Residential DR: AC Direct Load Control vs Smart Thermostats

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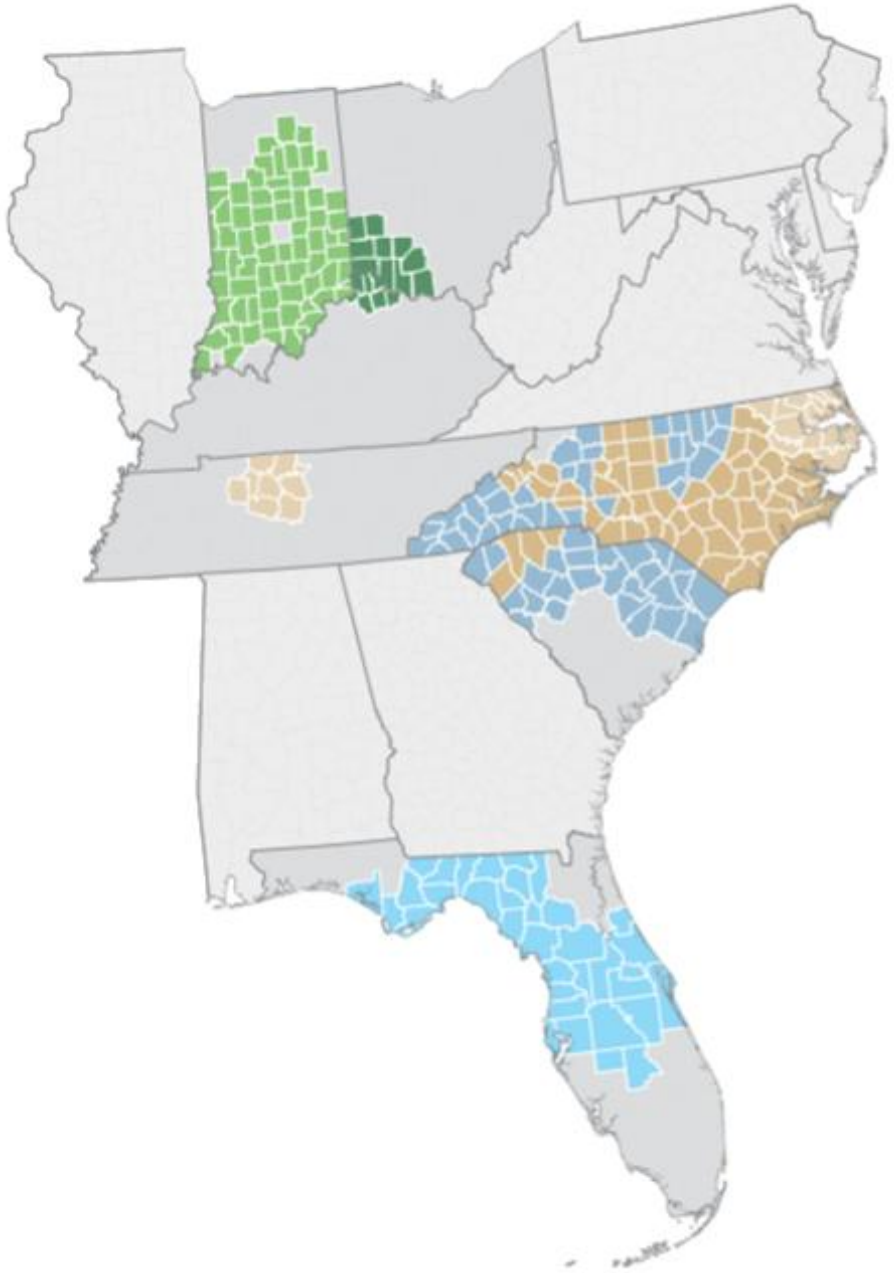
Agenda

- DR Program Overview
- Load Impact Comparison
- Opt-Out Trends
- Customer Experience
- Technology Comparison

Duke Energy – Demand Response



Less Electric Load on the Grid

Over 288,000 customers in the Carolinas are helping reduce electric load a few key days each year.

Good for the Environment

This helps preserve natural resources and delays the need for new power plants and transmission lines.

