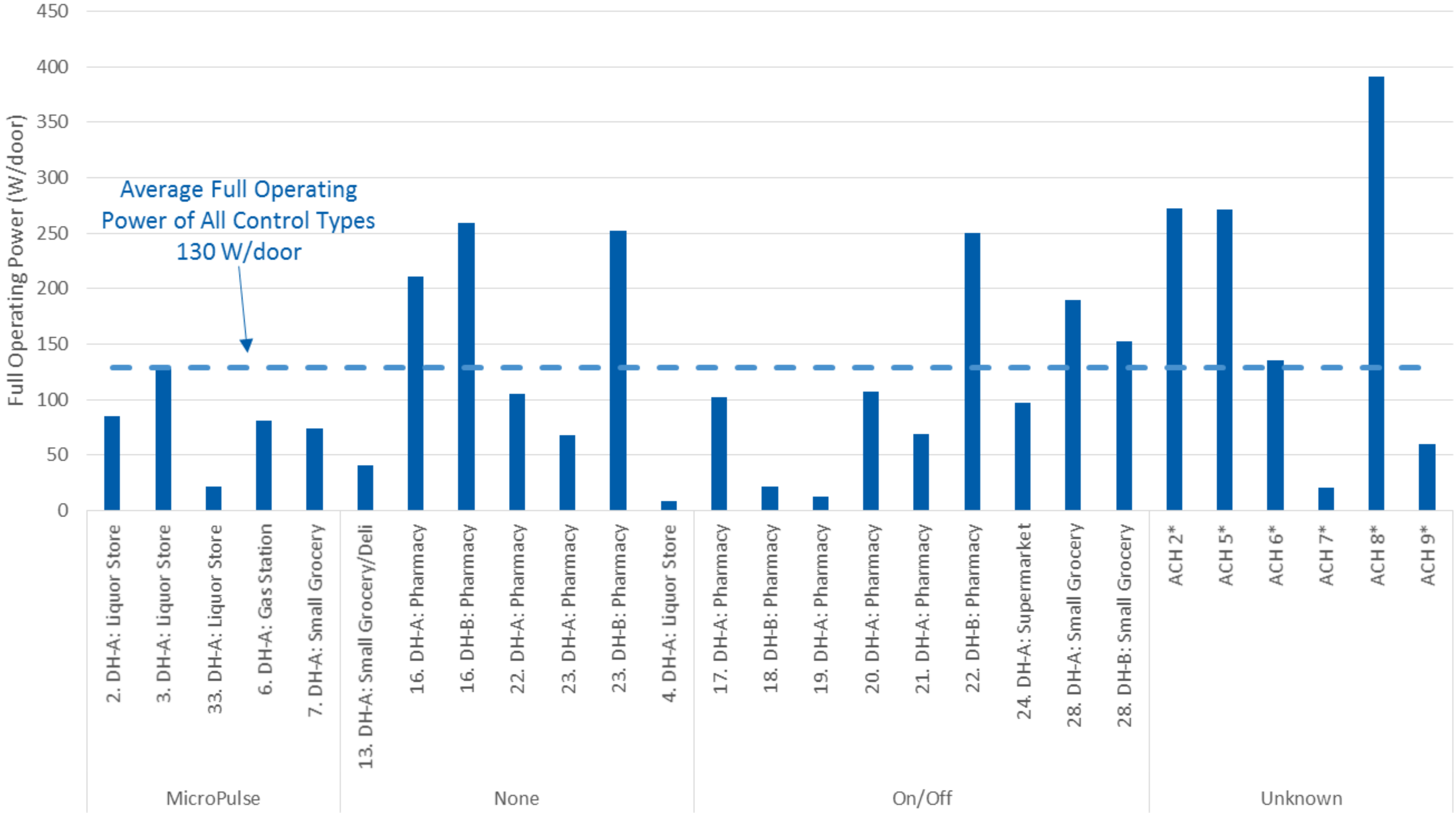
Door Heater Controls

Door Heater Power (W/door)



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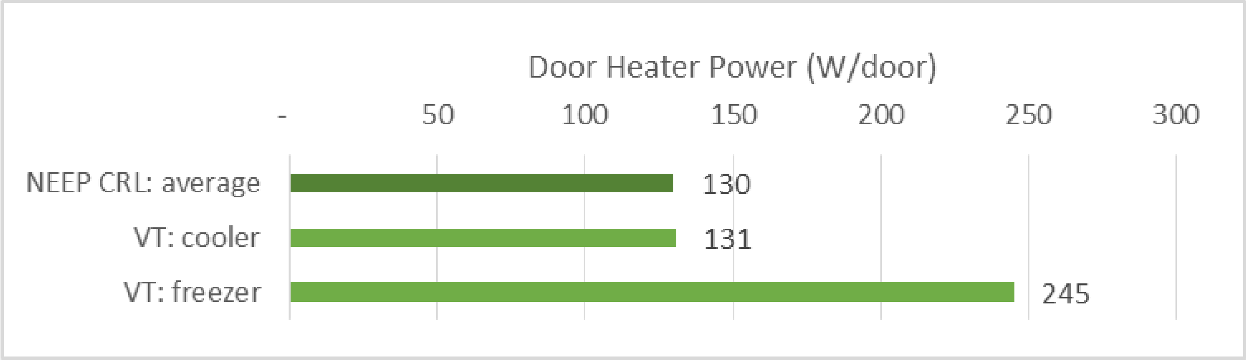
*Indicates secondary data

