



*Better Buildings Residential Network
Peer Exchange Call Series*

*Water Heaters that Shift Load, Combine with Heat Pumps,
and More*

November 14, 2024

Agenda and Ground Rules

- Moderator
 - **Jonathan Cohen**, Better Buildings Residential Network
- Agenda Review and Ground Rules
- Residential Network Overview and Upcoming Call Schedule
- Opening Poll
- Featured Speakers
 - **Samuel Rosenberg**, Pacific Northwest National Laboratory (PNNL)
 - **Eric Olson**, Northwest Energy Efficiency Alliance (NEEA)
 - **Chris Granda**, Energy Solutions
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media, social media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- One-on-One brainstorming conversations

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming Calls (2nd & 4th Thursdays):

- *12/12/2024: New DOE Tools to Help Qualify for Thousands in Tax Credits from the Inflation Reduction Act*
- *1/9/2025: Known Unknowns: Key Energy Efficiency Trends in the New Year*

Peer Exchange Call summaries are posted on the Better Buildings [website](#) a few weeks after the call



Samuel Rosenberg
PNNL

Load Flexibility with Heat Pumps in Rural Cold Climates

November 14th, 2024

Samuel Rosenberg

Data Scientist, Building Scientist

PNNL is operated by Battelle for the U.S. Department of Energy



Project Team



Sam Rosenberg, PNNL



Chitra Nambiar, PNNL



Alex Vlachokostas, PNNL



Abinesh Selvacanabady, PNNL



Cheryn Metzger, PNNL



Alexander Rees, US DOE

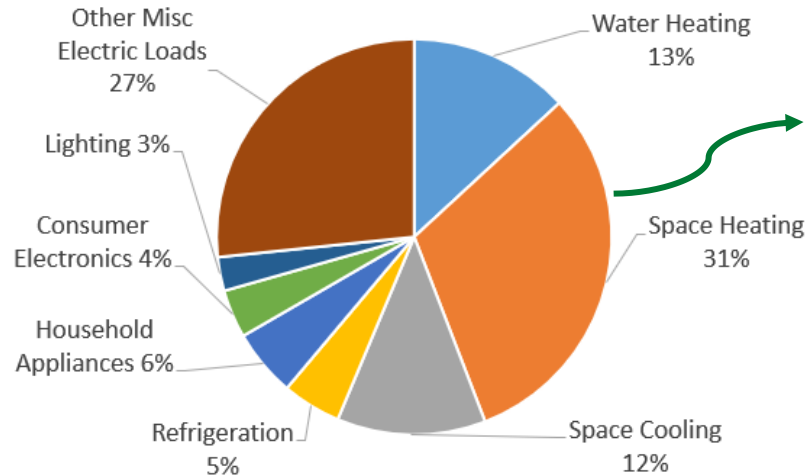
Why are we doing field DR research in cold climates?

-  Winter peaking is prevalent in cold climates
-  Financial impact
-  Understand real-world impacts
-  Develop plans to meet goals
-  Success Stories



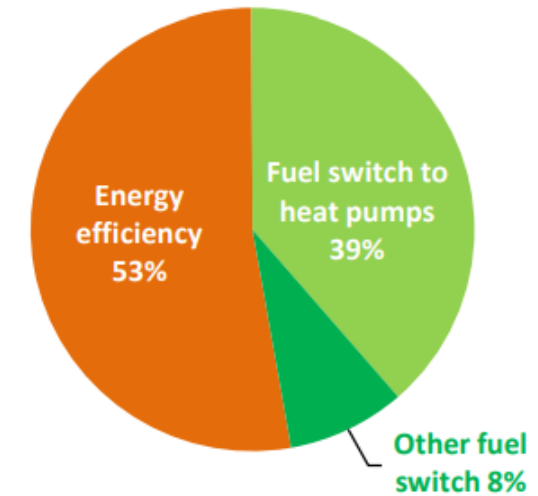
Space heating consumes the most energy of all residential end uses and has the highest potential for decarbonization. Heat pumps are energy-efficient and can be demand flexible to help address this problem

Percent of 2024 Residential Energy Consumption
by End Use



Space heating consumes the most energy of all residential end uses

Heat pumps projected as a key solution for decarbonization



IEA. CC BY 4.0.

- Heat pumps for cold climates are a promising solution for lowering emissions – *but need more testing in extreme cold climates.*
- Demand-flexible heat-pumps can stabilize the grid and improve energy resilience by using locally available renewable energy – *few studies exist on residential winter demand-flexibility with heat pumps.*
- Demand-response with heat-pumps may impact thermal comfort and interfere with daily routines – *DF/DR program administrators have limited resources to consider occupant impact in their planning.*

Study Goals



How can residential HVAC load flexibility (LF) impact rural, cold-climate peak load energy consumption?



Understand CTA-2045-based communication



Evaluate occupant comfort implications of residential LF

What is CTA-2045?

- Initially published in 2013
- ANSI/CTA-2045-B published in 2021
- Allows devices to connect to various demand response (DR) systems via a modular communication interface
- Allows communication via various pathways
- **Simple use: get setpoint, set setpoint**

Consumer
Technology
Association™

ANSI/CTA Standard

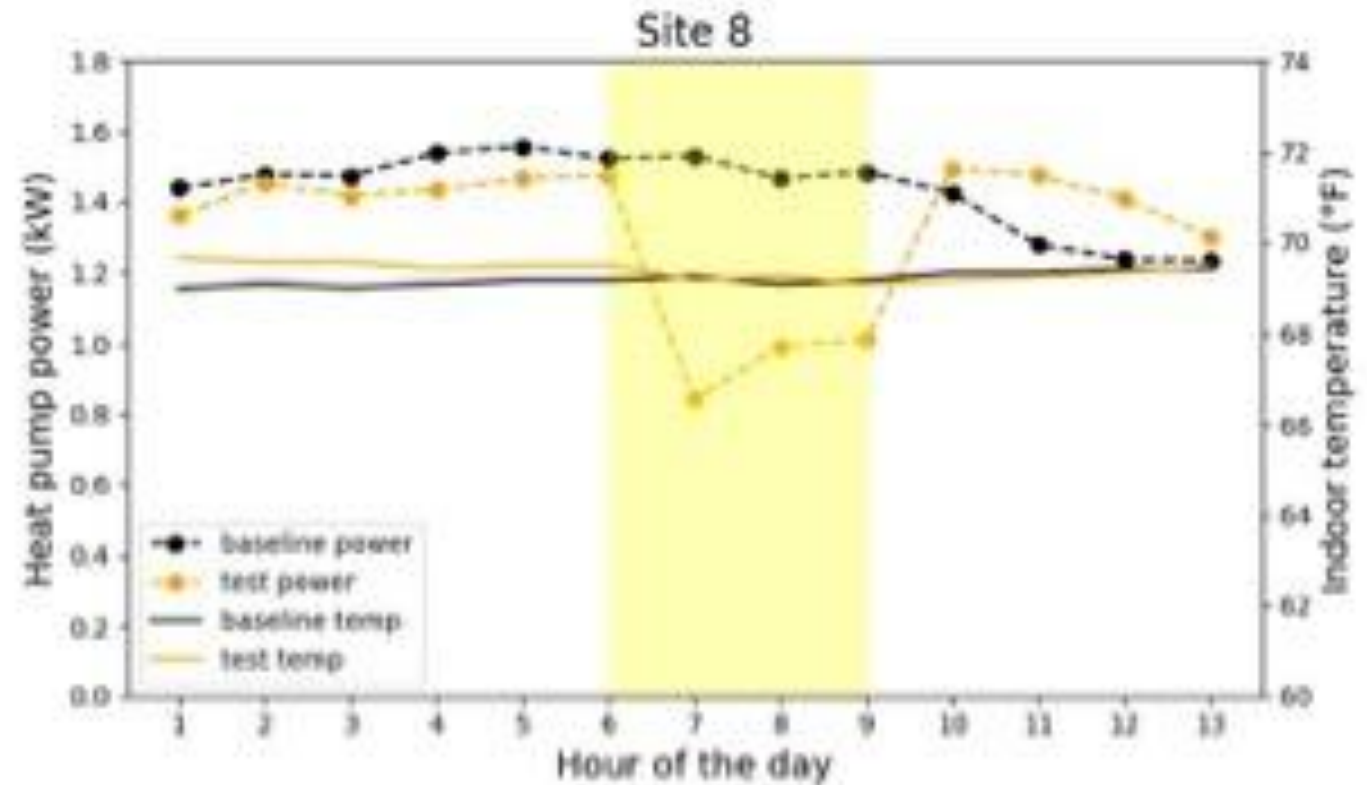
Modular Communications Interface for Energy
Management