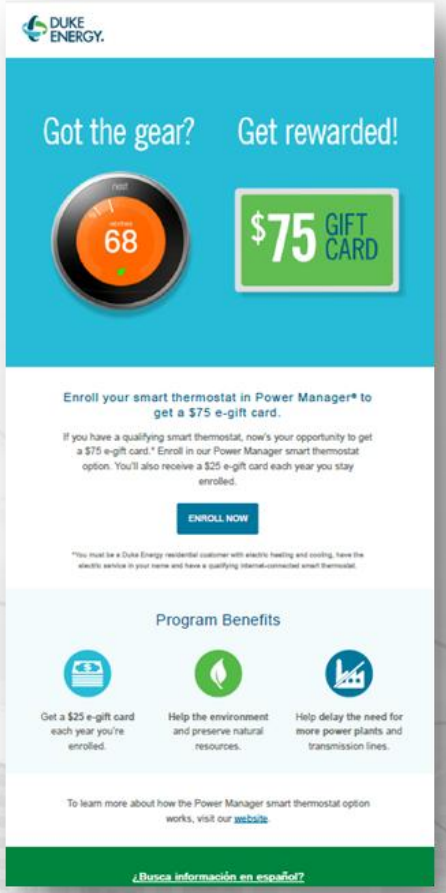
Greater Energy Savings

Participants help keep energy costs low for themselves and other customers across the region.

Enrollment Option	Participation Rewards	Customers
Smart Thermostat (Heat + Cool)	$75 initial, $25 annually	85,000
AC Control Switch	$25-$32 annually	930,000
Heat Strip Control Switch	$24-$25 annually	400,000

Demand Response Offerings

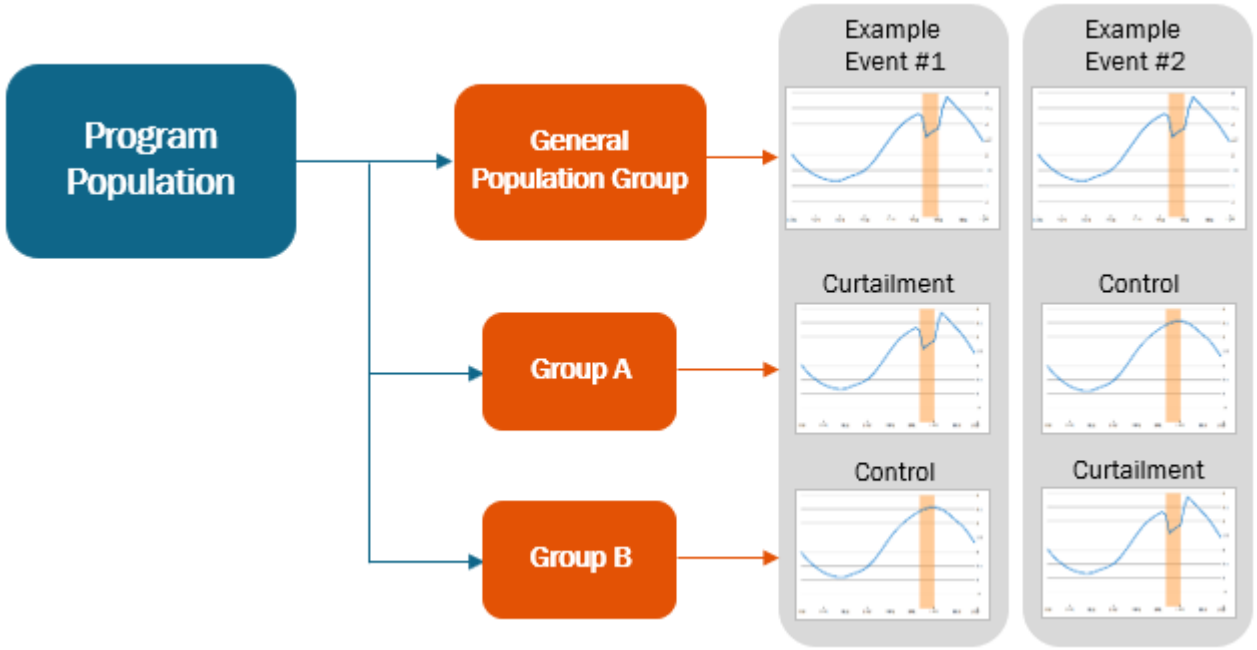
	Switches	Thermostats
Location	• Air Conditioning: FL, NC, SC, IN, KY • Heat Strips: FL, NC, SC	• Air Conditioning: NC, SC, IN • Heat Pump w/electric aux: NC, SC
Operation	• Switch disconnects compressor and may disconnect fan load. Fully disconnects the auxiliary heat strip	• Standard temperature offsets and preconditioning
Customer Experience	• 89% owner • Less digitally active • 28% have called us • 14 years as a customer • Move-in-move-out process • No need to accept new technology	• 87% owner • More digitally active • Only 19% have called • 7 years as a customer • App and web based • One touch enrollment



Load Impact Evaluation

Randomized Controlled Trial (RCT)

RCT Design



Population Size

Group	AC Switch Households	Smart Thermostat Households
Group A	5,000	5,000
Group B	5,000	5,000
General Population	230,000	20,000

