RESIDENTIAL DEHUMIDIFICATION

Updating Savings Estimates, Program Opportunities and assessing load flexibility of residential dehumidifiers

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Background

- A majority of single family homes in Wisconsin run dehumidifiers, representing about 2% of the state's annual electric load
- Dehumidifier operation is concentrated in summer months corresponding to higher contributions to peak load
- What are the opportunities for dehumidifier efficiency programs and what flexibility is there to curtail dehumidifier operation during peak conditions?

Project Overview

- Phase 1: Energy efficiency and program potential
  - Evaluate energy efficiency potential of standalone dehumidifiers
  - Review existing programs & models
  - Develop program recommendations

- Phase 2: Evaluate load flexibility of residential dehumidifiers
  - Dehumidifiers operate indiscriminately during peak conditions
  - Document and evaluate current options for dehumidifier load control

Agenda

- Phase 1 (2020)
  - Brief overview
- Phase 2 (2021)
  - Objectives
  - Controls
  - Methodology
  - Results

Phase 1 Findings

- EnergySTAR 5 rated units provide payback in 4 years compared to most dehumidifiers manufactured before 2012 (~30% of total units)
- Removing older units from circulation is the key to savings
- No cost premium for new Energy Efficient models
- Dehumidifier recycling is cost-prohibitive unless paired with other appliance recycling program or bulk recycling efforts
  - Existing Fridge and Freezer recycling program ended
  - Opportunities remain with larger-scale organized efforts

Phase 1 Deliverables

- TRM workpapers for standalone dehumidifier applications
- Savings adjustments for potential study
- Dehumidification best practices guide

Phase 2: Dehumidifier Load Flexibility

Phase 2 Objectives

1. Demonstrate the ability of standalone dehumidifiers to provide load flexibility—either from a demand response signal or by scheduling off-peak operation.

2. Understand how controlling dehumidifier operations impacts dehumidification efficacy and indoor relative humidity levels.

Literature Review

- Technology has improved over recent years to allow real-time communication/control with household appliances
- Limited research on demand response beyond air conditioning units
- Scheduling is best if pre-programmed or controlled by utility
- No research has been found on effect of humidity/comfort

Controls

Chosen Controls

- **Smart Dehumidifier**

  Real-time control of dehumidifier through smart phone app

- **Smart Thermostat**

  Real-time control of dehumidifier through smart thermostat app but requires dehumidifier hard-wired to thermostat

- **Smart Plug**

  Scheduling (on/off) of existing dehumidifiers

Strategy	Description
Smart dehumidifier	Models equipped with connectivity and remote scheduling
Smart thermostat	DR signal communicated through a third-party smart humidistat
Timer	Controlled by plug-based mechanical or digital timer
Smart plug	Controlled via a connected smart plug
Custom controller	Custom hardware & software to enable arbitrary control

Site Overview

	Dehumidifier	Capacity (pints/day)	Setpoint (% RH)	Control Type	Occupancy	Air Conditioning
Site 1	Soleus Air	70	40	Smart Plug	4	Part time
Site 2	Honeywell	50	50	Smart Dehumidifier	2	Portable unit
Site 3	Emerson	50	50	Smart Dehumidifier	1	None
Site 4	GE	50	50	Smart Plug	2	Yes
Site 5	SantaFe	98	40	Smart Thermostat	4	Yes
Site 6	Pelonis	30	55	Smart Plug	2	Yes

Experimental Overview

Demand Response Events

Type	Name	Action	Start	End
1	Residential Peak	Turn off dehumidifier	3:00 PM	7:00 PM
1	Back-to-Back Peak	Turn off dehumidifier	3:00 PM	7:00 PM
2	Pre-Dry	Adjust setpoint down	2:00 PM	3:00 PM
		Adjust setpoint up	3:00 PM	7:00 PM