ANSI/CTA-2045-B



Previous Study – Portland, OR

- We have done CTA-2045-based DR/LF before
- Evaluated CTA-2045 capabilities with enabled heat pumps
- Showed potential for peak load management
- Developed methods for delivering events



Bring on the cold! Cordova, AK

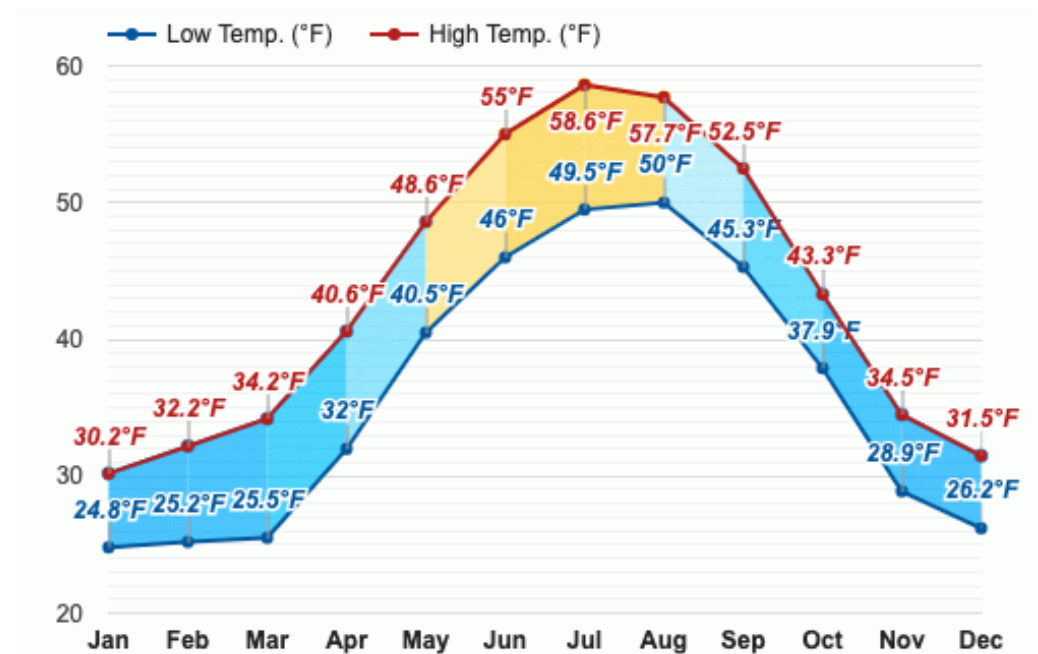
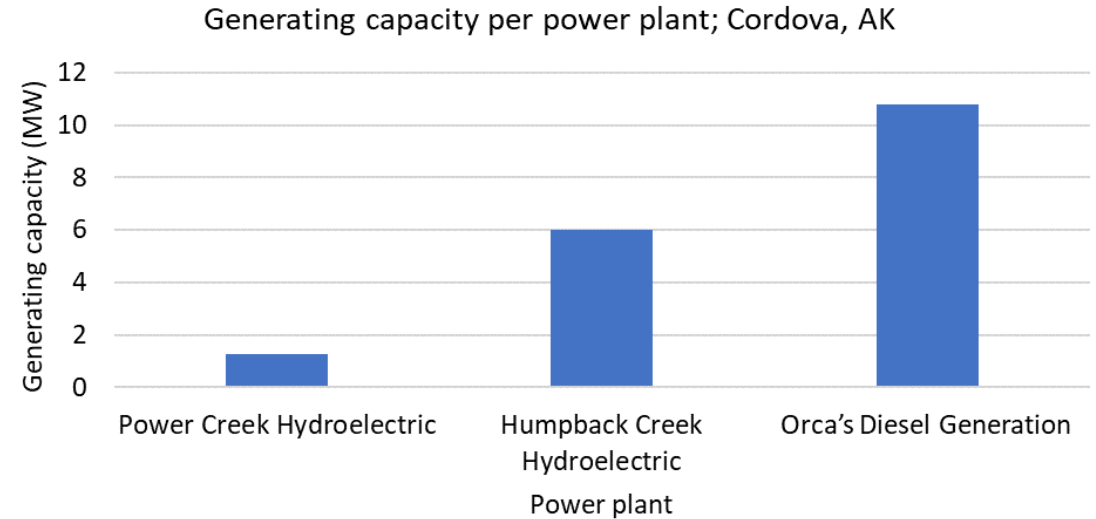
- Co-op electric utility
- Local momentum



Cordova Characteristics

What leads to a reasonable environment for residential electrification and DR programs?

- Excellent weather for heat pumps
- Renewable/fuel grid mix
- Existing heating systems less-than-optimal



Study Setup

- Sent local HVAC tech to a manufacturer heat pump training course
- Recruited participants
- Installed heat pumps, communication devices, and data loggers in three homes
- Collected information from local electric utility
- Developed LF methods to:
 - Keep occupants comfortable
 - Maximize peak load reduction
 - Minimize post-event peaking