PLMA™
Load Management Leadership

Load Impact Comparison

Event dispatch options

AC Switches

- Cycling options
  - 50%, 64%, 100%

Smart Thermostats

- ↓ Precooling options
  - None, 60 min 1°F, 90 min 2°F
- ↑ Event period offsets
  - 3°F, 4°F

Direct comparison via overlapping events

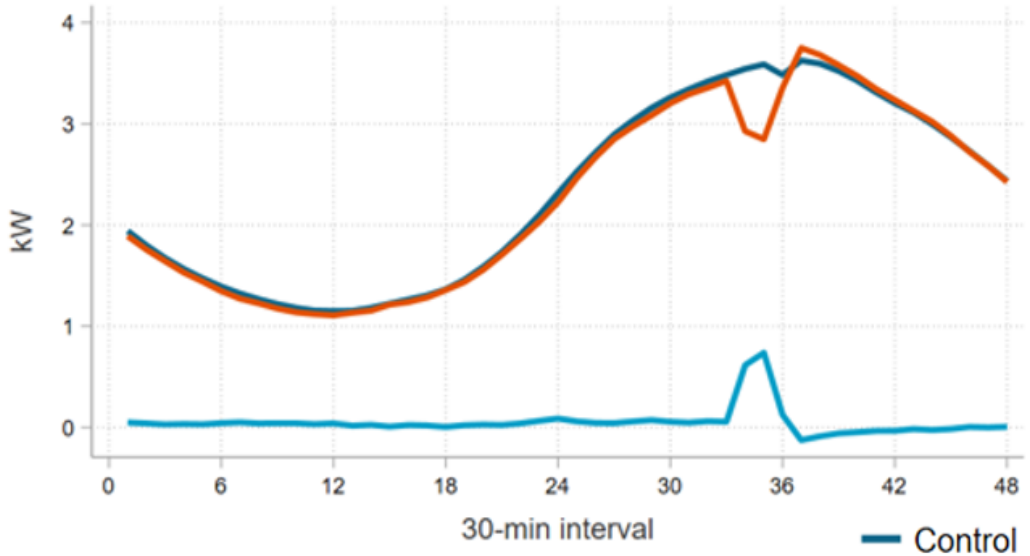
	AC Switch			Smart Thermostats				
Event Date	Start Time	End Time	Event Type	Start Time	End Time	Pre-Cool	Offset	System Temp.
8/11/2021	4:00 PM	4:28 PM	Full shed	3:55 PM	5:00 PM	90 min 2°F	4°F	89°F
	4:00 PM	4:28 PM	64%					
8/12/2021	4:00 PM	4:28 PM	Full shed	3:55 PM	5:00 PM	90 min 2°F	4°F	91°F
8/13/2021	3:55 PM	5:00 PM	64%	3:55 PM	5:00 PM	60 min 1°F	3°F	94°F
8/23/2021	4:00 PM	4:28 PM	Full shed	3:55 PM	5:00 PM	90 min 2°F	4°F	91°F
8/30/2021	2:55 PM	5:00 PM	64%	3:55 PM	5:00 PM	90 min 2°F	3°F	92°F
	3:55 PM	6:00 PM	64%					

Load Impact Comparison

- 3° Thermostat setback impacts 2x larger than 64% AC Cycling
- Exact event location and time-period overlap- 1 hour

AC Switch

Event Date	8/13/2021
Start Time	3:55 PM
End Time	5:00 PM
Event Strategy	64% cycling
System Temperature	94°F
Event Impact	0.67 kW



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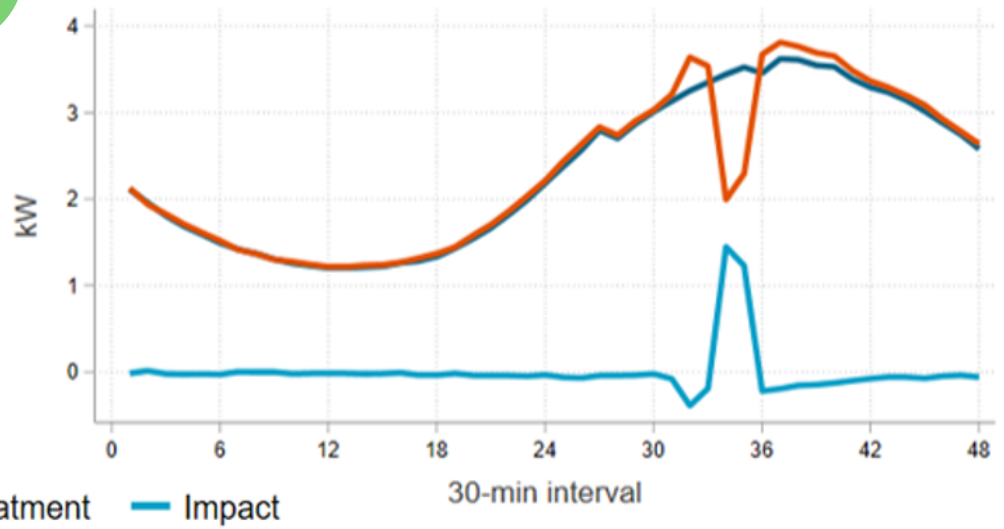
Smart Thermostat