Door Heater Controls

Door Heater Power – TRM Comparison



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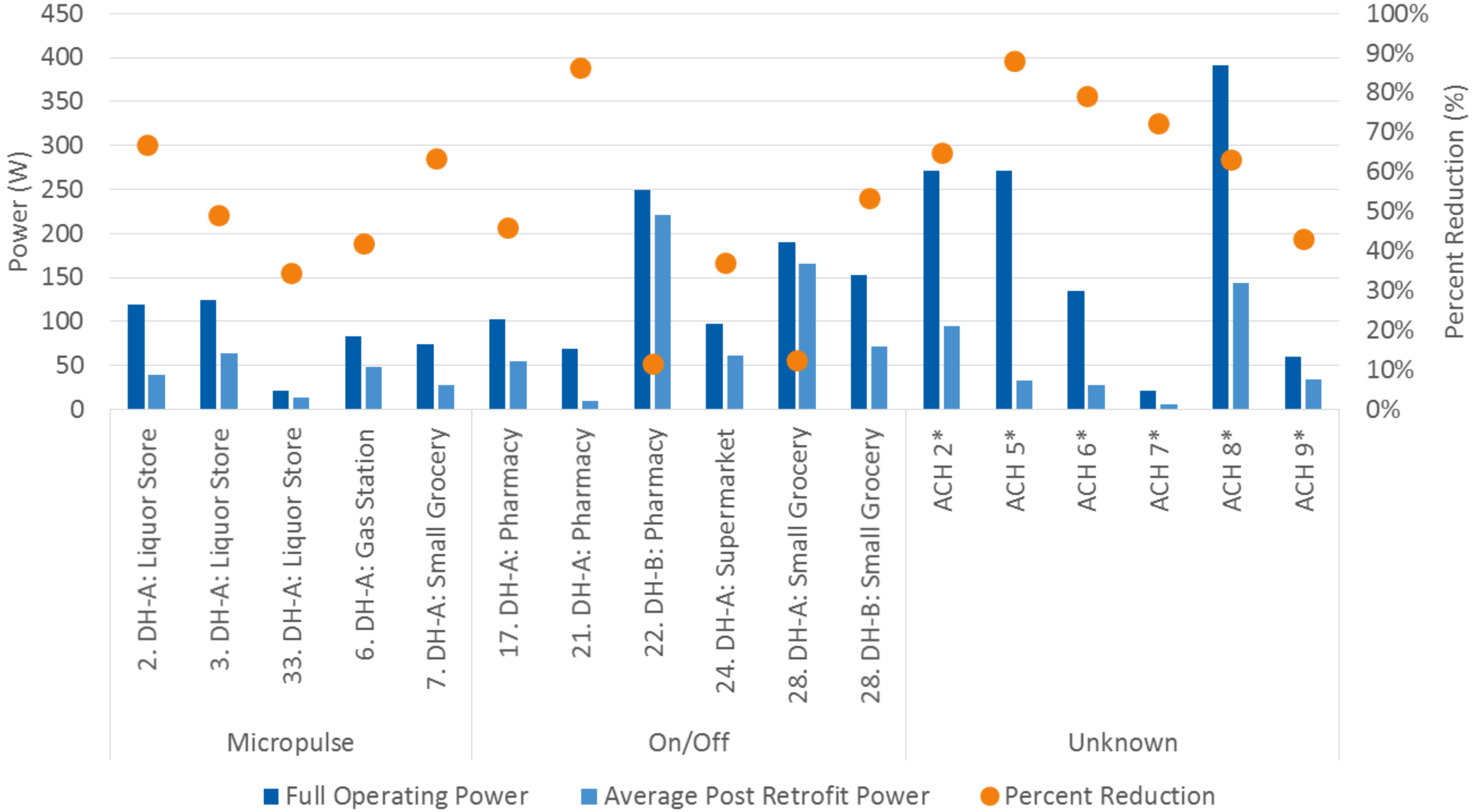
Note: Not all TRMs use each parameter; in some cases, we use TRM information to calculate parameters for comparison

