Adopting Energy Efficiency in Connected Homes

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Smart Stuff is the New Hotness…

…but there are definitely still a lot of kinks to work out

Types of Connected Homes Products in HEMS (Smart Home Ecosystem)		
Functionality	Category	Short Definition
Control-based	Smart Lighting	Lighting bulbs, controls, and fixtures that have automated control functionality
	Smart Plug	Single communicating piece of hardware that controls or provides feedback about connected energy consuming devices
	Smart Hub	Device that enables and manages interaction between existing smart hardware within a single home
	Smart Hub and Smart Switch	Dual function wall mounted smart switch that also enables and manages interaction between existing smart hardware within a single home
	Smart Switch	Wi-Fi enabled wall switch that controls or provides feedback about connected energy consuming devices
	Smart Appliance	Communicating appliance which can be controlled remotely via various interfaces
	Smart Thermostat	HVAC Wi-Fi enabled control utilizing remote or rule based mechanisms
	Smart Home Platform	Software platform that enables multiple different hardware devices to operate as a home automation system
Information-based	Energy Portal	Online dashboard that is consumer or program administrator facing
	Data Analytics Platform	Cloud based analytics platform that analyzes large volumes of data collected from existing smart hardware
	In-Home Display	Physical display that collects data from existing hardware and provides real time feedback and/or prompts
	Load Monitor	Single non communicating piece of hardware that displays energy consumption data of the connected appliance or devices
	Web Service Platform	Cloud-based platform that focuses on more than just energy

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A Note on Smart Thermostats

	Characteristics
Programmable thermostats	Retains basic thermostat capability, regardless of link status
	Can collect temperatures, HVAC run-times and HVAC performance information from field systems
	Temperature stability
	Programmable for schedules and setbacks
Wi-Fi thermostats	Wi-Fi-enabled
	Online dashboard and/or mobile app connected to the user account
	Intuitive user interface (UI) that may include touchscreen or buttons
Smart thermostats	Proximity sensing allows a user to accept and act upon external data (like the location of a smart phone). Occupancy sensing directly detects and acts upon internal sensors (inside the thermostat).
	“Learning,” optimization, or adaptive control; algorithms that learn user behavior or track usage to improve performance
	Basic demand response capabilities: allows remote connection with utilities, who, with authorization, can adjust thermostat settings during peak demand periods (optional).


Smart controls for DHPs

Cielo Breezi

Sensibo

Tado

Momit

Smart Outlets

GE Smart Switch

iDevices Switch

Belkin Insight Switch

Cielo Control Switch

Smart Water Controls

Carina

Kenmore
Smart WH

Aquanta

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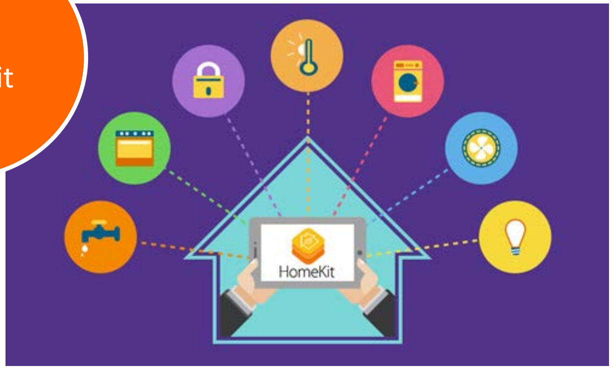
Smart home platforms

Lowe's Iris

Apple HomeKit



Samsung Smart-Things

Alexa?

Kirio

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Home Energy Monitoring Products

Neurio

Curb

Sense

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How much energy can connected devices save?

In-home displays
- Electric savings range: 5–22%
- Gas savings range: 5–22%

Energy portals
- Electric savings range: 5.7–7.4%
- Gas savings range: 5.7–13%

Smart thermostats
- Electric savings range: 2–16%
- Gas savings range: 8–12.5%
- Can save energy in oil- and propane-heated homes, too

Smart plugs and strips
- Demand savings range: 0.5 –1.0 kW per customer
- Energy savings range: 1–4.58%

In the most heating dominated climates in the U.S., this type of product could save an average of 10 Million BTUs per year (that’s about 3000 kWh or 100 therms).