Event Date	8/13/2021
Start Time	3:55 PM
End Time	5:00 PM
Pre-cool	1°F for 60 mins
Offset	3°F
System Temperature	94°F
Event Impact	1.34 kW



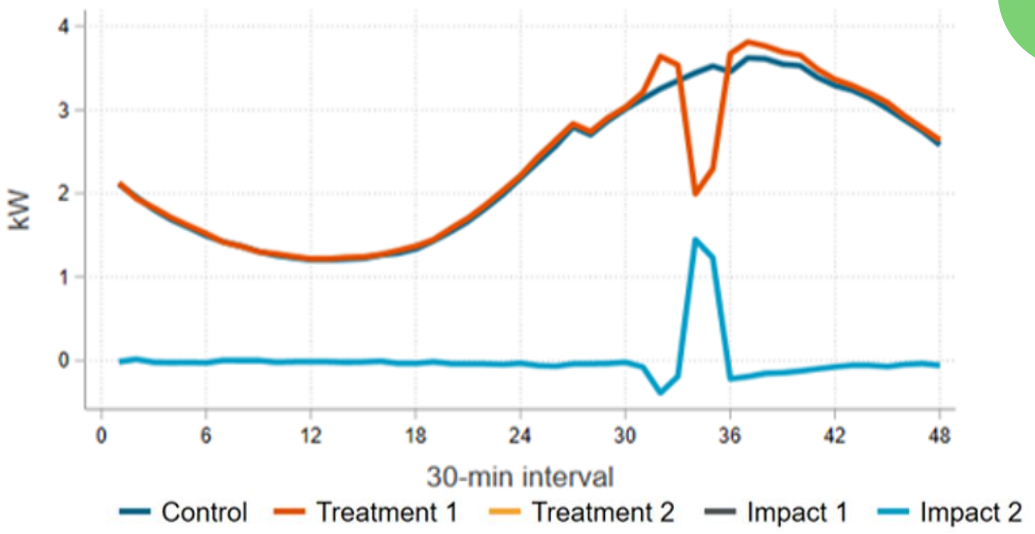
Control Treatment Impact

Load Impact Comparison

- 4° Thermostat setback impacts larger than 3° Thermostat setback even under cooler temperatures

Smart Thermostat - 3° Offset

Event Date	8/13/2021
Start Time	3:55 PM
End Time	5:00 PM
Pre-cool	1°F for 60 mins
Offset	3°F
System Temperature	94°F
Event Impact	1.34 kW