Door Heater Controls

%Runtime



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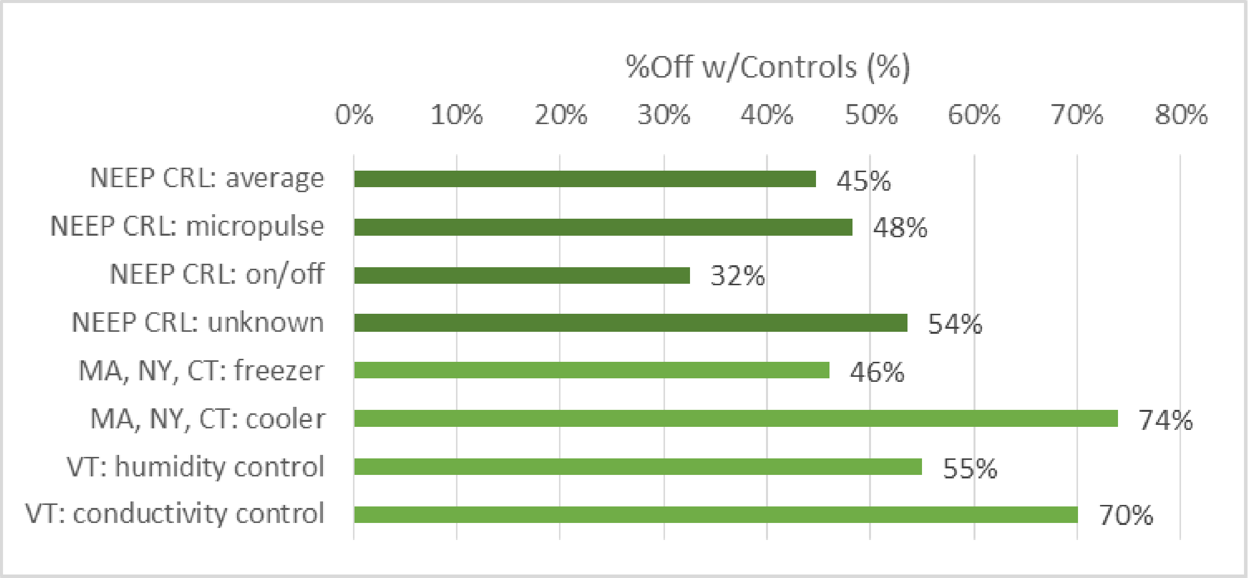
*Indicates secondary data

Door Heater Controls

%Runtime – TRM Comparison



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Note: Not all TRMs use each parameter; in some cases, we use TRM information to calculate parameters for comparison

Door Heater Controls
Aggregation Decisions

- One site did not use a door heater in the baseline case.
  - Used data from post-installation case only
- At one site, store manger manually turned off heaters at night in pre and post case.
  - Included in analysis
- Three sites showed no savings
  - Dropped from the loadshape calculations

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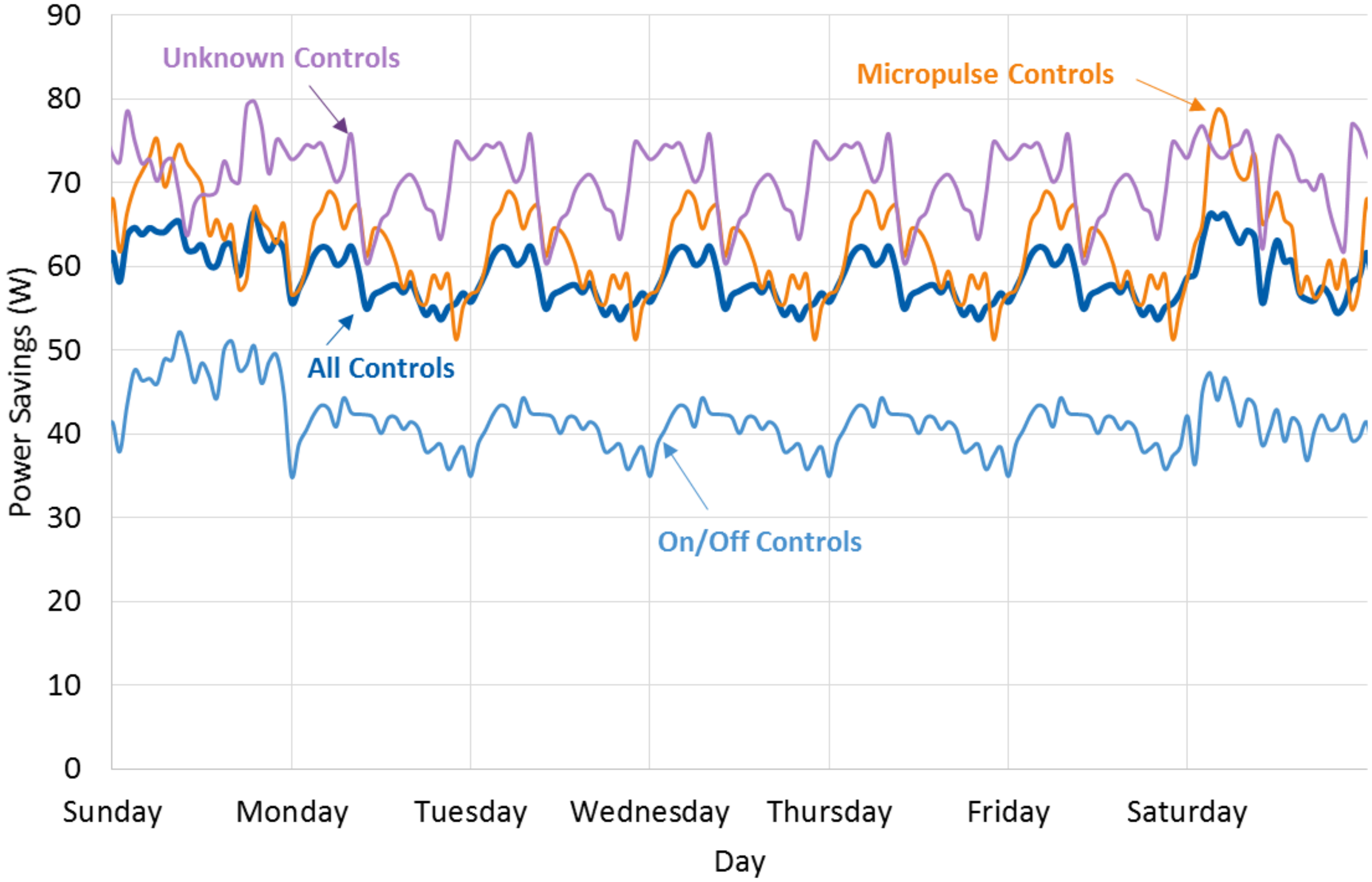
Door Heater Controls