Indoor unit of mini split



Outdoor unit of mini split

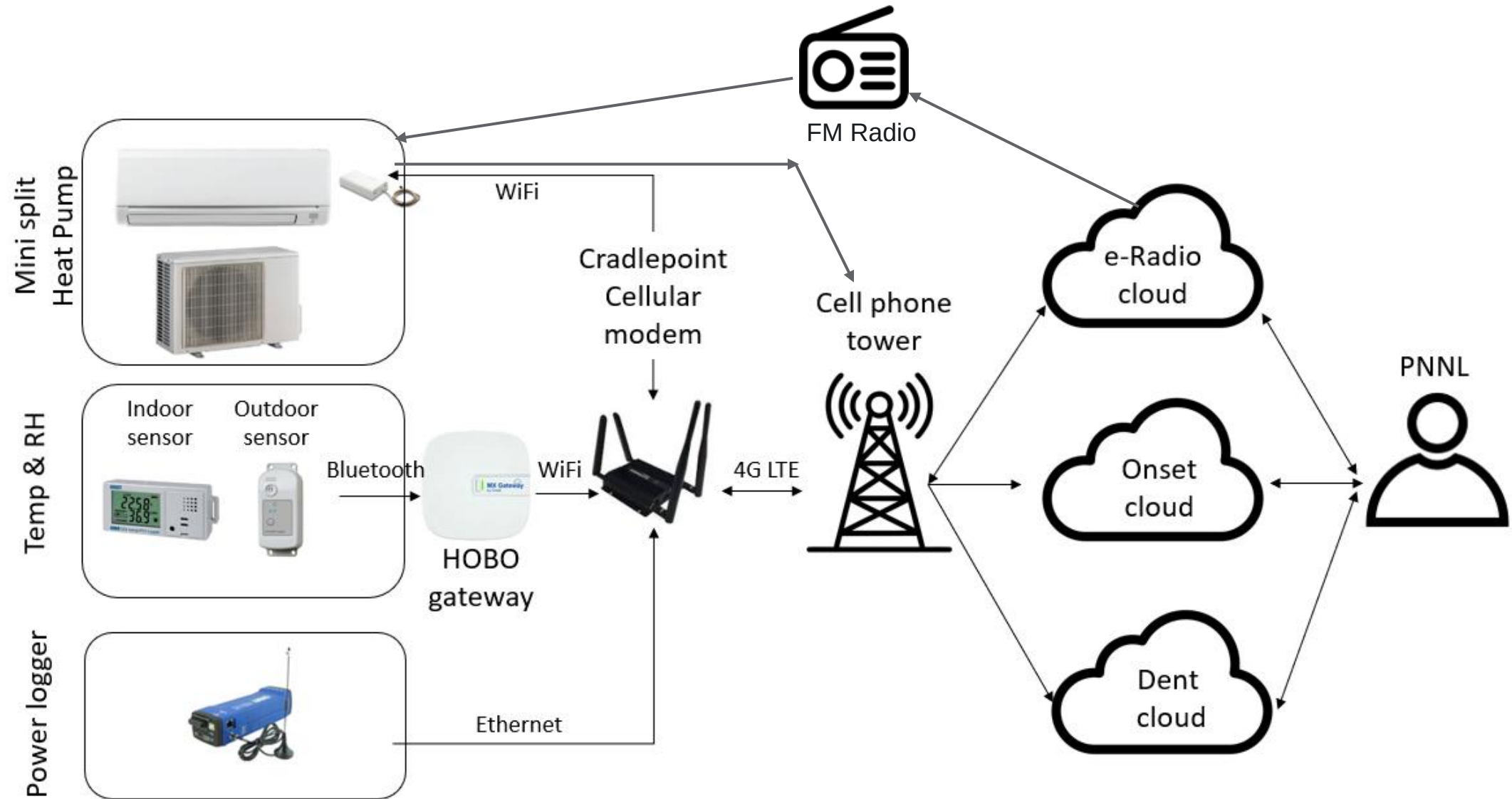


CTA-2045 interface



CTA-2045 module

Study Communication Diagram



Load Flexibility Event Types

1-hour event, 2 °F
setpoint reduction,
no preheating

1-hour event, 2 °F
setpoint reduction, 1
hour of preheating
at 2 °F above
setpoint

2-hour event, 2 °F
setpoint reduction,
no preheating

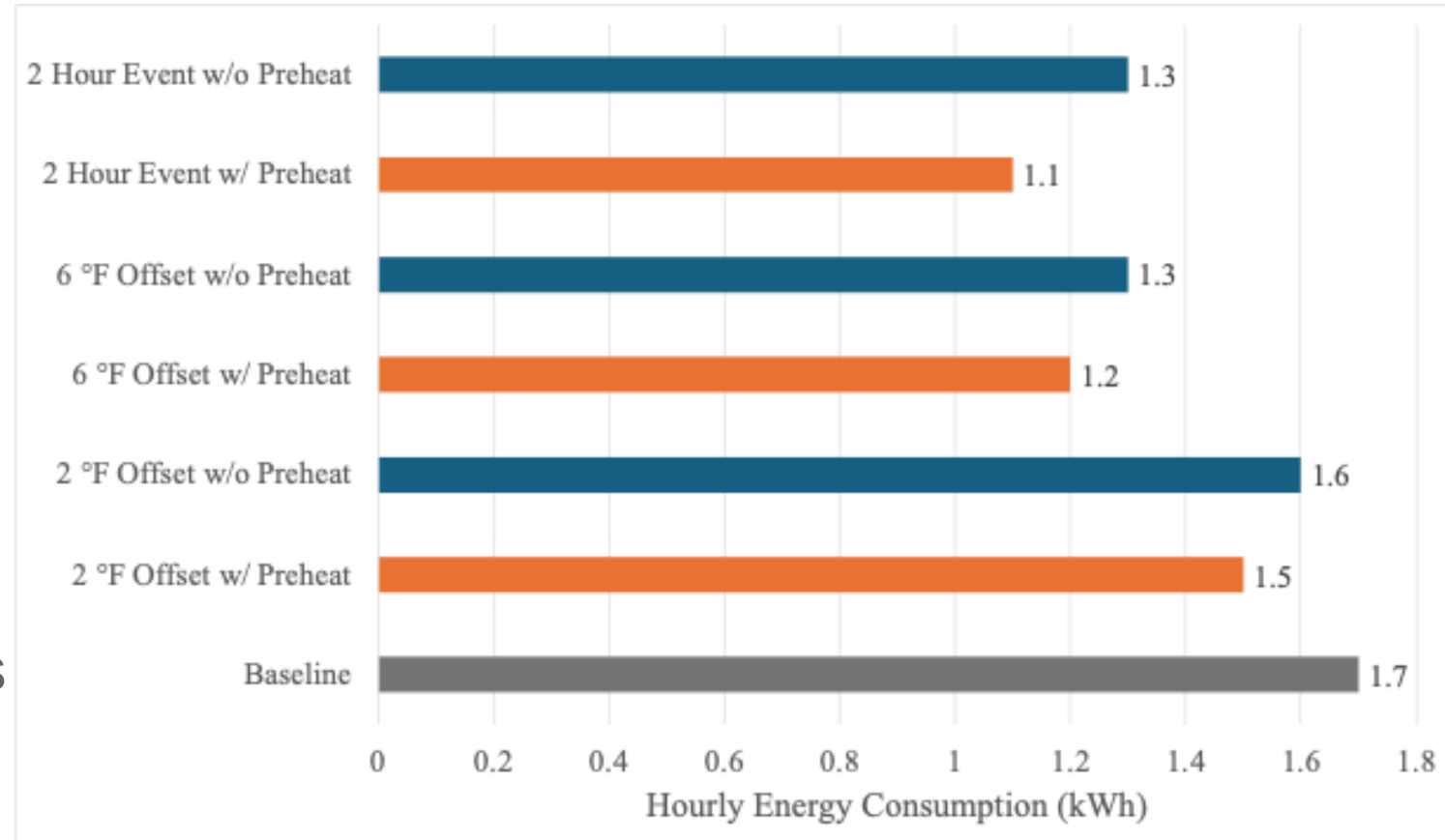
2-hour event, 2 °F
setpoint reduction, 1
hour of preheating
at 2 °F above
setpoint

2-hour event, 6 °F
setpoint reduction,
no preheating

2-hour event, 6 °F
setpoint reduction, 2
hours of preheating
at 2 °F above
setpoint

Load Flexibility Event Aggregated Results

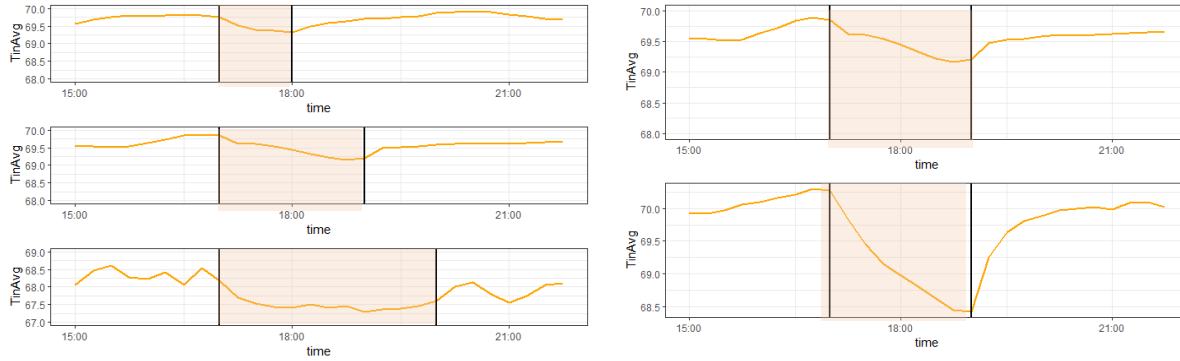
- 6% - 35% hourly energy consumption reduction during test hours
- Pre-heating increases peak load reduction across all tests
- Large setpoint reductions can be effective***