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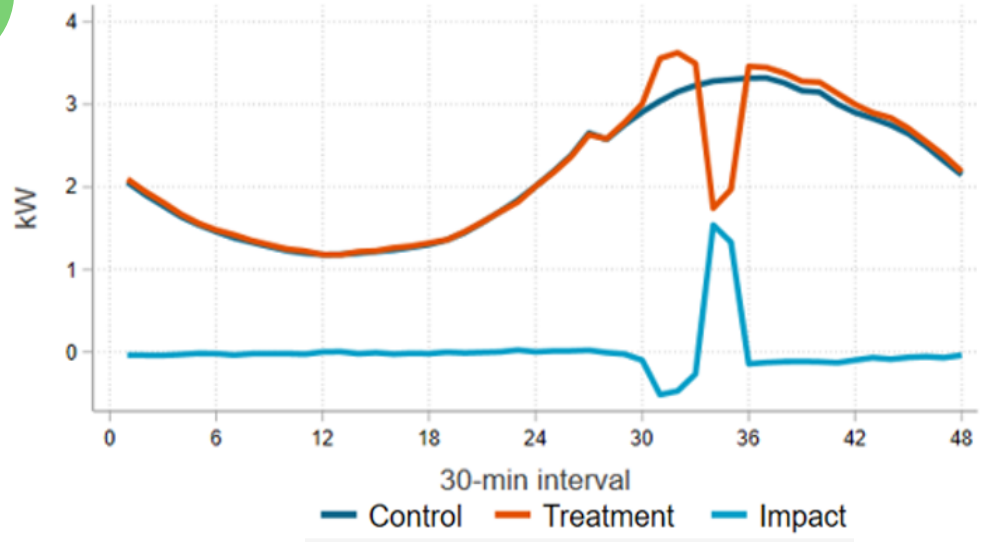
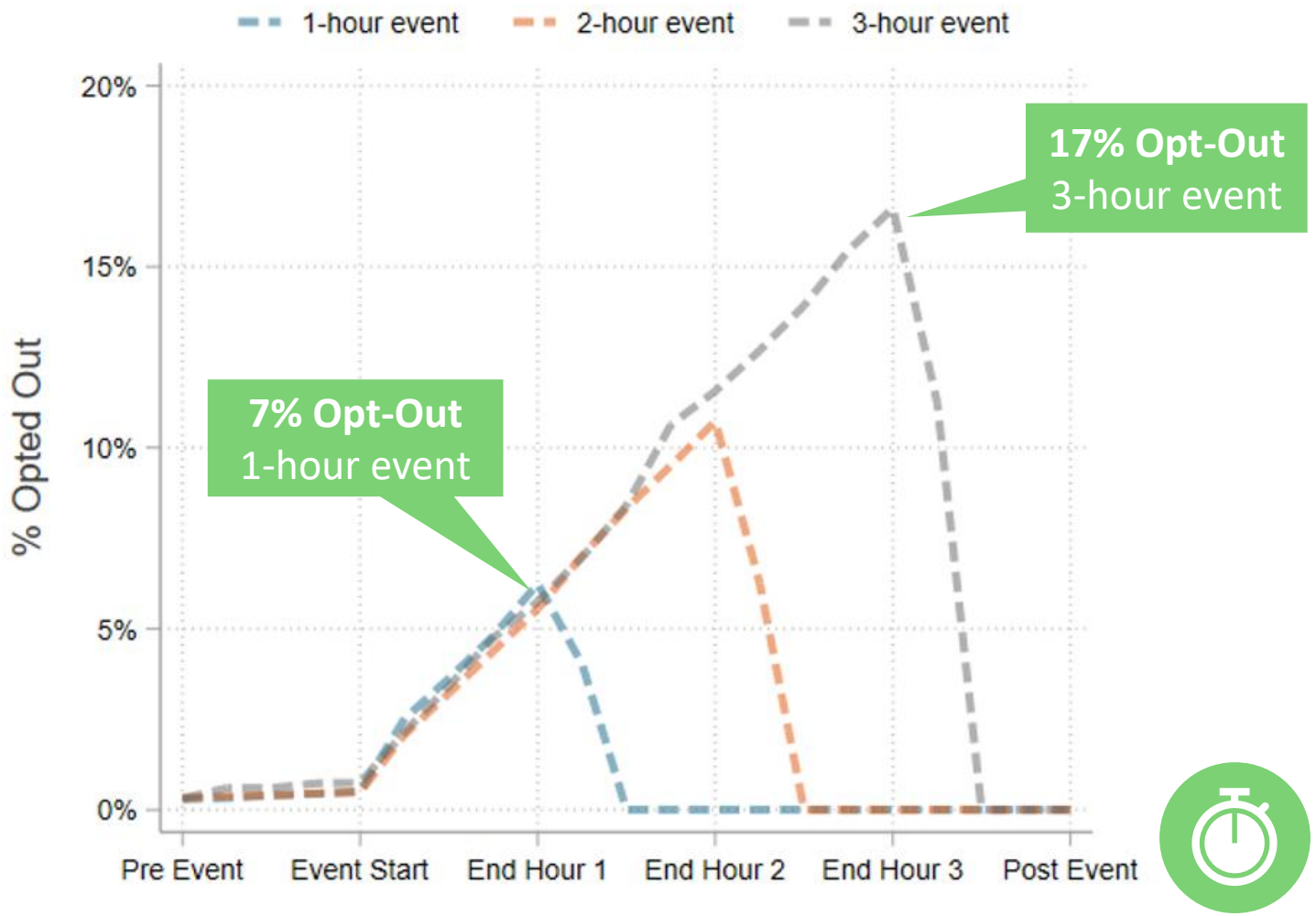
Smart Thermostat - 4° Offset

Event Date	8/11/2021
Start Time	3:55 PM
End Time	5:00 PM
Pre-cool	2°F for 90 mins
Offset	4°F
System Temperature	89°F
Event Impact	1.43 kW