Equipment Savings Loadshapes



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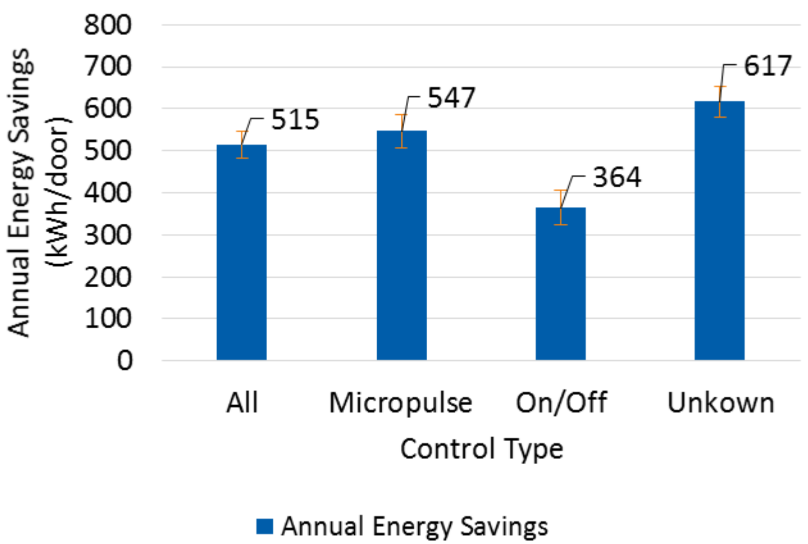
Door Heater Control