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Smart Home Ecosystem: Example

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Benefits of Smart Technology

Good for Homeowners

- Convenience
- Security and safety
- Health and comfort
- Energy Savings

Good for Everyone

- Energy Savings
- Planning for renewables
- Energy Balance - Path to net zero energy
- Resilience

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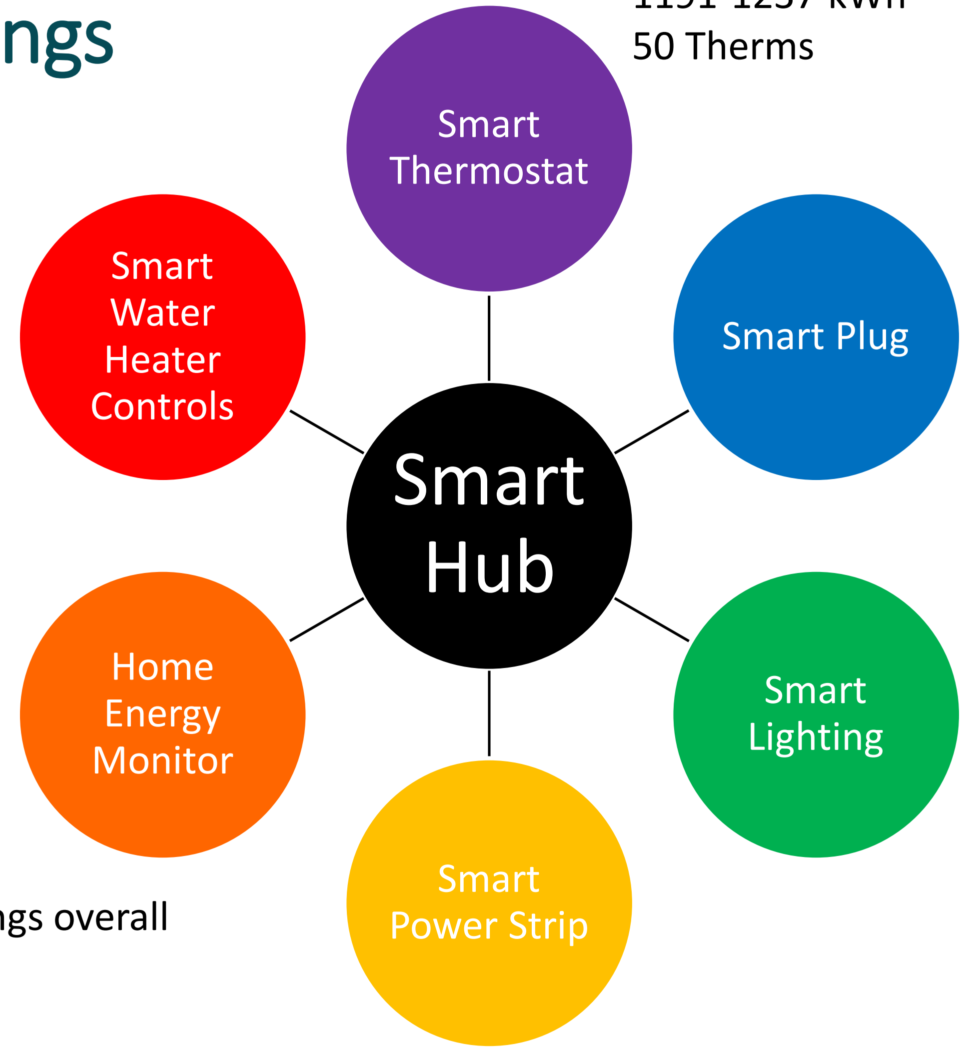
Benefits now: Energy Savings