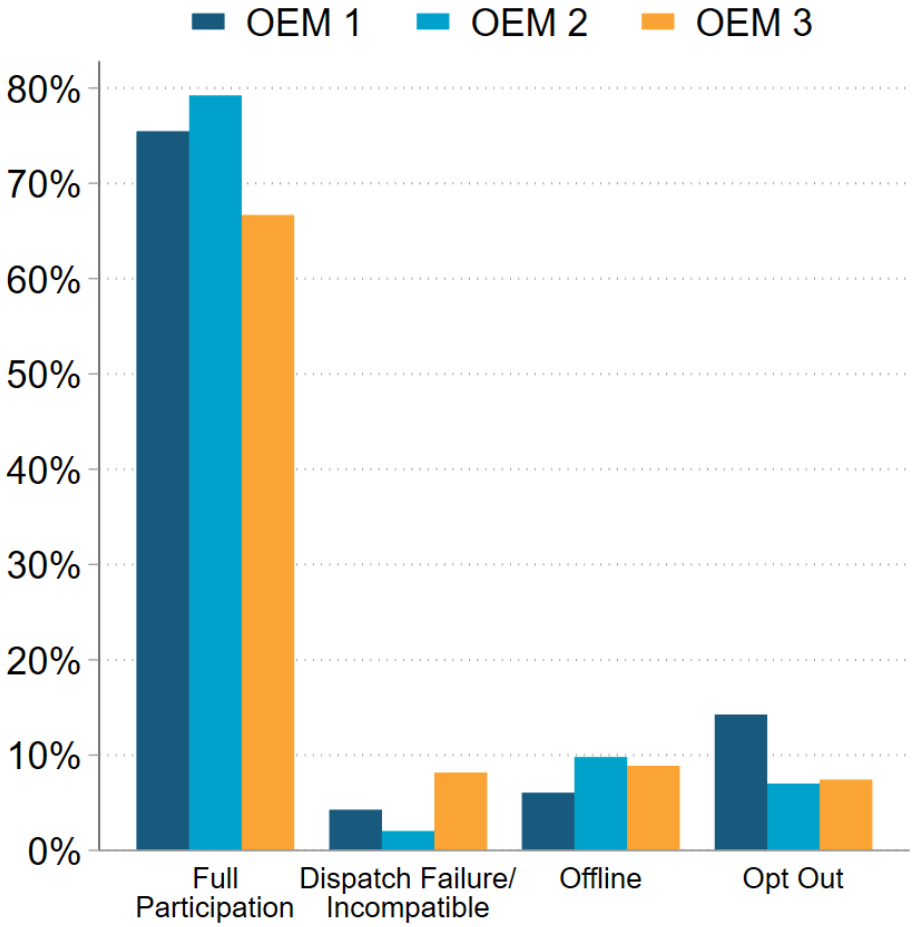
Smart Thermostat: Opt-out Trends

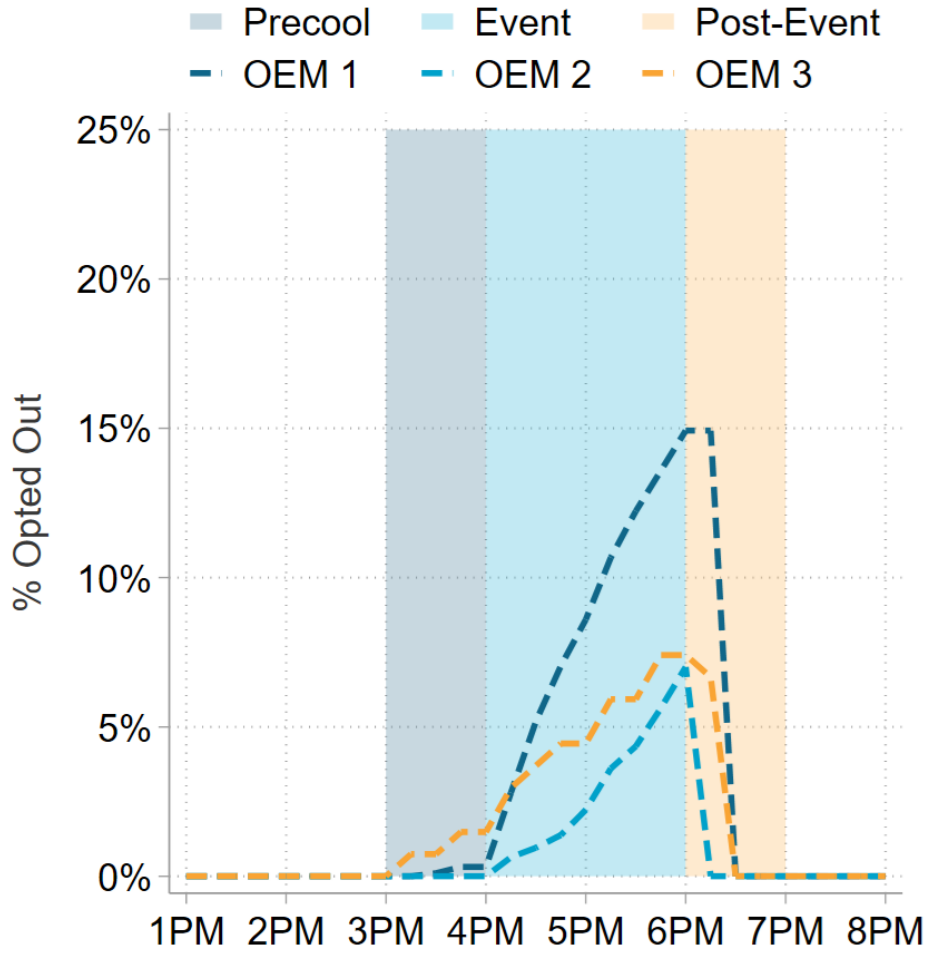
- Opt-outs increase with event duration



Opt-outs aren't the full story

- Dispatch failure and offline thermostats also reduce participation
- OEM 1 had highest optout rate, but only slightly lower *Full Participation* levels





Customer Experience

- 2021 – First opportunity to survey both AC Switch and Smart Thermostat participants
  - Phone and web launch in the evening after a Power Manager event concluded
- Surveys touched on:
  - Thermal comfort
  - Event awareness
  - Actions taken if aware
  - Program satisfaction drivers
- Ran identical surveys on an event day and a hot non-event day
  - Thermal comfort, for example, may be no different on a hot non-event day than an event day

Customer Experience

- Smart thermostats: More survey reports of thermal discomfort than AC Switch
- Neither Smart thermostat nor AC switch respondents show a measurable uplift in thermal discomfort due to an actual event

"Was there anytime [on X day] when the temperature in your home was uncomfortable?"
% of Respondents Answering "Yes"

Year	Research Group	AC Switch	Smart Thermostats