Equipment Savings Metrics

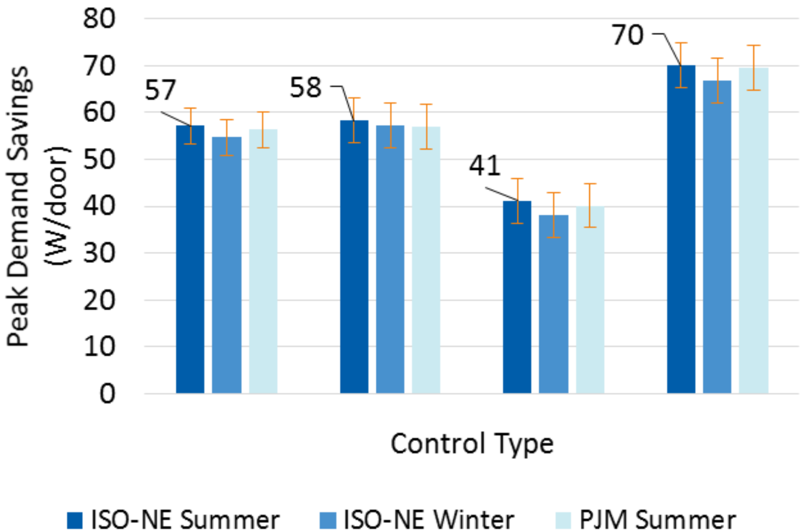
Annual Energy Savings



*Error bars indicate relative precision at 90% confidence interval

Control Type	Annual Total Energy Savings	
	RP @ 90%	RP @ 80%
All	6%	5%

Peak Demand Savings



*Error bars indicate relative precision at 90% confidence interval

Control Type	ISO-NE Peak Summer Demand Savings	
	RP @ 90%	RP @ 80%
All	7%	5%

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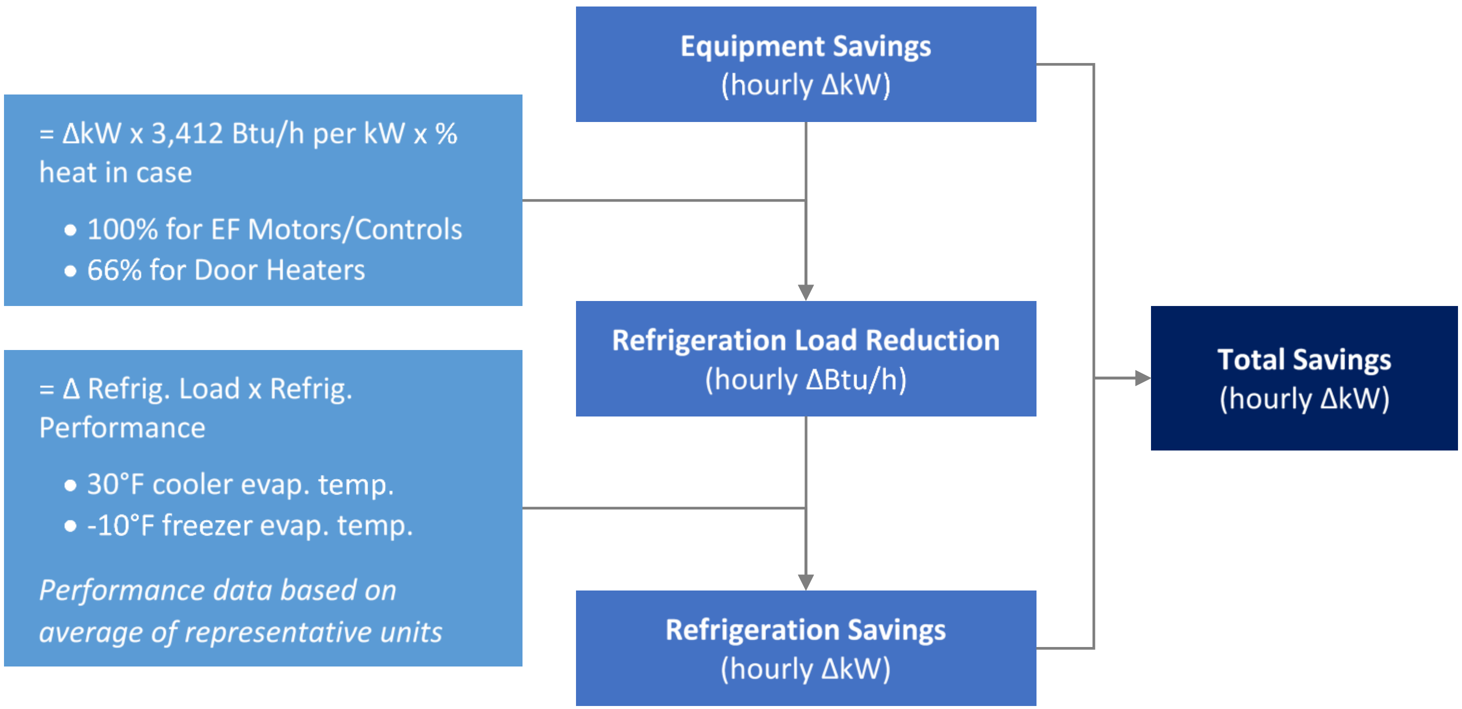
Interactive Refrigeration Impacts