$249.99
1191-1237 kWh
50 Therms

$150.00
~330 kWh
30 Therms

$49.99
~28 kWh

$14.97
~72 kWh

$219.99
2-8% savings overall

$59.99
~216 kWh

Smart Home Bundle estimated savings:
~1760 – 2150 kWh
~80 Therms

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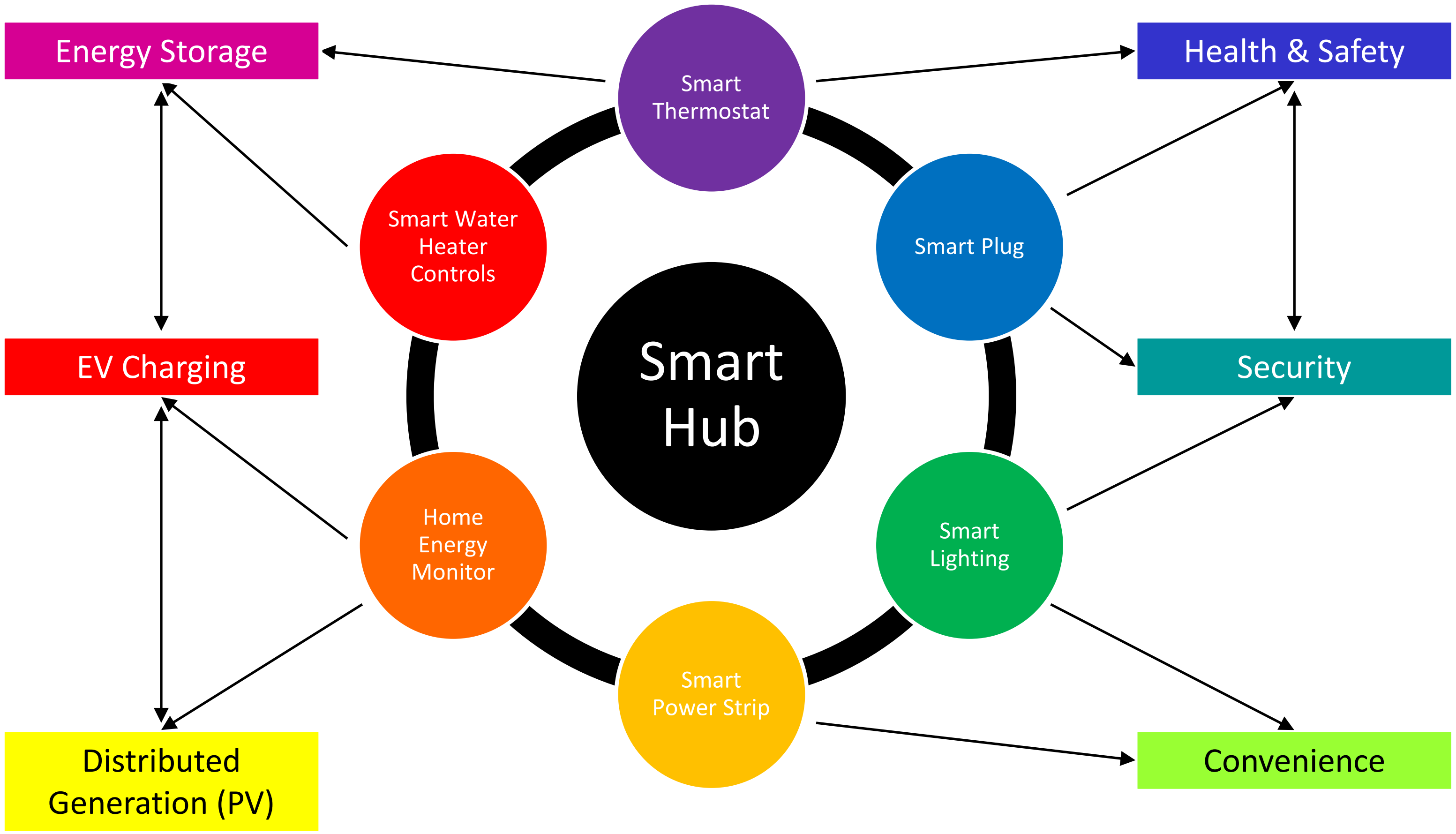
Benefits in the future:
Home as energy management system



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Thank you!

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Home Energy Management Systems (HEMS) Product Demonstration in NYC

NREL NATIONAL RENEWABLE ENERGY LABORATORY

conEdison

NEW YORK STATE OF OPPORTUNITY. | NYSERDA Supported

- NYSERDA-sponsored project to create stakeholder engagement and consumer education strategy to accelerate broad-market adoption of HEMS across NY State.
- Smart Home Product demonstration targeting HVAC, lighting, and plug loads
- 24 homes (12 single-family, 12 multi-family)
- Pre/post energy M&V and homeowner surveys
- HEMS installation begins November/December 2017.