Experimental Summary

Sites	Days	Events	Inside RH (%)	Outside W (%)
6	268	55	48	0.009

	Regular	B2B	Pre-Dry
Event	31	18	6
Sites	6	5	2

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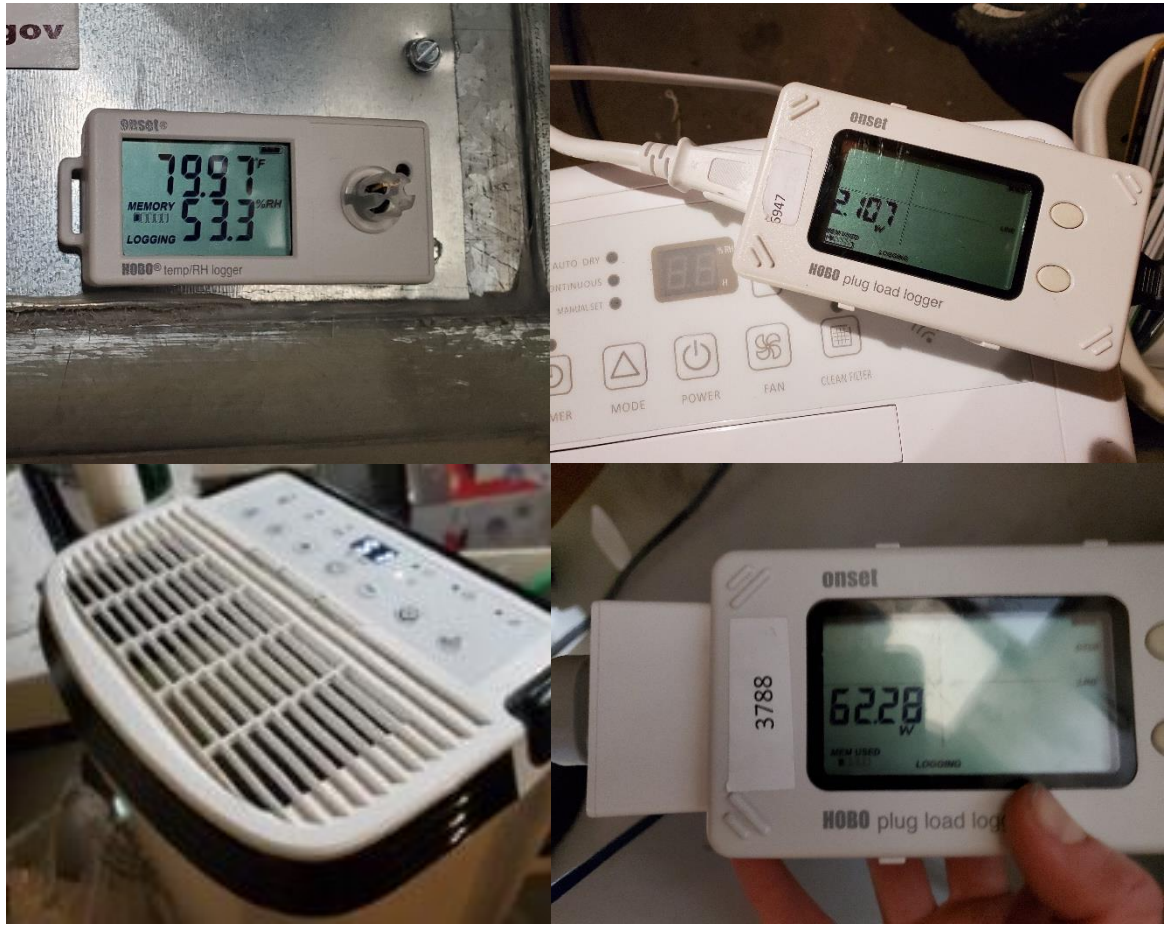
Instrumentation

- **Relative Humidity (%)**
  Thermostat and dehumidifier space
- **Temperature (°F)**
  Thermostat and dehumidifier space
- **Power (W)**
  Dehumidifier