Interactive Refrigeration Savings **Method**



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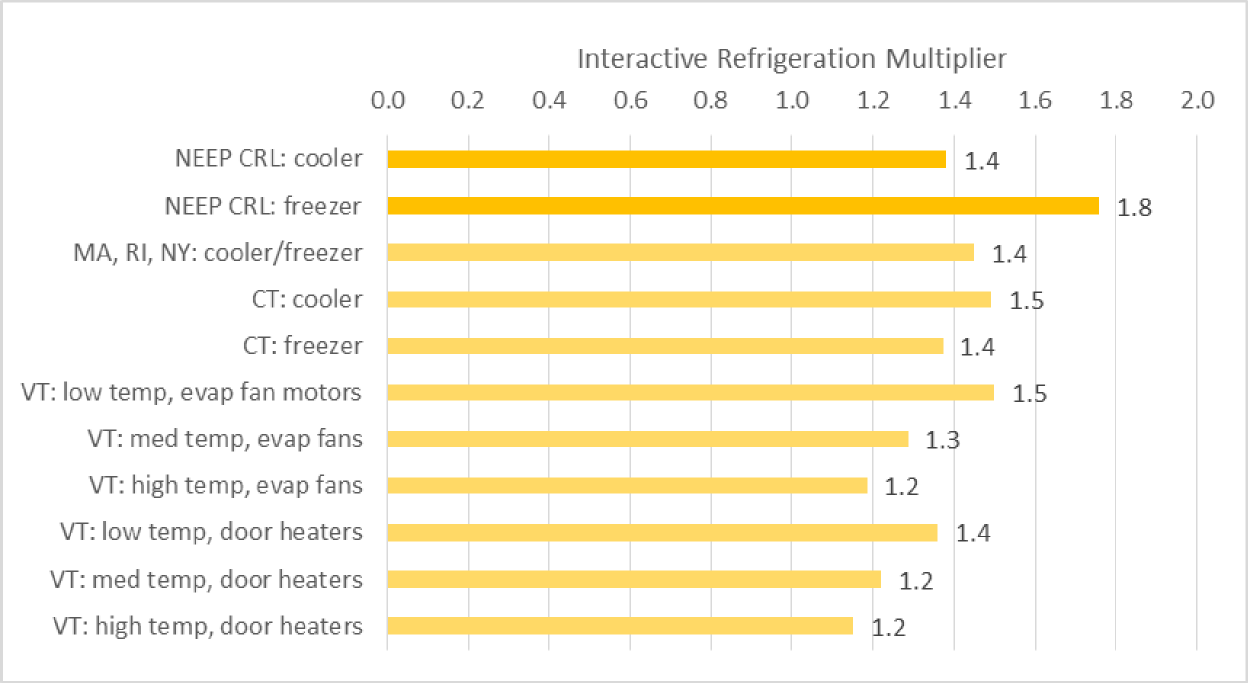
Interactive Refrigeration Savings

TRM Comparison



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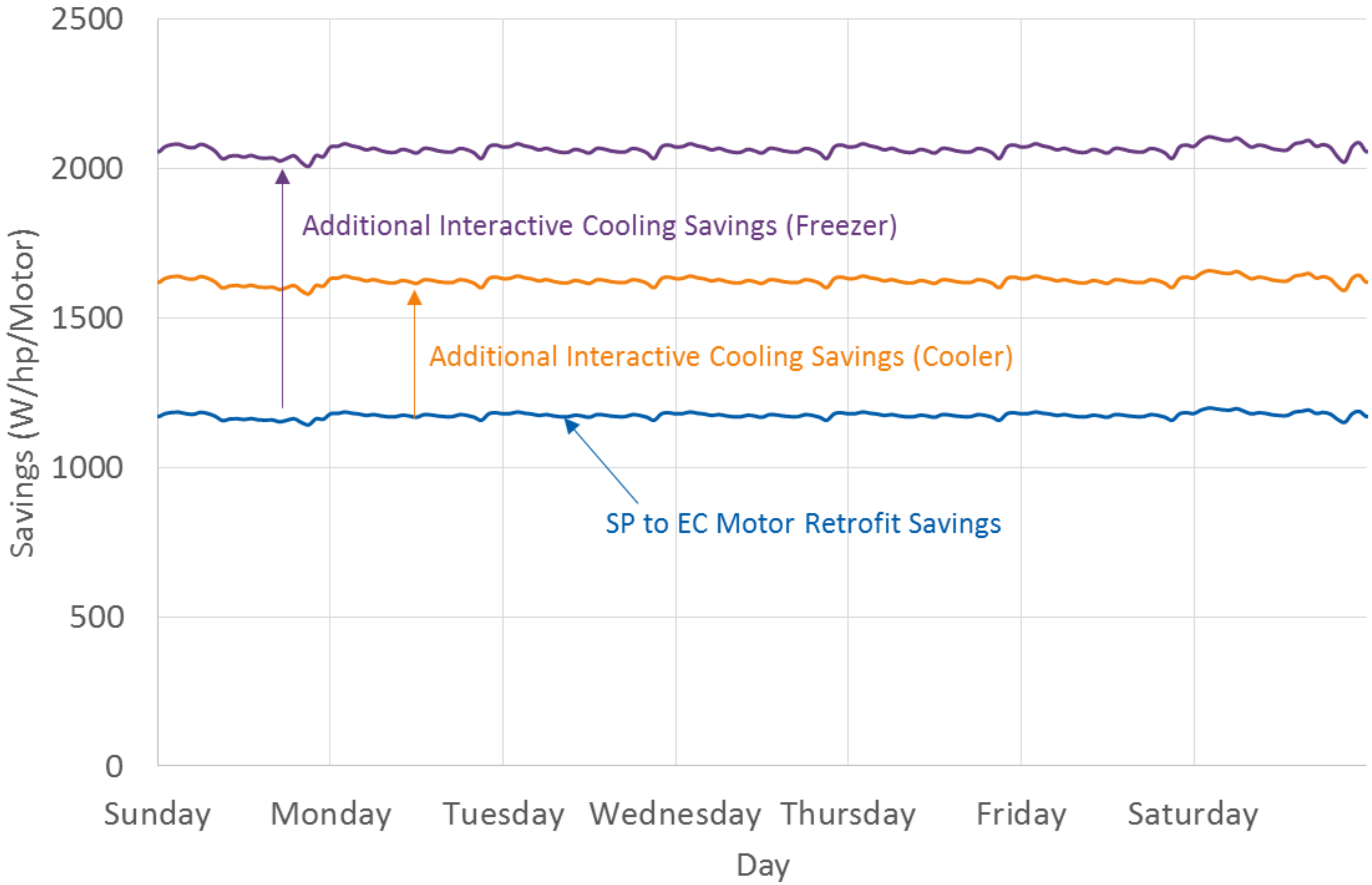
Note: Not all TRMs use each parameter; in some cases, we use TRM information to calculate parameters for comparison