ANSI/CTA-2045 Modular Communication Interface Standard

EPRI ELECTRIC POWER RESEARCH INSTITUTE

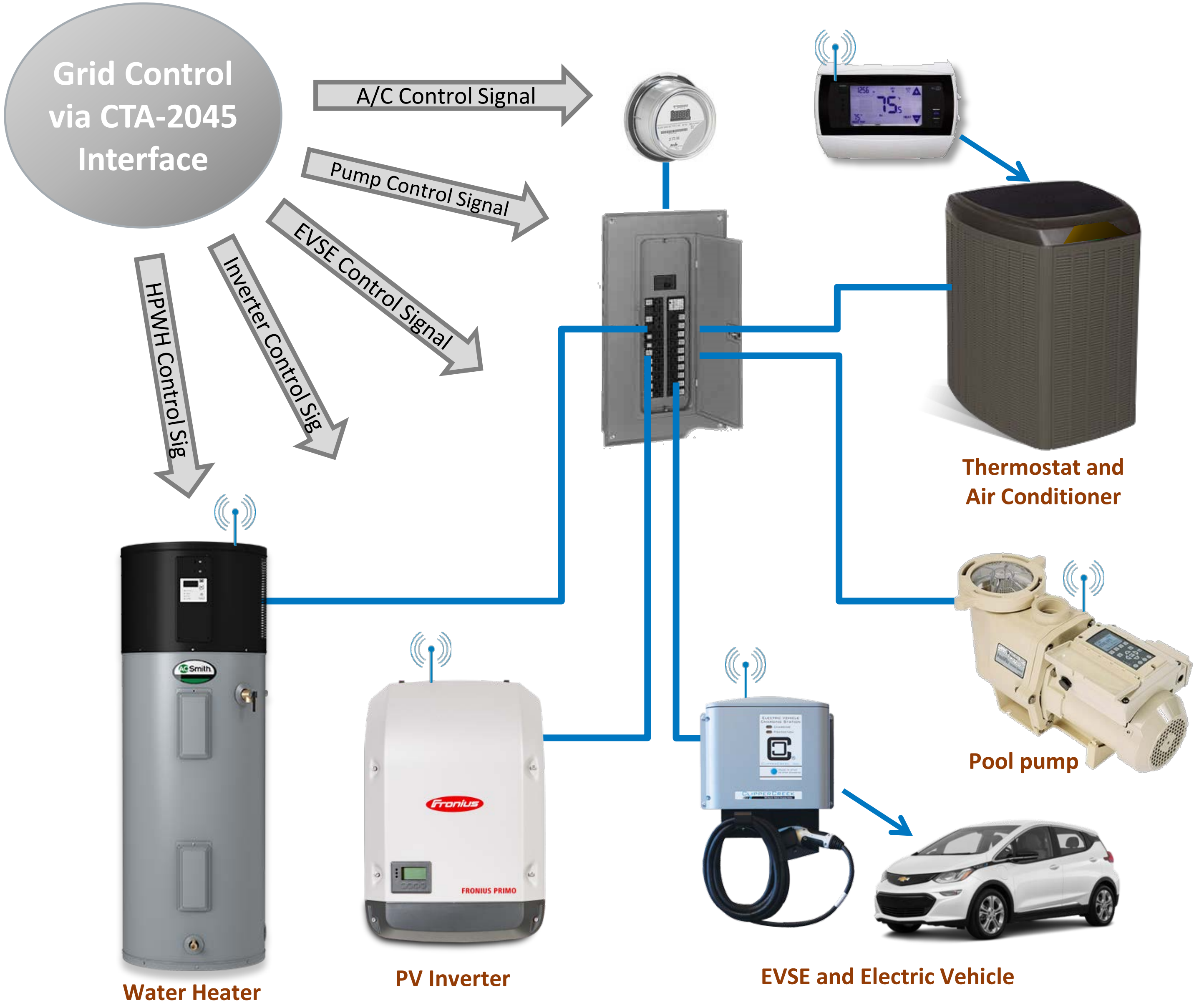
AO Smith. Innovation has a name.