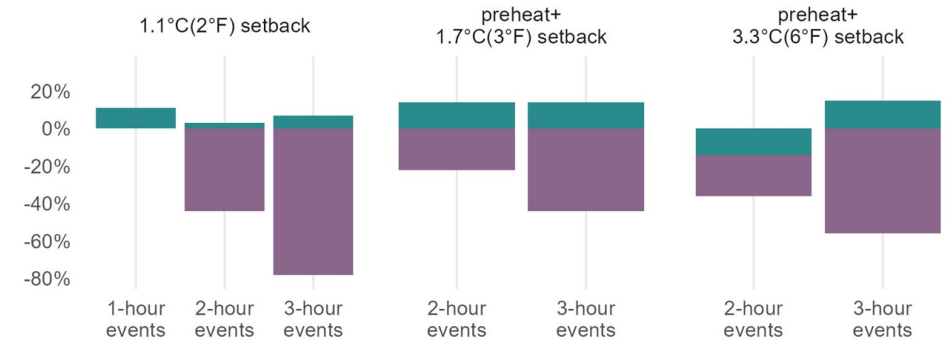
Progress and Key Findings

Results for (3) comparison of outcomes of DF/DR event types of *varying durations, offsets, and preconditioning strategies*

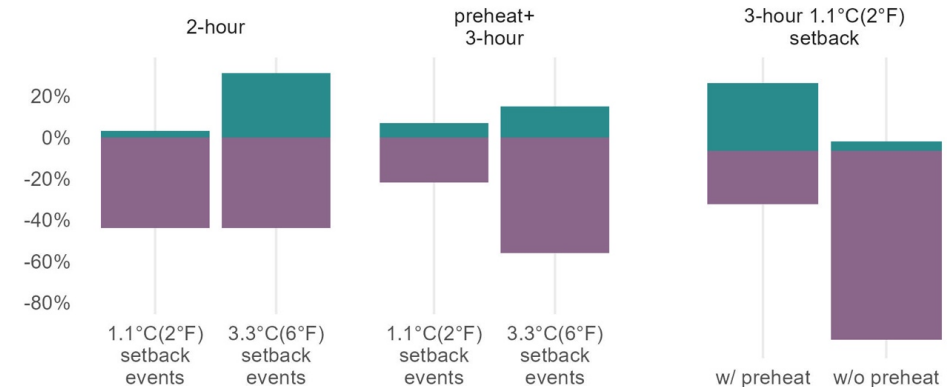


- DF event energy savings increase when **setback temperature** change is larger
- DF event energy savings larger for events with less **comfort action**
- Longer durations – increase **likelihood of comfort action**, hence **reduced participation** and **lower energy savings**
- Larger setbacks are tolerated if event duration does not exceed 2 hours