2016	Event (n = 95)	12%	
	Non-Event (n = 89)	13%	
2019	Event (n = 73)	18%	
	Non-Event (n = 72)	18%	
2021	Event (n ACS = 37; n ST = 82)	9%	18%
	Non-Event (n ASC = 68, n ST = 81)	15%	27%

Customer Experience

- Smart thermostat participants are more likely to report perceiving an event after a hot day (actual event or not) than AC Switch participants.
  - Likely tied to information available on the app and on the thermostat
  - Survey day events were similar for AC switch and smart thermostats (duration and start time)
- Nearly all AC Switch and Smart Thermostat respondents report that enrolling is easy (93% and 94%)
- 79% of both Smart Thermostat and AC Switch respondents would recommend program
- Lowest agreement (44% and 51%) that Duke Energy communicates on program enough… fine line to walk, though!

Technology Comparison

AC Direct Load Control

PROS

- ▲Device stays at location
- ▲No opt-out (pro for load drop, not for customer control)
- ▲No adoption of new technology
- ▲Winter/Summer now on 1 device

CONS

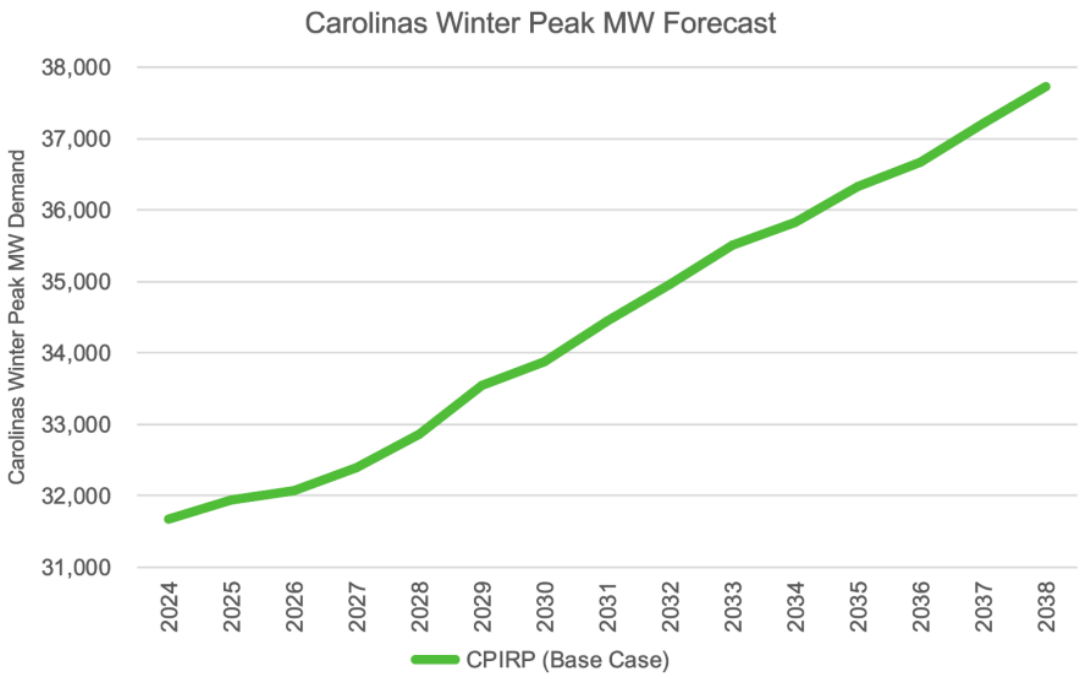
- ▼Costs! Switch, Network, Install
- ▼Maintenance
- ▼Large population of 1-way devices
- ▼Compatibility