PENTAIR

Fronius

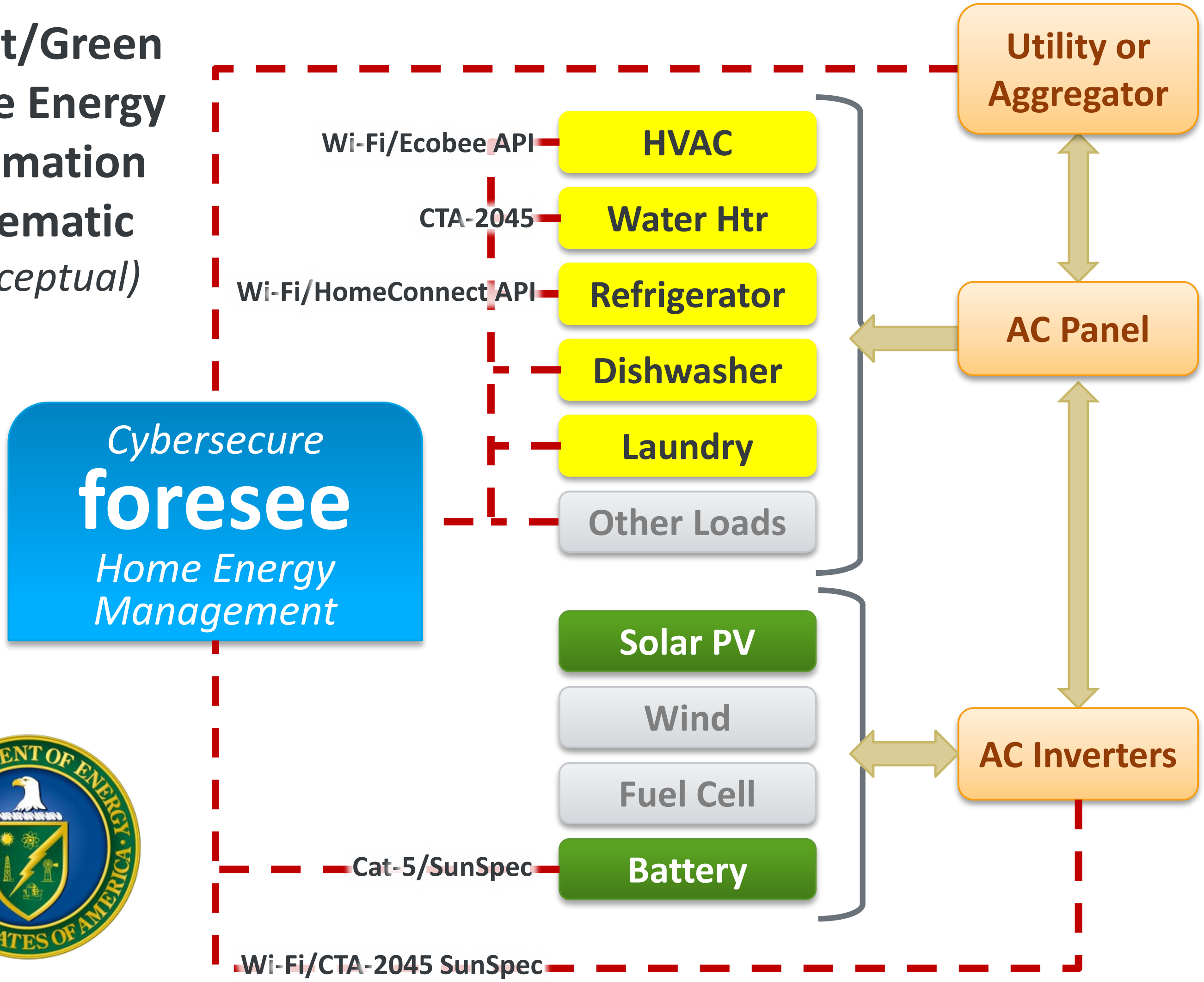
CLIPPERCREEK RELIABLE. POWERFUL. MADE IN AMERICA.