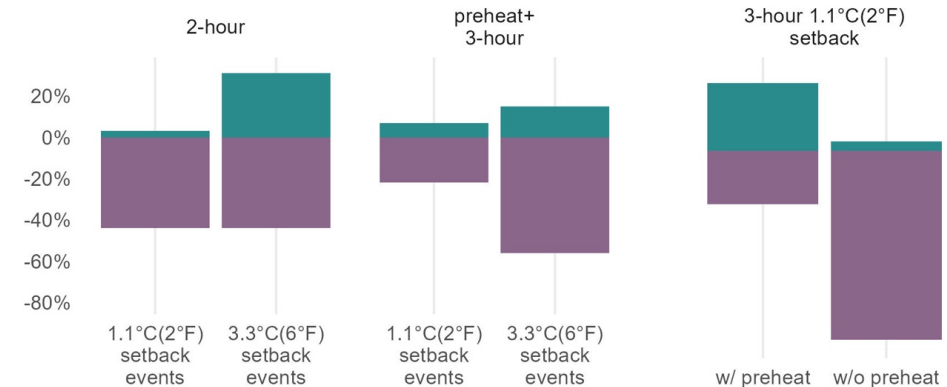
a. Effect of event duration



b. Effect of setpoint ΔT

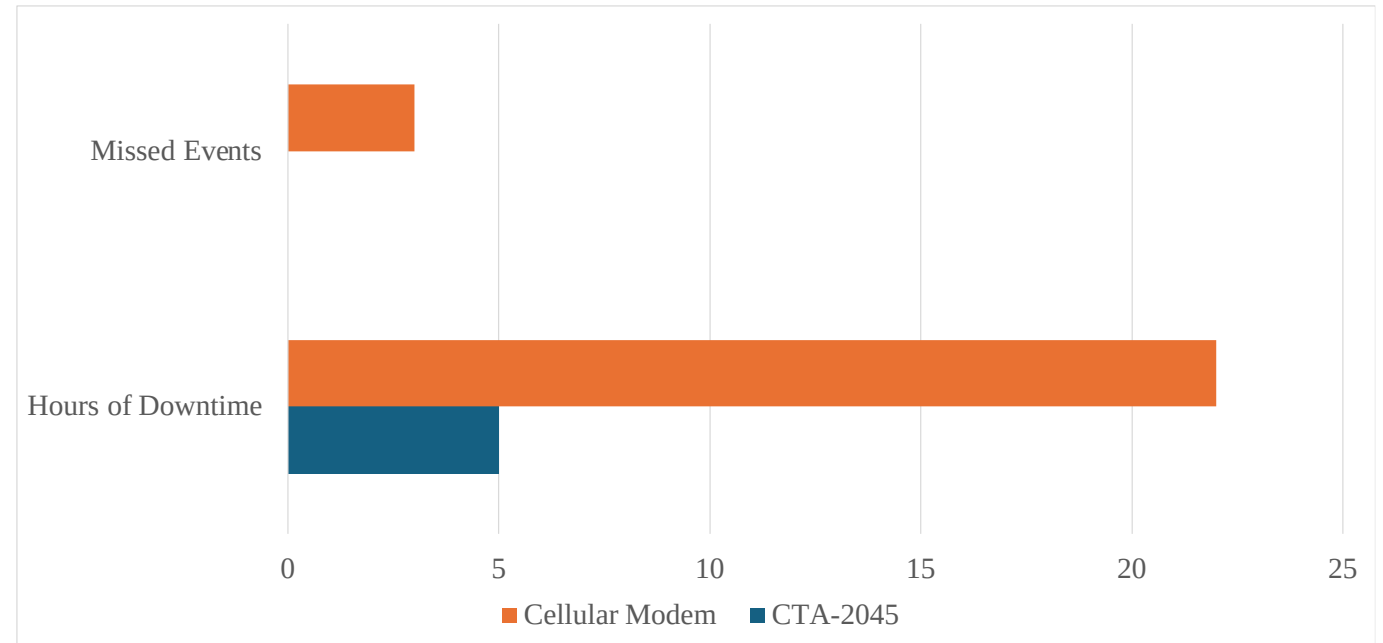


c. Effect of preheat



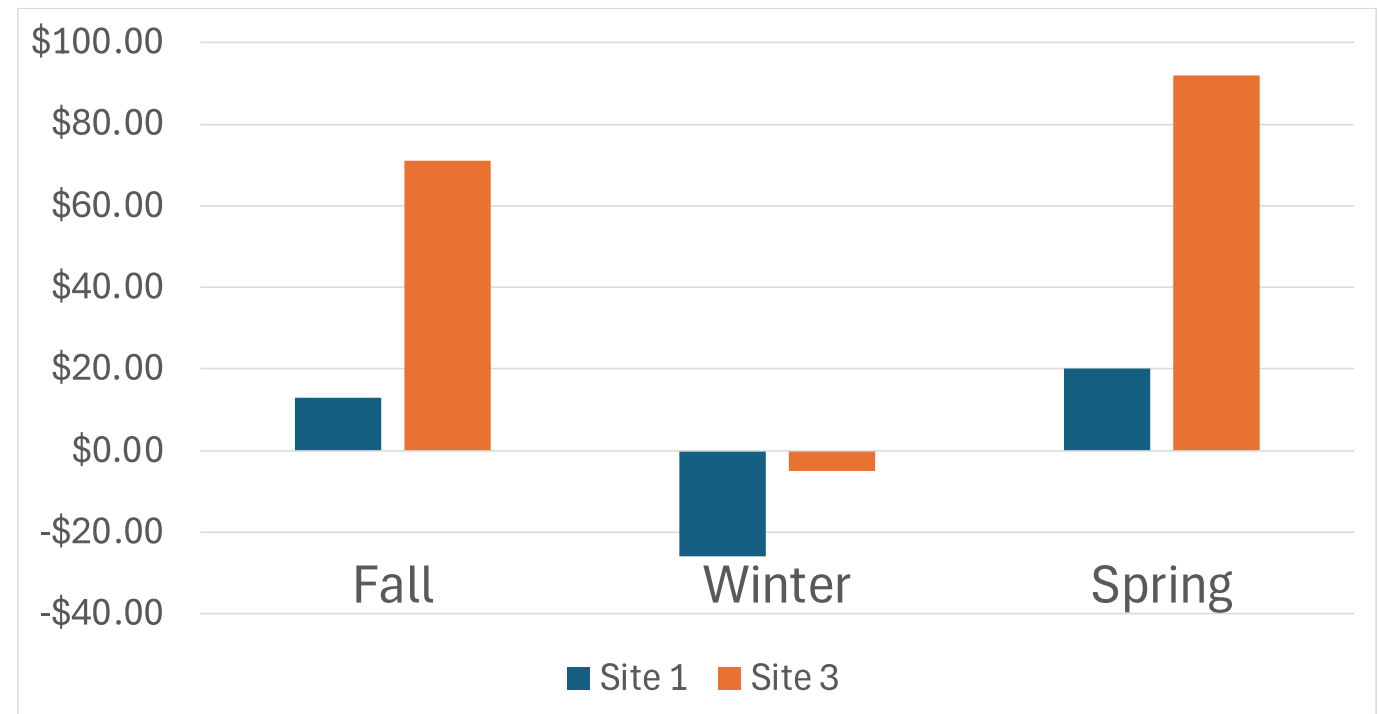
CTA-2045 Communication Reliability

- CTA-2045 communication can use LTE, WiFi, and FM to send signals
- Other DR communication relies on WiFi
- Uptime for CTA-2045-enabled device resulted in 0 missed signals



Billing Analysis

- Savings in the swing seasons
- Fuel oil is expensive (\$0.22/kWh)
- Electricity is cheap (\$0.17/kWh)



Next Steps

- Evaluate peak load management in even colder climates (Elim, AK)
- Explore other methods of DR communication
- Bolster occupant comfort evaluation



Thank you

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Eric Olson
NEEA



Water Heaters That Shift Load

Eric Olson

Senior Product Manager, Emerging Technology

November 14, 2024





Topics

- Why do we need flexible loads?
- What services can water heaters provide?
- How did connectable water heaters come to be?
- How should you connect to water heaters?
- What should I do to get connected?
- What does the future of connected water heaters look like?



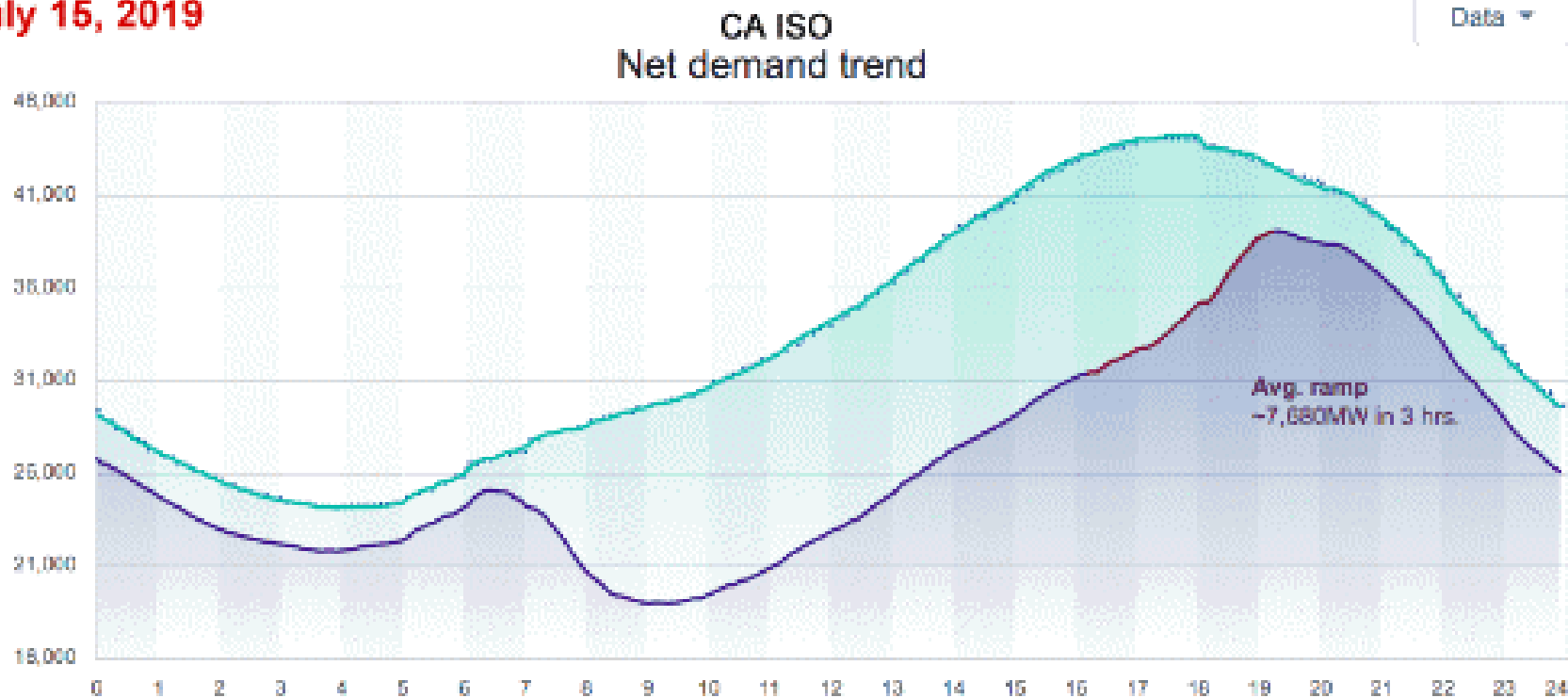
Smart Grid Devices: Load Shifting Example-Water heaters solve a current and future challenge*

Net demand (demand minus solar and wind) AS OF 15:20

This graph illustrates how the ISO meets demand while managing the quickly changing ramp rates of variable energy resources, such as solar and wind. Learn how the ISO maintains reliability while maximizing clean energy sources.