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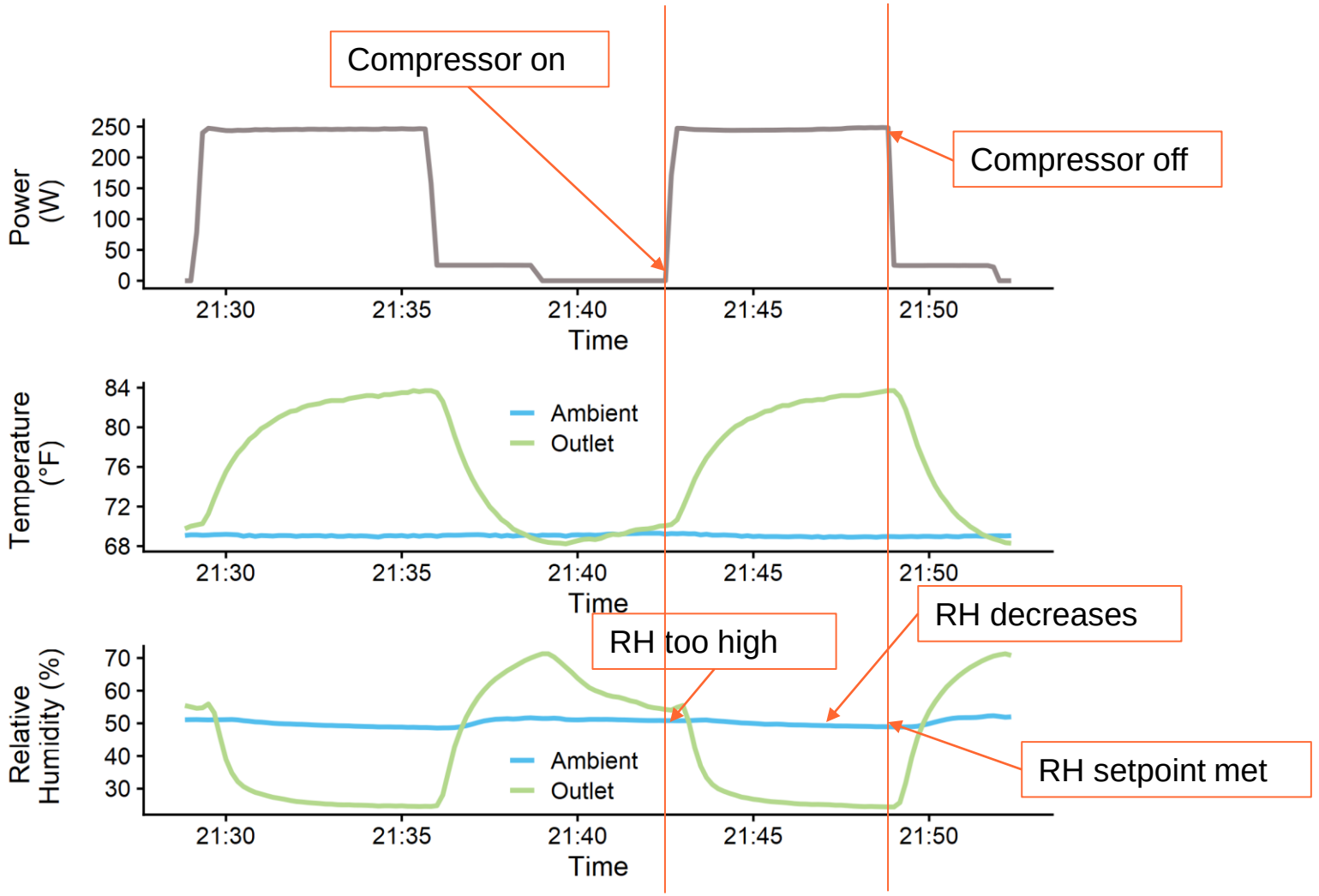
Typical Dehumidification Cycle

- Compressor turns on when RH % is too high
- RH % decreases as dehumidifier runs
- Compressor turns off when RH % setpoint is met