Radio Thermostat
Radio Thermostat Company of America



Emerging Research: Unifying Home Automation Services

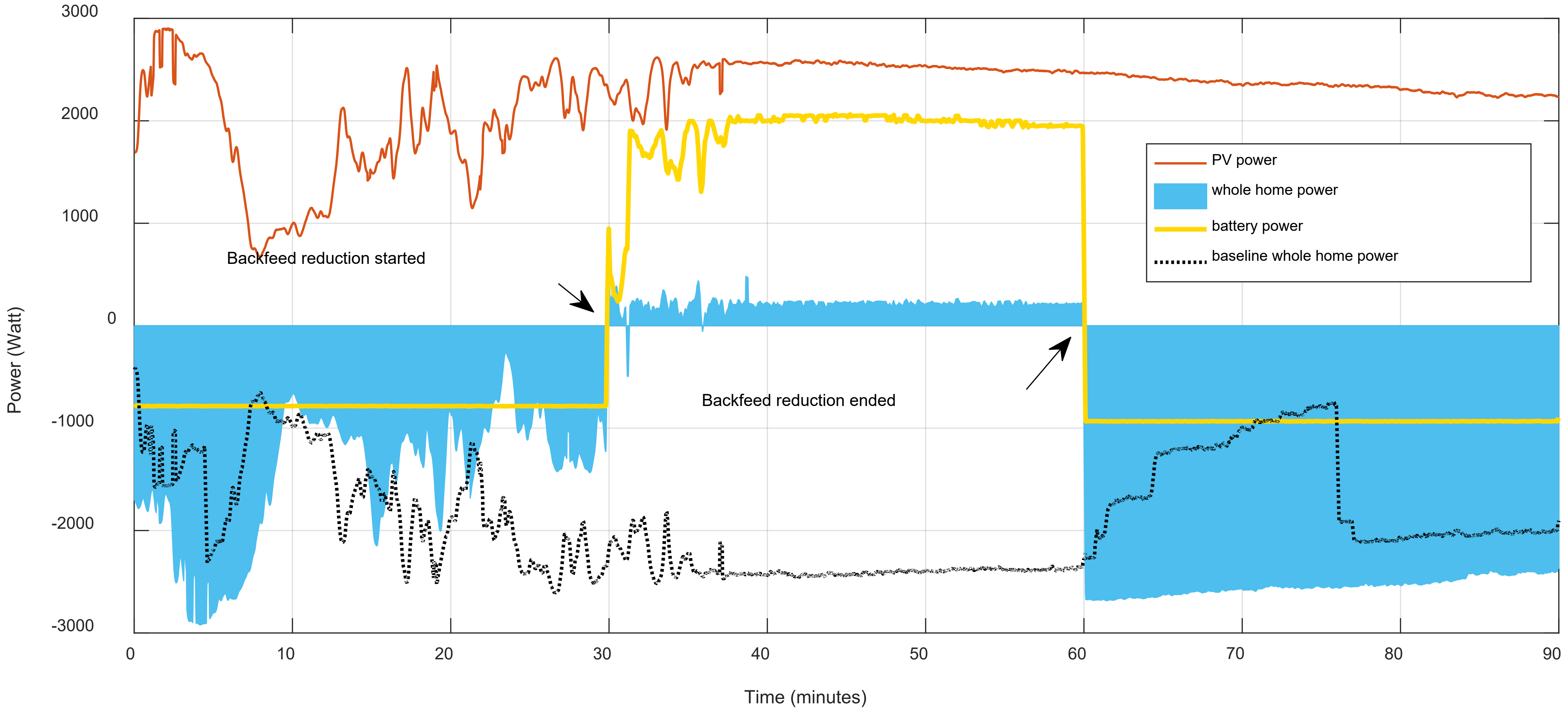
Smart/Green Home Energy Automation Schematic *(conceptual)*



Software Control Method: X. Jin, K. Baker, D. Christensen, and S. Isley, "Foresee™: A User-Centric Home Energy Management System for Energy Efficiency and Demand Response", Applied Energy (2017). http://www.sciencedirect.com/science/article/pii/S0306261917311856