01

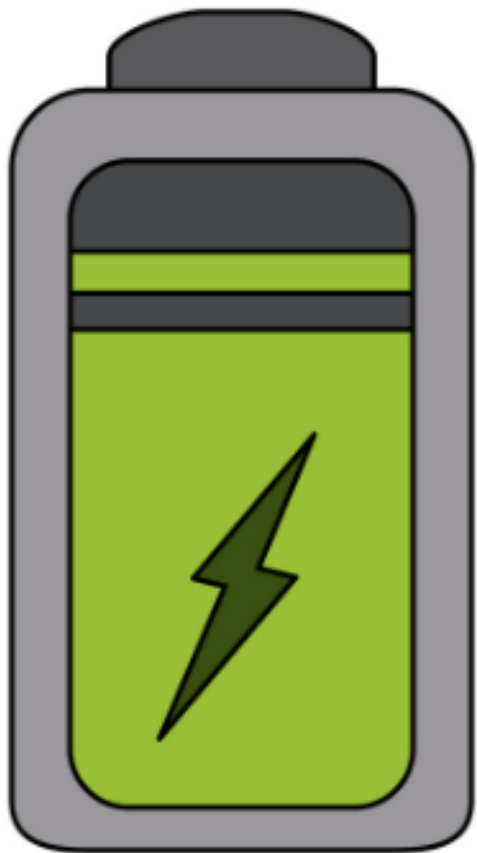
CA Demand & Net Demand July 15, 2019



* Graphic courtesy of SkyCentrics



Water heaters are big batteries

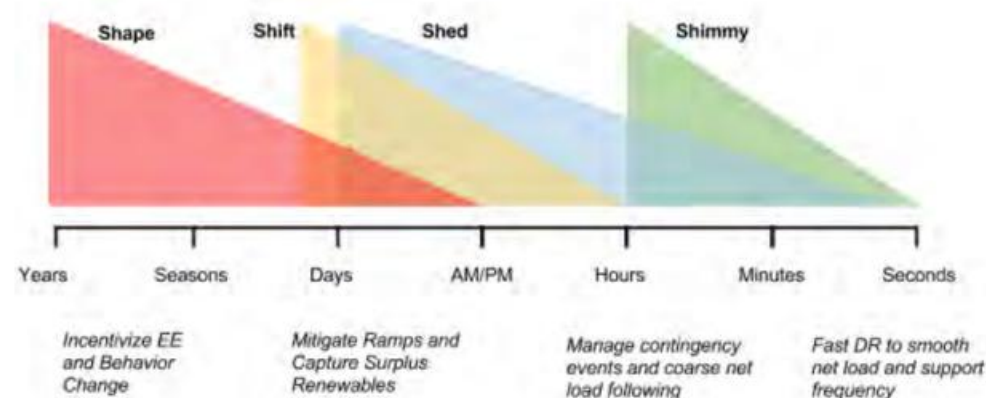


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- Store Energy
- Shift Energy
- Shed Energy
- Absorb Energy
- Level Energy Use
- Provide Ride through

Shape, Shift, Shed and Shimmy*

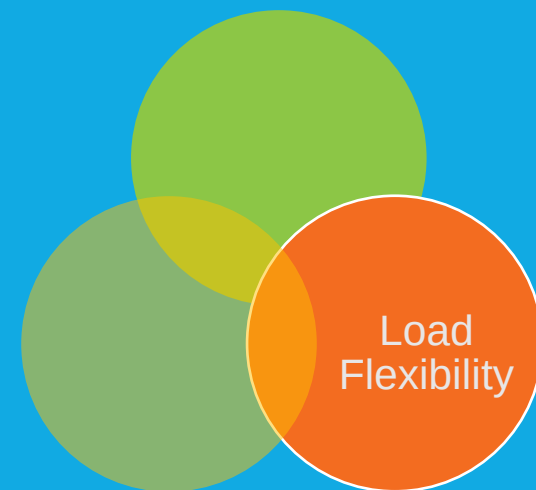


*<https://eta-publications.lbl.gov/sites/default/files/lbnl-2001113.pdf>



Key Load Flexibility Concepts (cont.)

- **Flexible Smart loads:** Loads associated with devices whose usage can be modulated to help balance supply and demand (e.g., residential appliances, space conditioning and water heating).
- **Controls:** Devices and strategies that tell flexible load assets when and how to operate or provide a signal to inform the decision to participate.
- **Communications architecture:** Hardware and software that transmits signals from a grid operator or third-party aggregator to the customer using protocols like OpenADR or IEEE 2030.5.
- **Grid integration** concerns how the larger energy system manages load assets, by either directly controlling the assets or providing price information to allow asset owners (and their devices) to make their own decisions.



Load flexibility has the technical potential of reducing daily storage requirements by anywhere from 37%–81%.

NREL



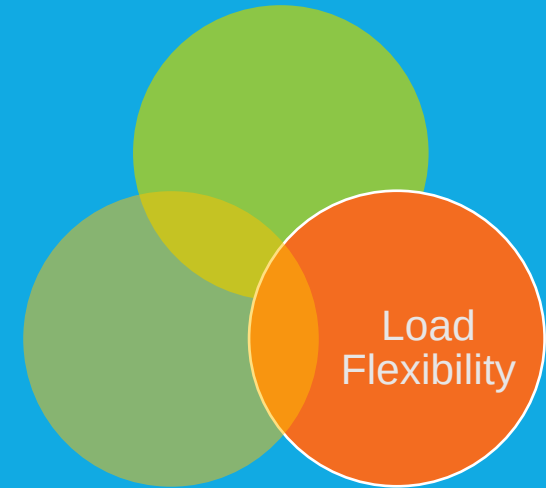
Opportunity Description

Load flexibility:

Applying the tools of market transformation to support the nation's ability to shift/ shed energy demand to maximize the efficient use of energy on the grid and the integration of more renewables.

Value to the nation:

- Integration of intermittent resources
- Targeted demand reduction, load building and system balancing
- Avoided system costs
- Grid resilience and reliability

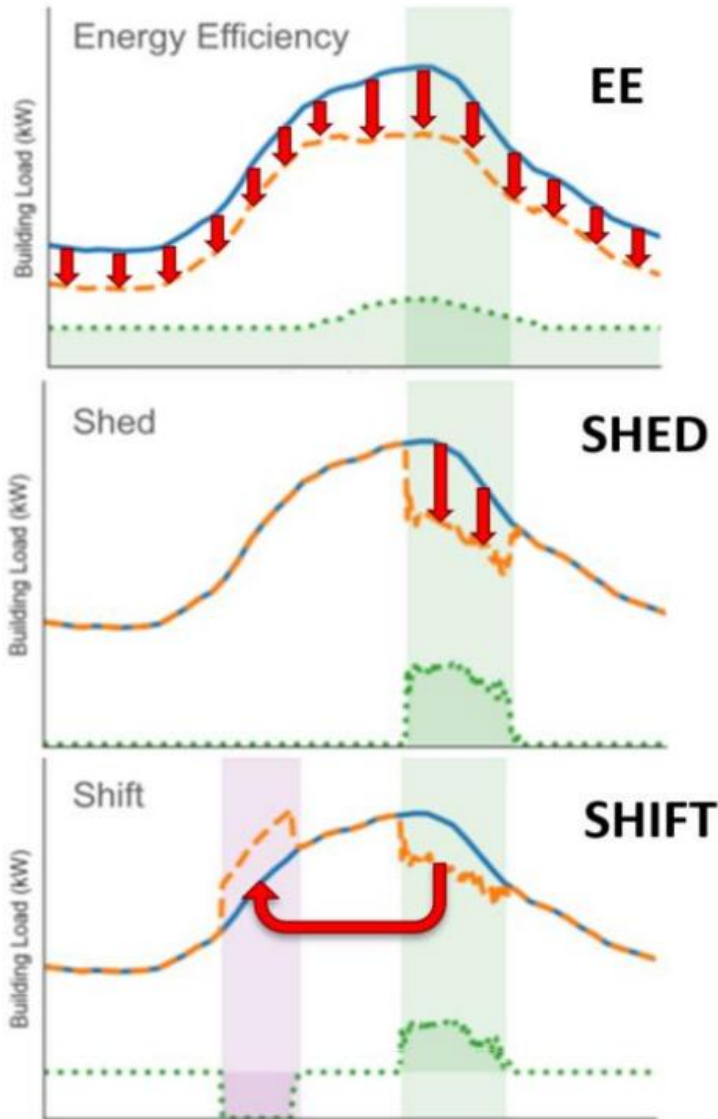


“The more aggressive the electrification initiative, the greater the need for flexibility to meet changing demand and to manage the electrical grid.”

- EPRI, *Seattle City Light Electrification Assessment*



Key Load Flexibility Concepts (cont.)