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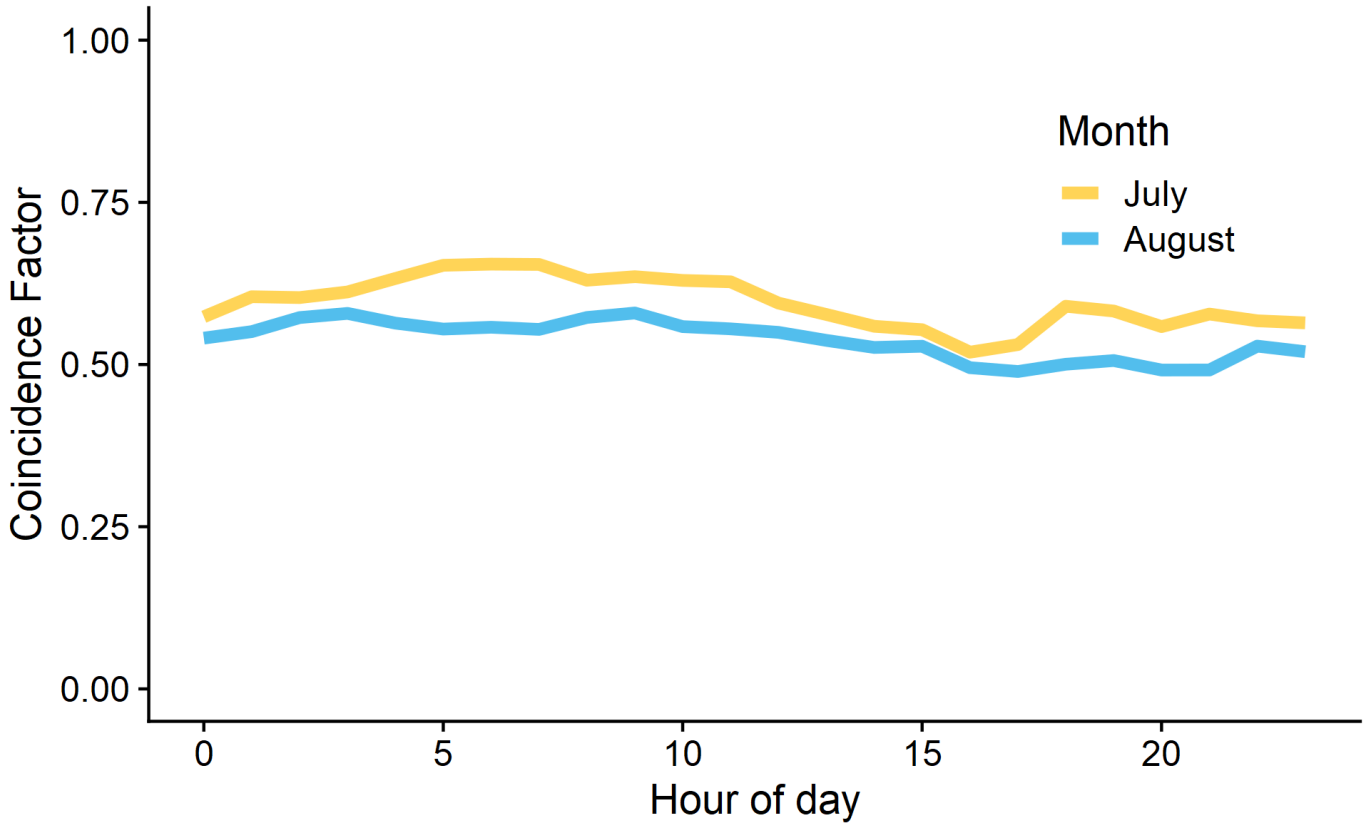
Baseline Dehumidifier Load Profile

- Units (6) run 49% to 65% of capacity in peak months
- Higher dehumidifier loads in July than August
- Units have significant spare capacity in current applications