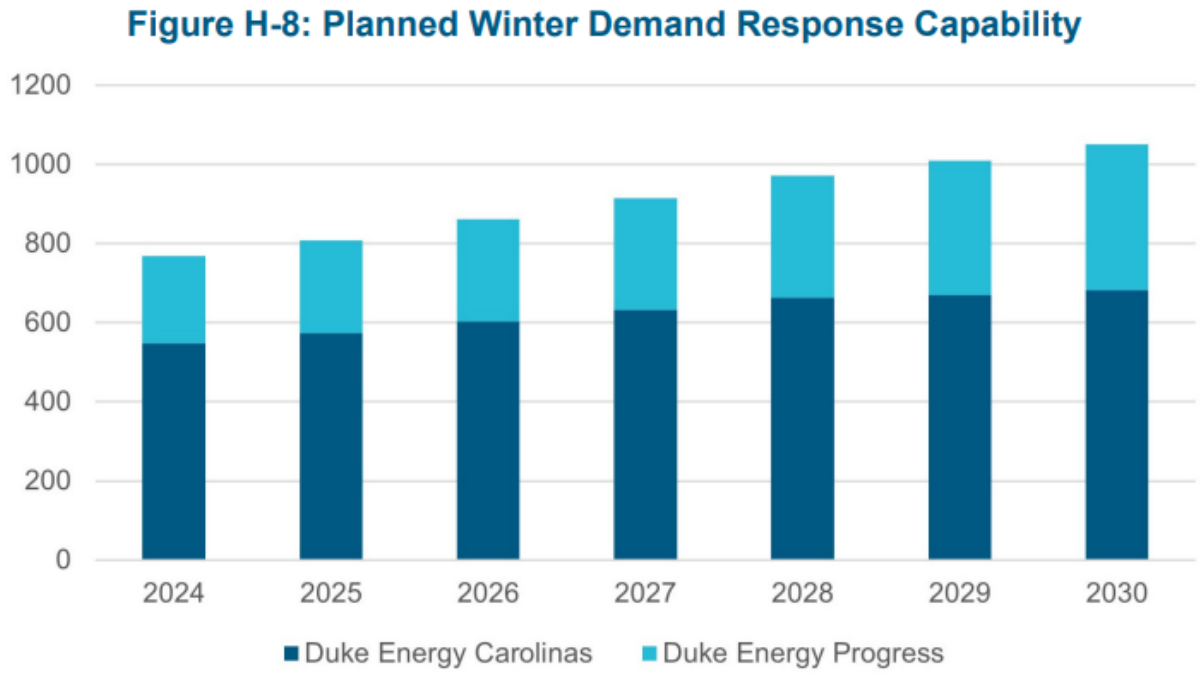
Smart Thermostats

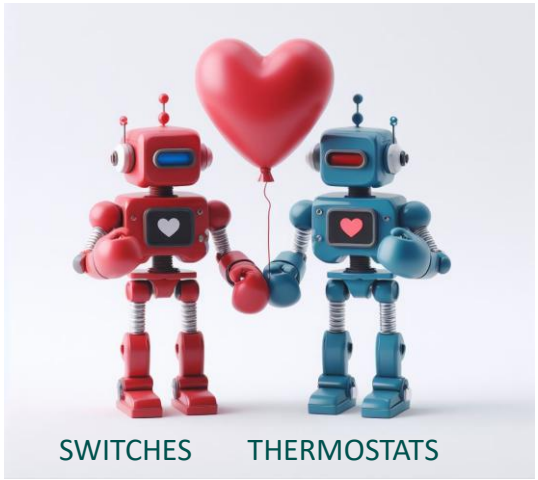
- ▲Customer control of comfort
- ▲Precooling/Preheating
- ▲Faster enrollment
- ▲Performance analysis
- ▲Winter/Summer on 1 device

- ▼Unknowns and differences by manufacturer
- ▼Shorter load drop period
- ▼Attrition due to customers moving
- ▼Compatibility

What is the future?







Q&A

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