Evaporator Fan Motor Retrofit
Total Savings Loadshape (1 week)



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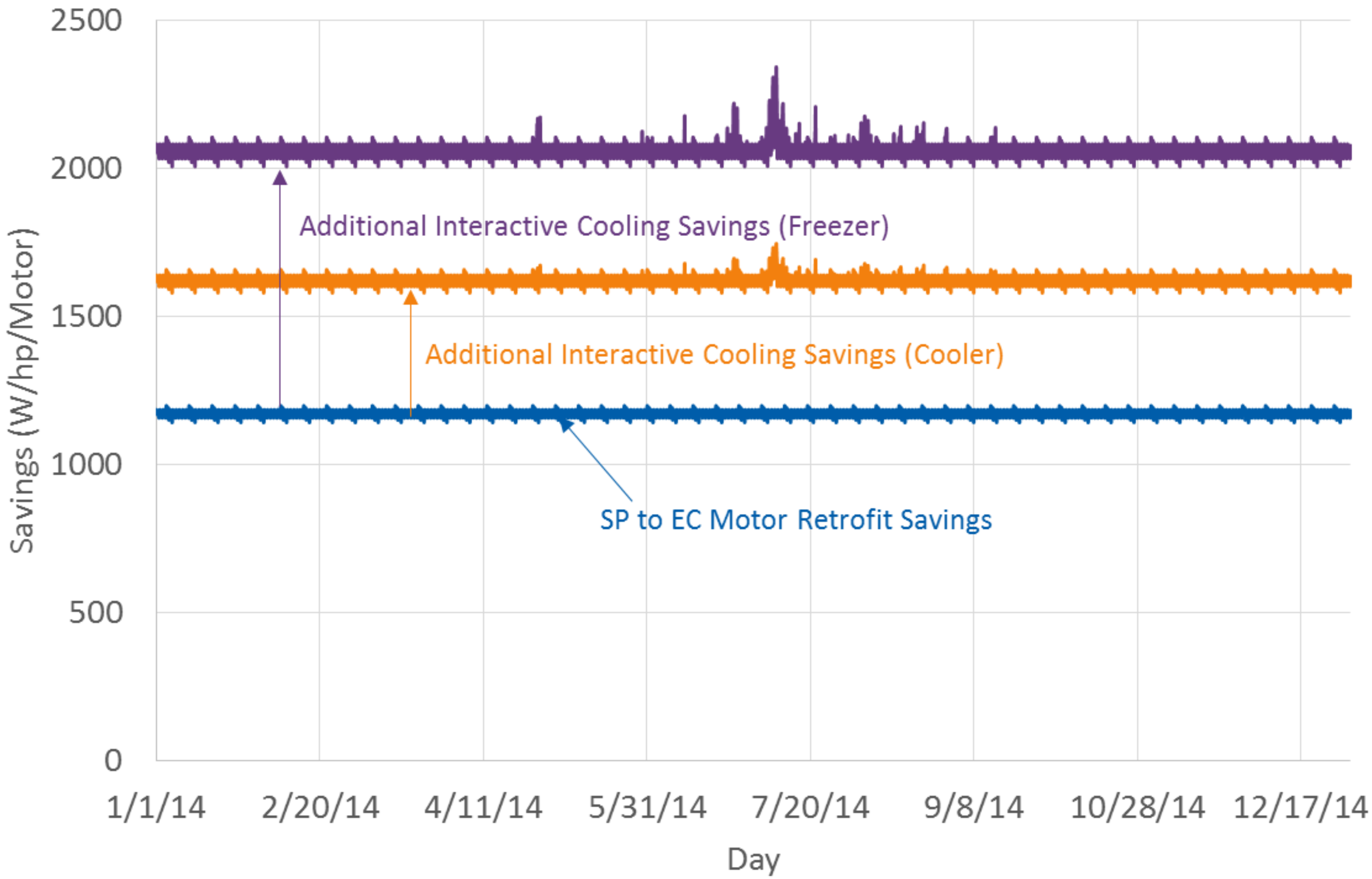
*Results shown incorporate weather data from Boston, MA

Evaporator Fan Motor Retrofit
Total Savings Loadshape (1 year)