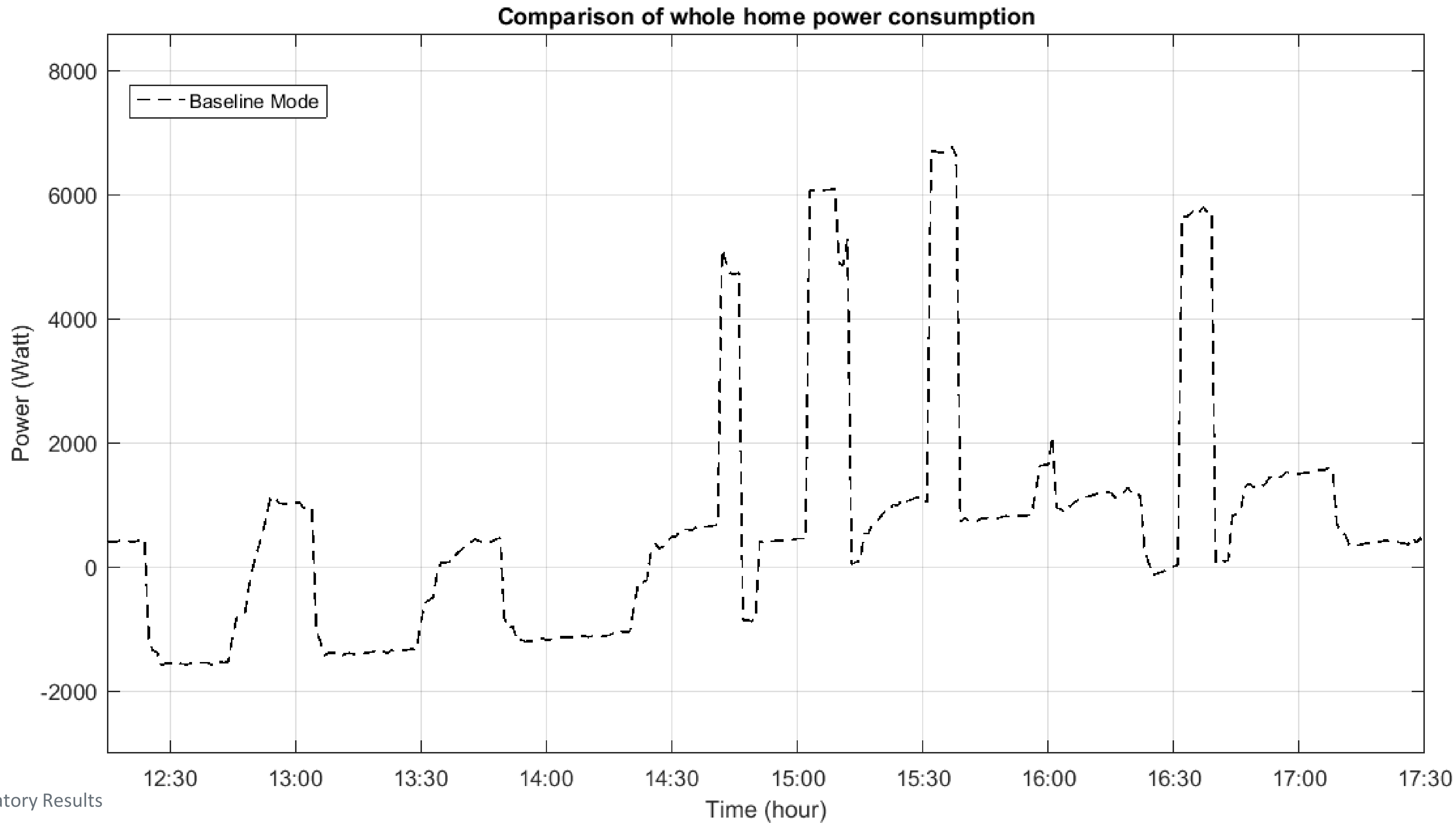
Laboratory Methodology: "Hardware-in-the-Loop Simulation of a Distribution System with Air Conditioners under Model Predictive Control" B Sparn, M Ruth, D Krishnamurthy, A Pratt, M Lunacek, W Jones - NREL/CP-5D00-67392, 2017. https://www.nrel.gov/docs/fy17osti/67392.pdf