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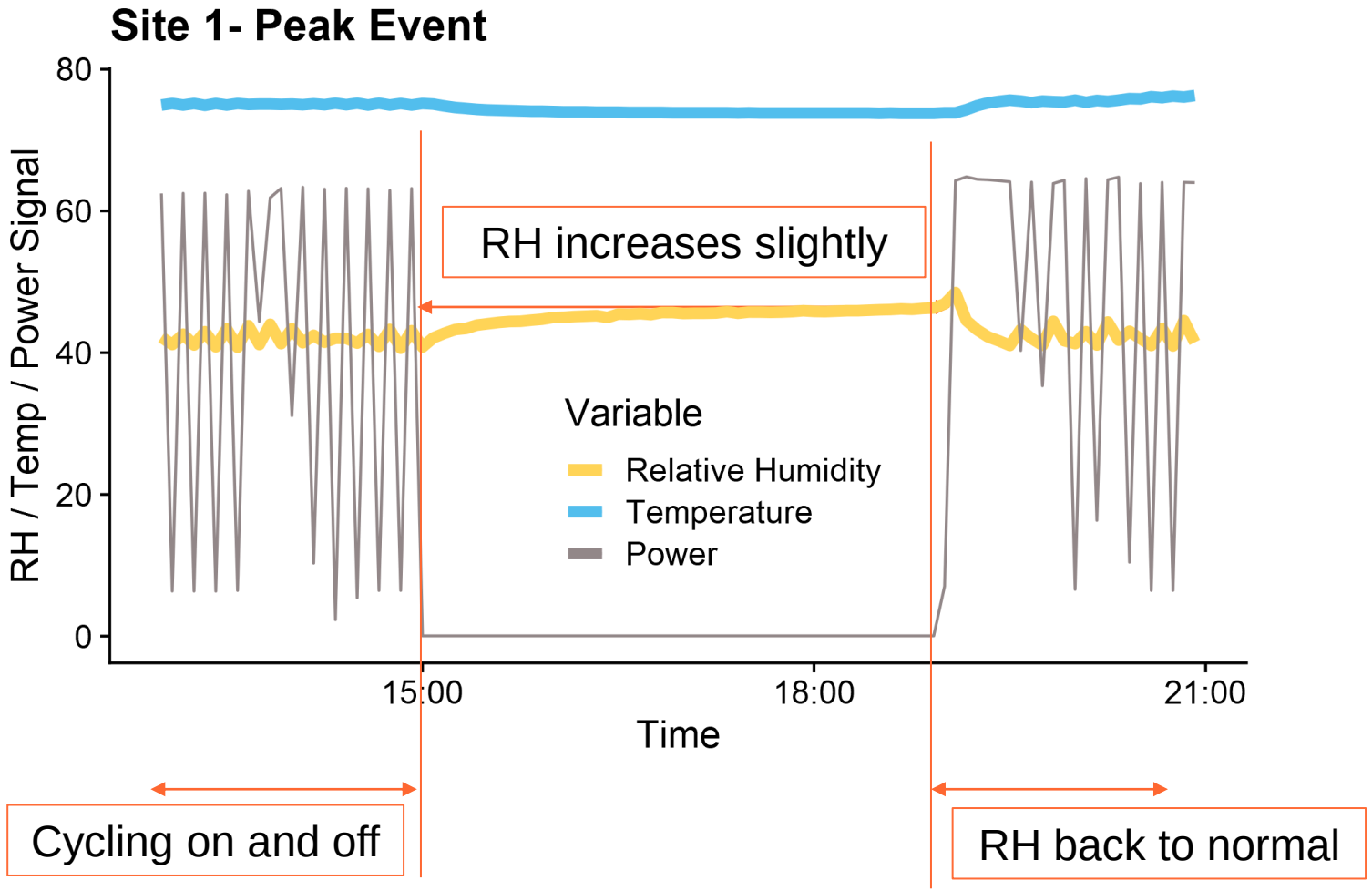
Demand Response Event Type 1

- Dehumidifier remotely turned off from 3 pm to 7 pm
- Replicates typical summer residential peak load
- ~4% increase in RH over event, ~ 1 hour recovery