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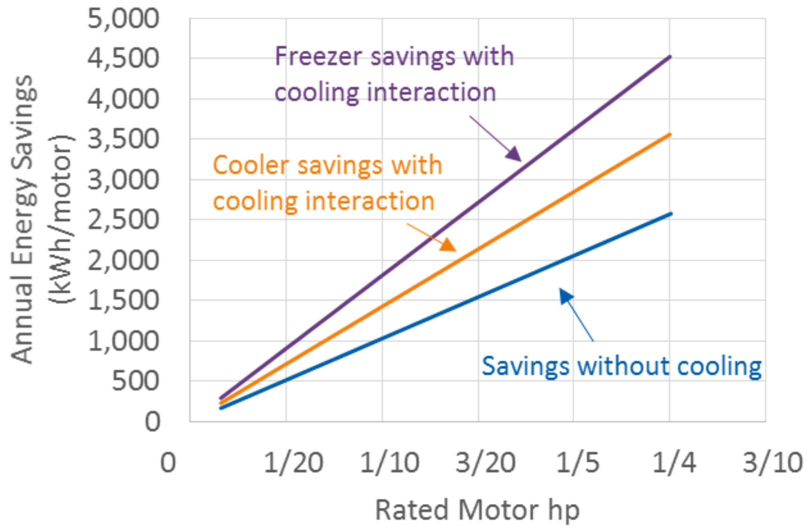
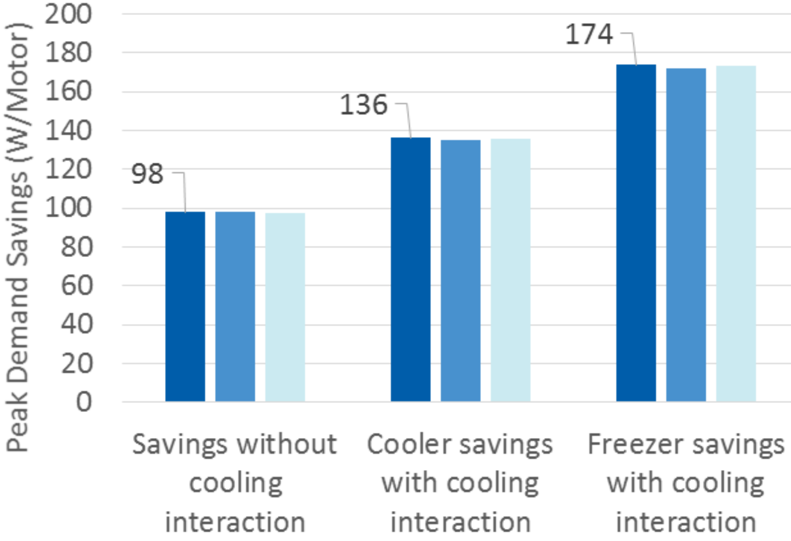
*Results shown incorporate weather data from Boston, MA

Evaporator Fan Motor Retrofit
Total Savings Metrics

Annual Energy Savings



Peak Demand Savings (at hp = 1/12 hp)



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Note: This example is based on SP motor baseline and Boston, MA weather data.

Summary of Findings

- All three measures provide reliable energy and demand savings
- Easy to install and unobtrusive
- Appropriate for large and small commercial refrigeration

Summary of Findings

- Evaporator Fan Motor Retrofits
  - Almost all baseline motors observed were shaded pole. PAs that use a blended SP/PSC baseline should consider using SP only.
  - These measures operate continuously and are good for peak kW savings
- Evaporator Fan Controls
  - Almost all baseline motors observed were shaded pole. PAs that use a blended SP/PSC baseline should consider using SP only.
  - At two sites, controls were disconnected by the customer
  - When it works, these measures operate continuously and are good for peak kW savings
- Door Heater Controls
  - Large variation and small sample sizes makes it difficult to draw conclusions, HOWEVER…
  - Two types of door heater controls perform differently
  - Three sites exhibited no savings despite installed controls
  - When it works, this measure operates continuously and is good for peak kW savings

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Summary of Savings

Parameter	EF Motor Retrofit	EF Motor Controls	Door Heater Controls
Reduction Factor	61% (power)	34% (runtime)	55% (runtime)
Annual Energy Savings (no RIE)	857 kWh/motor[1]	147 kWh/motor[2]	515 kWh/door[3]
Annual Energy Savings (w/RIE)[4]	1,186 kWh/motor[1]	204 kWh/motor[2]	713 kWh/door[3]
Peak Demand Savings (no RIE)[5]	98 W/motor[1]	14 W/motor[2]	57 W/door[3]
Peak Demand Savings (w/RIE)[4,5]	136 W/motor[1]	19 W/motor[2]	80 W/door[3]

[1]For average motor hp (1/12)
[2]EC savings for average EC motor hp (1/12), for all control types
[3]Average for all control types
[4]For a Cooler
[5]ISO-NE Summer

Next Steps

- Currently drafting report, complete by end of June
- Final report, data transfer, and loadshape tool to follow

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Questions

Contacts

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