Load Shed: Reducing load based on either dispatch or price signals

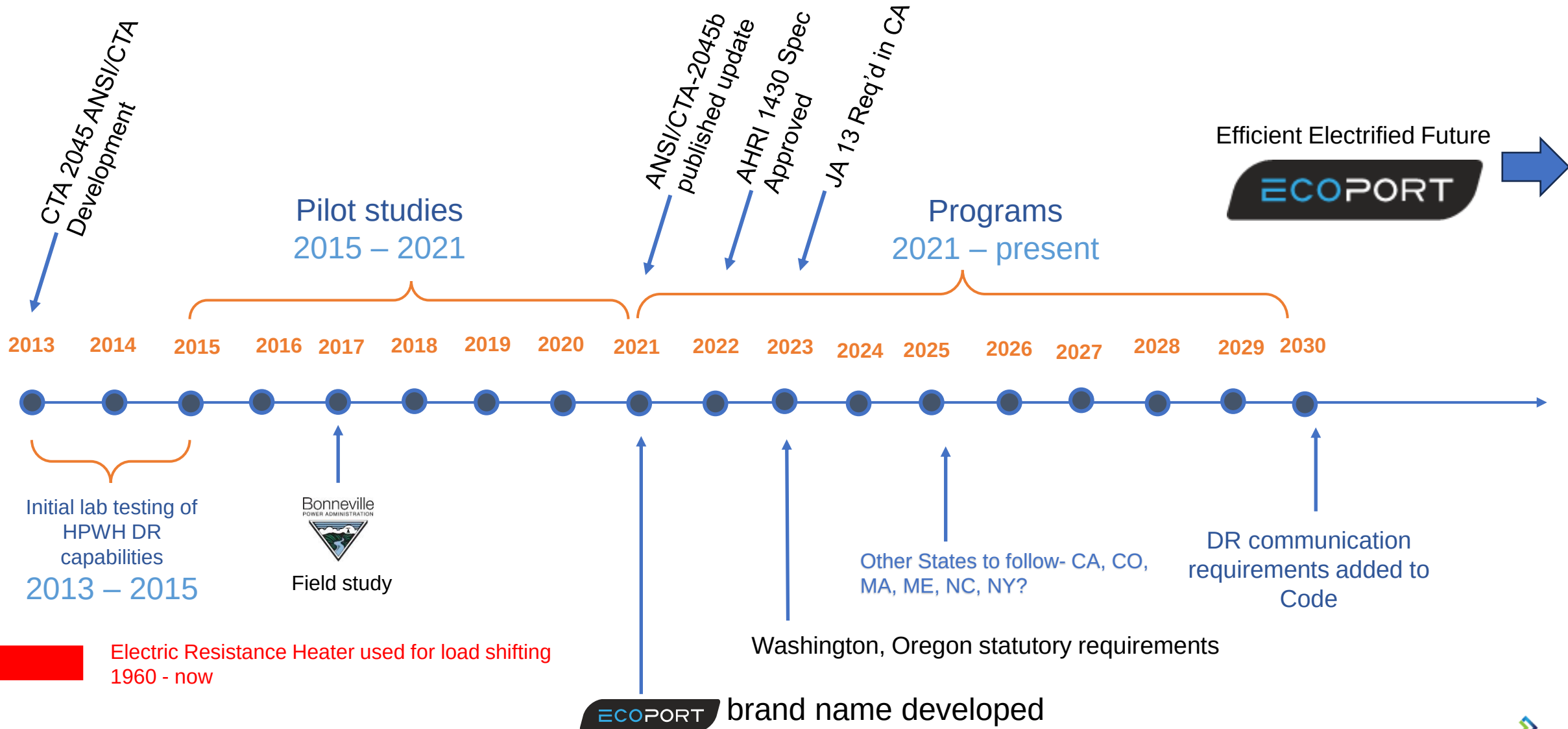
- Focus on grid peak conditions
- Example strategies: dimming lights, raising cooling setpoint, slowing down EV charging

Load Shift: Moving load from one time to another (may or may not be energy neutral)

- Focus on decarbonization – using renewable energy, ramping needs, peak conditions
- Example strategies: pre-cooling, charging/ discharging batteries, moving EV charging times



CTA 2045 ~ EcoPort™ Timeline





Connected Water Heaters: Case Studies



- **Case studies** of NEEA's current work (i.e., what, how, wow):
 - Advanced water heating spec
 - BPA/PGE demo project
 - AWHI connectivity story (1430)
- **Demonstrated:**
 - 278 water heaters connected – most all self installed
 - 600 events over 270 days
 - Minimal to no complaints
- **Lead to:** Washington and Oregon requiring CTA 2045 ports on all electric water heaters 40-80 gallons

**OpenADR & CTA-2045
work well together**

The more expensive OpenADR
can be placed in the cloud, or
in the CTA-2045 module.
Not recommended in the appliance.

Customers

Want to monitor and schedule their
devices through easy to use apps
Choice of Manufacturers

Utilities

Need options for communication paths
May need guaranteed communication
May need OpenADR...or not.

OEM

Can put minimum smarts for utilities only,
OR
Maximum smarts for additional features
through an OEM cloud connection

\$\$\$ CTA-2045 module
with OpenADR*

\$ CTA-2045
module

CTA-2045

Smart
Appliance

*OpenADR is expensive to code, certify, and has a yearly SSL certificate cost! Put it in the module if necessary, NOT IN THE APPLIANCE



IEEE 802.11b



CTA-2045



ECOPORT

*What can you do to help
the grid and make a
difference?*

*How can I be a Hyper
Transformer*



- Attach EcoPort enrollment stickers on every connectable water heater
- Encourage utilities to stand up programs
- Install a larger tank if possible and add thermal mixing valve if possible
- If you are installer, understand how you can provide added value to your customer and your utility
- Configure your water heaters to heat water at the optimal time
- Share your positive experiences with both efficiency and flexibility



Thank You!



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NW Natural®



Seattle City Light





Chris Granda
Energy Solutions

Connected Heat Pump Water Heaters for Low-Income Homes in North Carolina

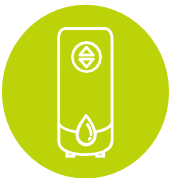
Chris Granda
Daniela Urigwe
Helen Davis

Project Goals

- Document energy savings and opportunities for water heater load shifting to reduce energy costs for low-income customers
- Document operation of connected, load shifting HPWHs for the Southeast U.S. climate and for participant load profiles
- Share lessons learned for implementing HPWH load shifting programs in low-income communities or with hard-to-reach customers