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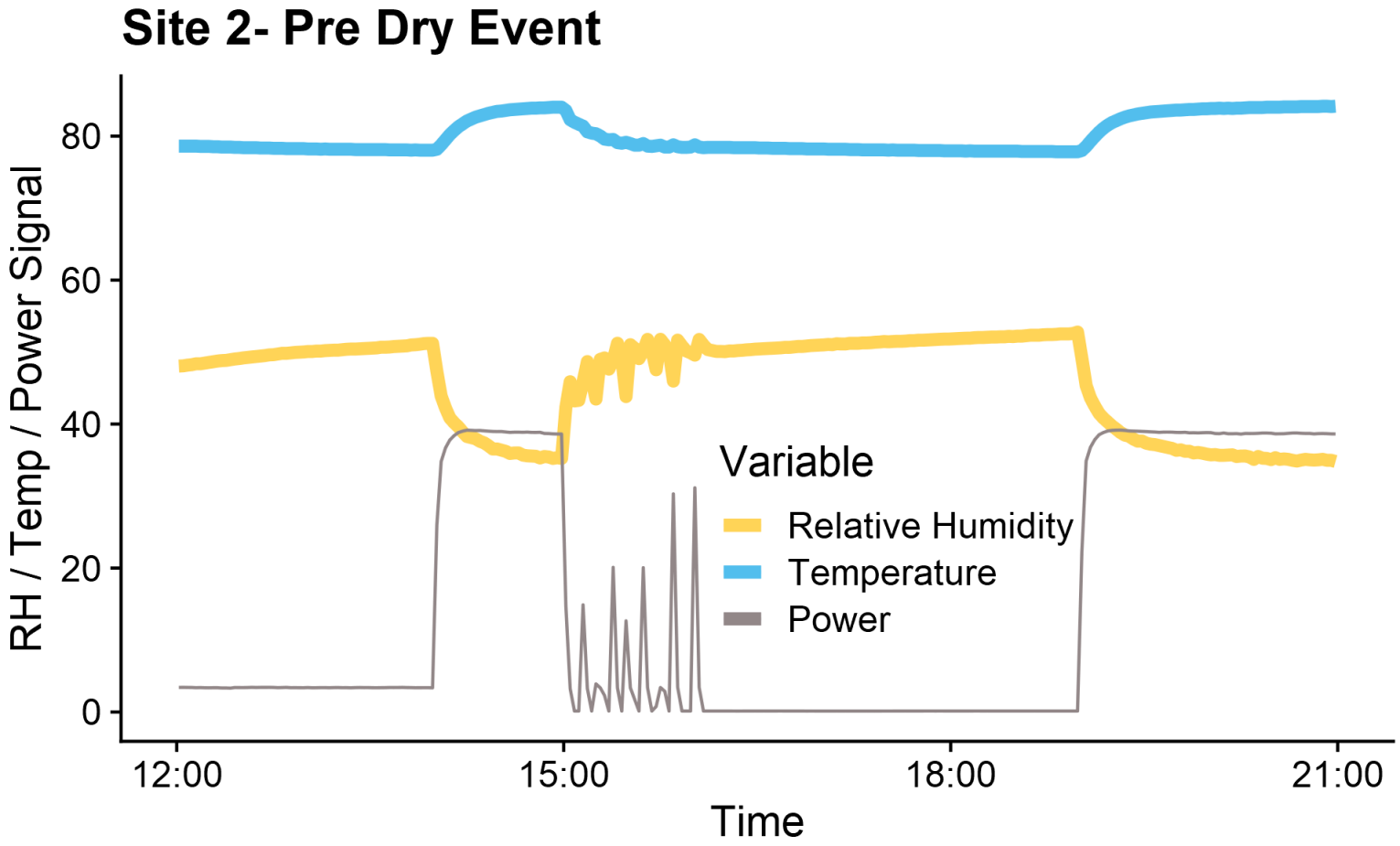
Demand Response Event Type 2

Pre-Dry Event

- Set RH = 40% from 2 - 3 pm
  Unit runs to pre-dry space
- Set RH = 60% from 3 - 7 pm
  Unit runs at low capacity and then coasts
- Set RH = 50% at 7 pm
  Unit runs to return to baseline humidity



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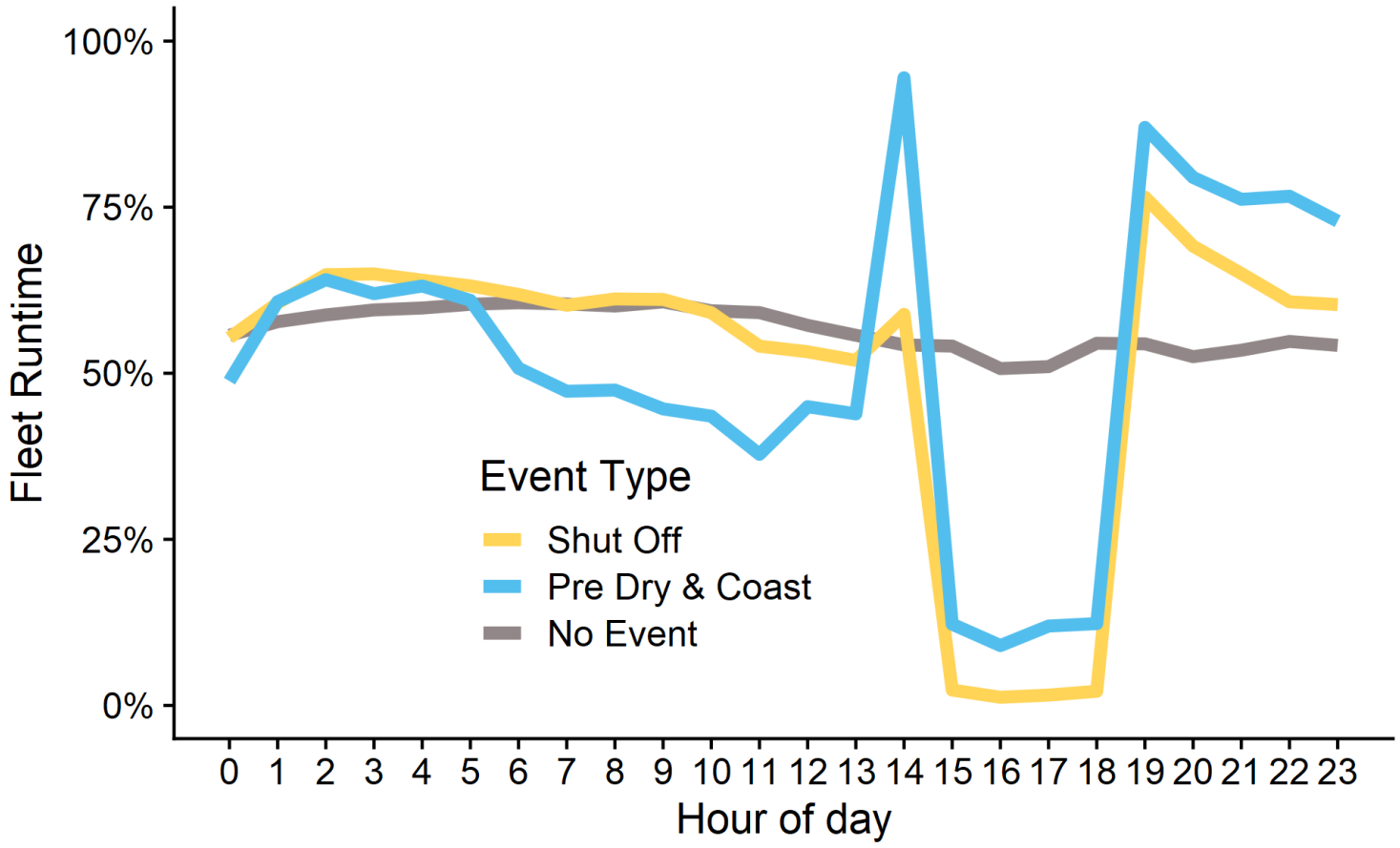
Demand Response Final Results

- Regular operation (grey)
  Average of July and August
- Event Type 1 (yellow)
  59 events drop average unit power to less than 1%
- Event Type 2 (blue)
  6 events successfully drop average unit power to ~12%
- Both event types have a recovery of 12% - 27% higher than average through the end of day