Project Facts



24 installations of 240-volt HPWHs with EcoPorts



Control via e-Radio cellular modules and CTA-2045 signals



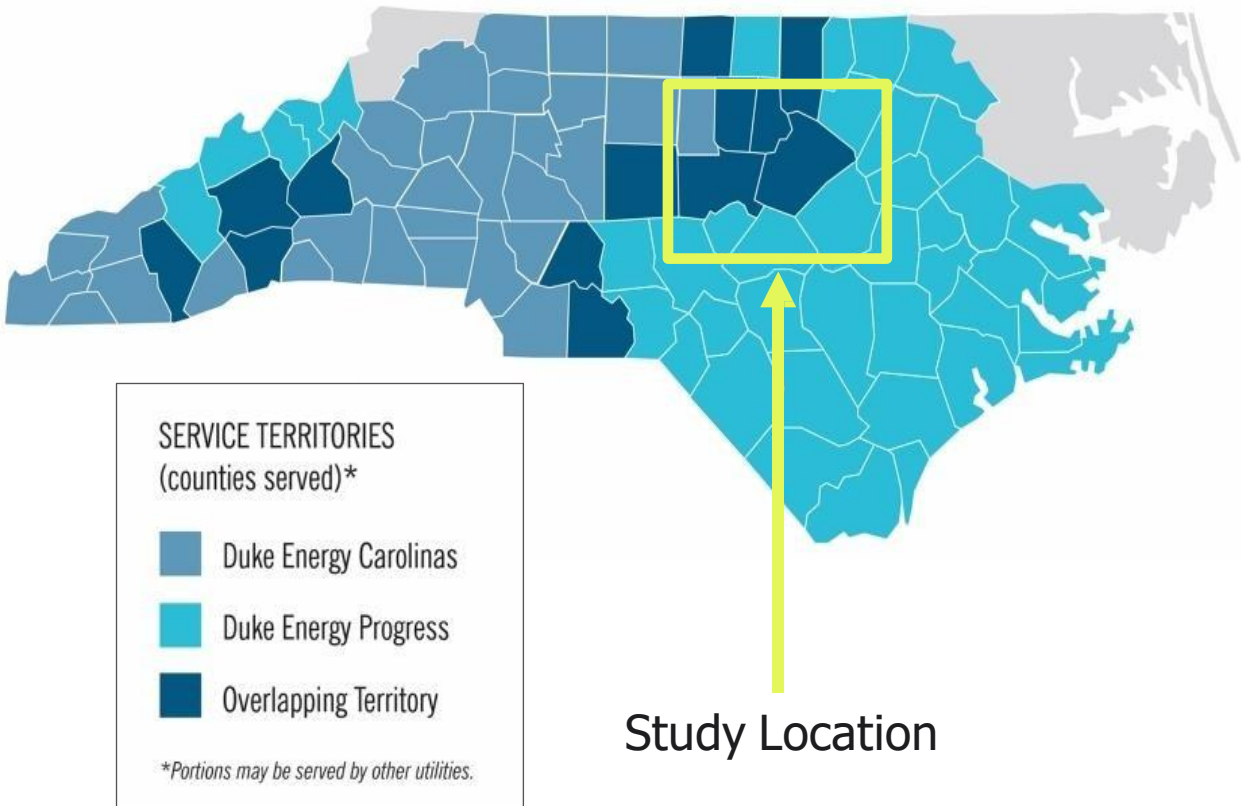
1 year of control and monitoring



23 50-gallon and 1 80-gallon HPWH in a variety of locations



No mixing valves or changes to participant water heating mode



Source: Duke Energy

Seasonal Load Shifting Strategies

Winter	Months	12 a.m.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	12 p.m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.
Cold	December January February																								
Shoulder	October November March April																								
Summer	Months	12 a.m.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	12 p.m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.
Hot	June July August																								
Shoulder	May September																								

Load Up

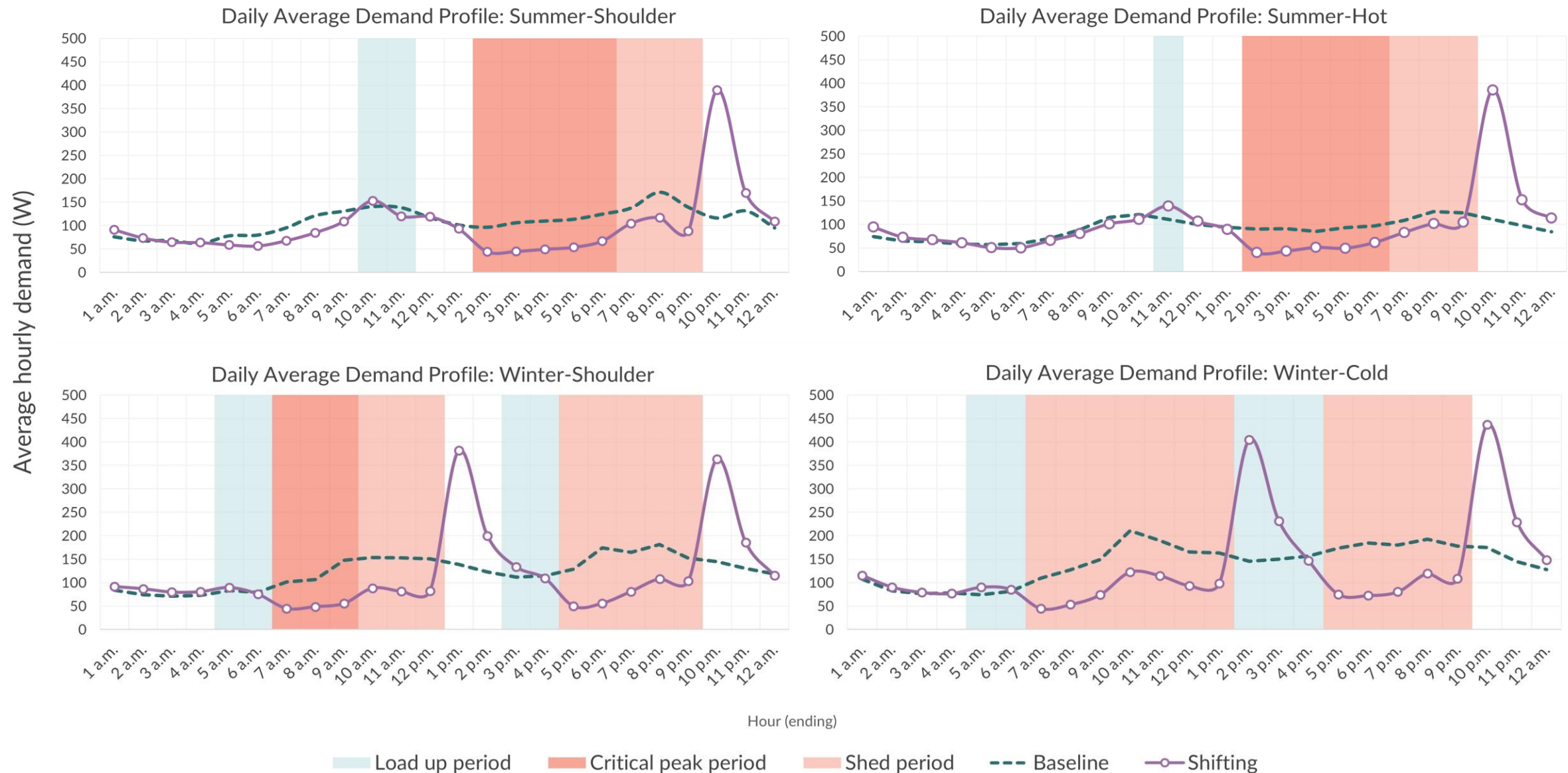
Critical Peak

Shed

Normal Operation



Results – Customer Demand Profiles by Season



Results – Load Shifting

Shifting Schedule	Shed Periods	Average daily energy savings (kWh, % of non- shifting baseline)		Average morning load shifted (kWh, % of non- shifting baseline)		Average evening load shifted (kWh, % of non- shifting baseline)	
Summer – Hot	Evening: 1-9 p.m.	0.10	4%			0.12	30%
Winter – Shoulder	Morning: 6 a.m.-12 p.m. Evening: 4-9 p.m.	0.11	4%	0.19	43%	0.35	50%
Winter – Cold	Morning: 6 a.m.-1 p.m. Evening: 4-9 p.m.	0.20	6%	0.38	35%	0.28	33%
Summer – Shoulder	Evening: 1-9 p.m.	0.34	12%			0.11	25%

Participant Benefits



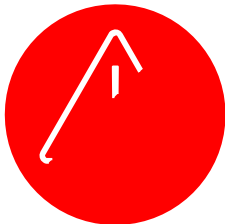
Energy Savings:*

920 kWh and \$110 annually per household



Load Shifting Savings:

- Up to 50% of energy shifted daily
- 60% demand reduction during winter peak
- \$44 annual TOU rate savings per household**



Caution:

Switching to a TOU rate could cause electricity cost to increase for loads that can't be shifted

** From switch from electric resistance to heat pump water heater, on Duke base electric rate*

*** Based on 2023 Duke time-of-use rates*

Thank you

Chris Granda

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Explore the Residential Program Guide

Resources to help improve your program and reach energy efficiency targets:

- [Handbooks](#) - explain *why* and *how* to implement specific stages of a program.
- [Quick Answers](#) - provide answers and resources for common questions.
- [Proven Practices](#) posts - include lessons learned, examples, and helpful tips from successful programs.
- [Technology Solutions](#) **NEW!** - present resources on advanced technologies, **HVAC & Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.
- [Health + Home Performance Infographic](#) – spark homeowner conversations.



<https://rpssc.energy.gov>

Health + Home Performance Infographic



DOE’s Health + Home Performance Infographic reveals the link between efficiency and health – something everyone cares about. Efficiency programs and contractors can use the question-and-answer format to discover a homeowner’s needs.

The infographic is ideal for the “kitchen table” conversations where people decide what to do – and who they want to do it. It also has links for homeowners to find a qualified contractor if they do not already have one.

[Download](#) this infographic from DOE’s Better Buildings Residential Network.

Looking for photos to help tell your energy efficiency story? Visit our image libraries:
<https://www.energy.gov/eere/better-buildings-residential-network/articles/image-libraries>

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or future call topic ideas to:
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