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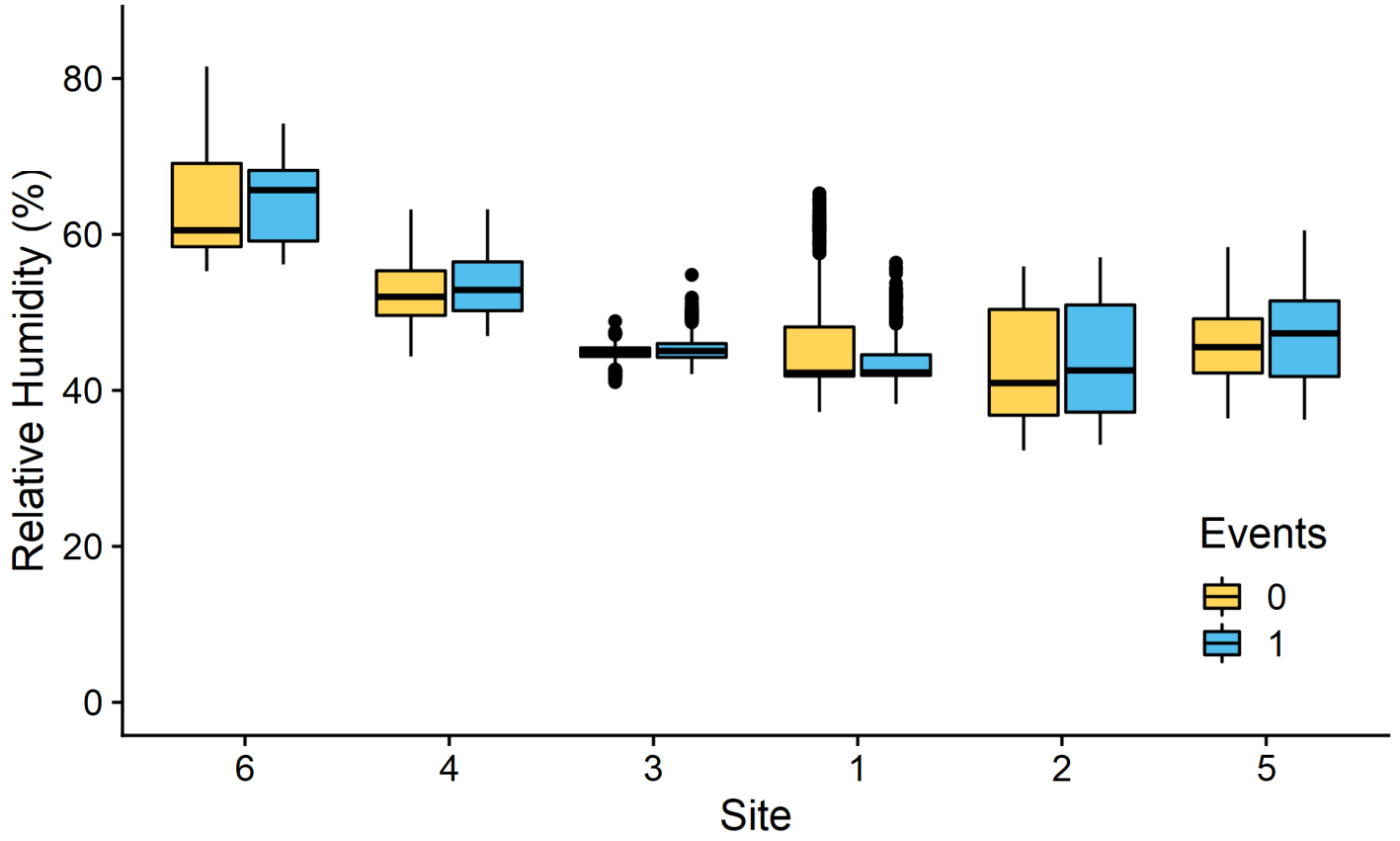
Indoor Comfort Outcome

- Unit operation consistent with prior monitoring
- No significant daily relative humidity increase
- Relatively quick (<4 hours) setpoint recovery



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Phase 2 Conclusions

- Dehumidifiers are flexible over typical peak load periods
  - Impacts to relative humidity are small
  - Relative humidity setpoints recover within a few hours
  - Smart thermostat apps, smart dehumidifier apps, and plug load control apps proved very reliable

- Suitability of these controls for peak load programs is mixed
  - Plug load and timer-based controls lack verification ability
  - Smart dehumidifier and smart thermostat controls may be low-effort additions to existing smart thermostat peak control programs
    - Units controlled by smart thermostats can be readily integrated into those platforms
    - Some smart dehumidifiers share a platform with smart thermostats (e.g. Honeywell)

THANK *you*

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