Example Use Case: Solar Self-Consumption



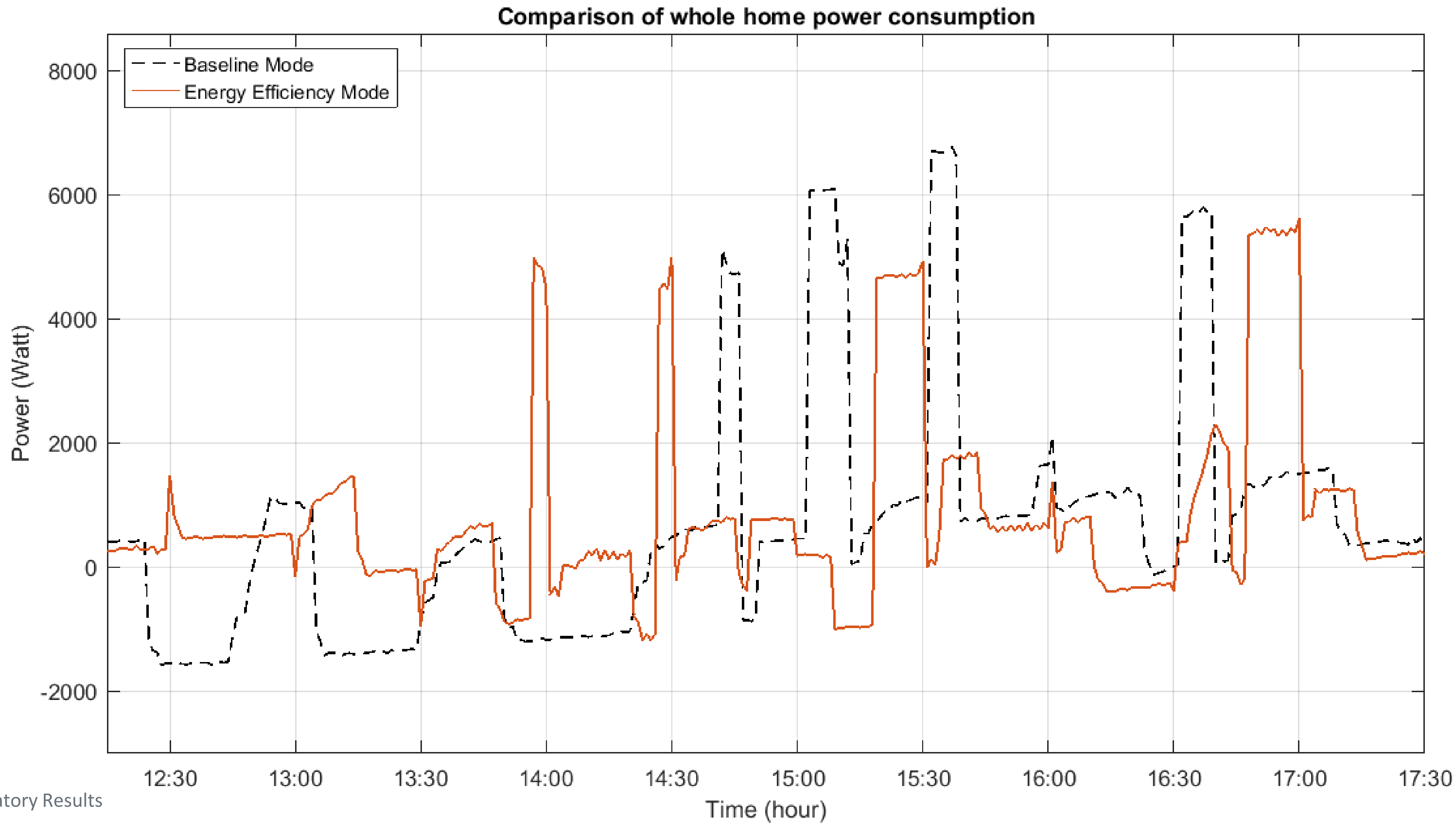
Preliminary Laboratory Results

Example Use Case: Demand Response



Preliminary Laboratory Results

Example Use Case: Demand Response



Preliminary Laboratory Results

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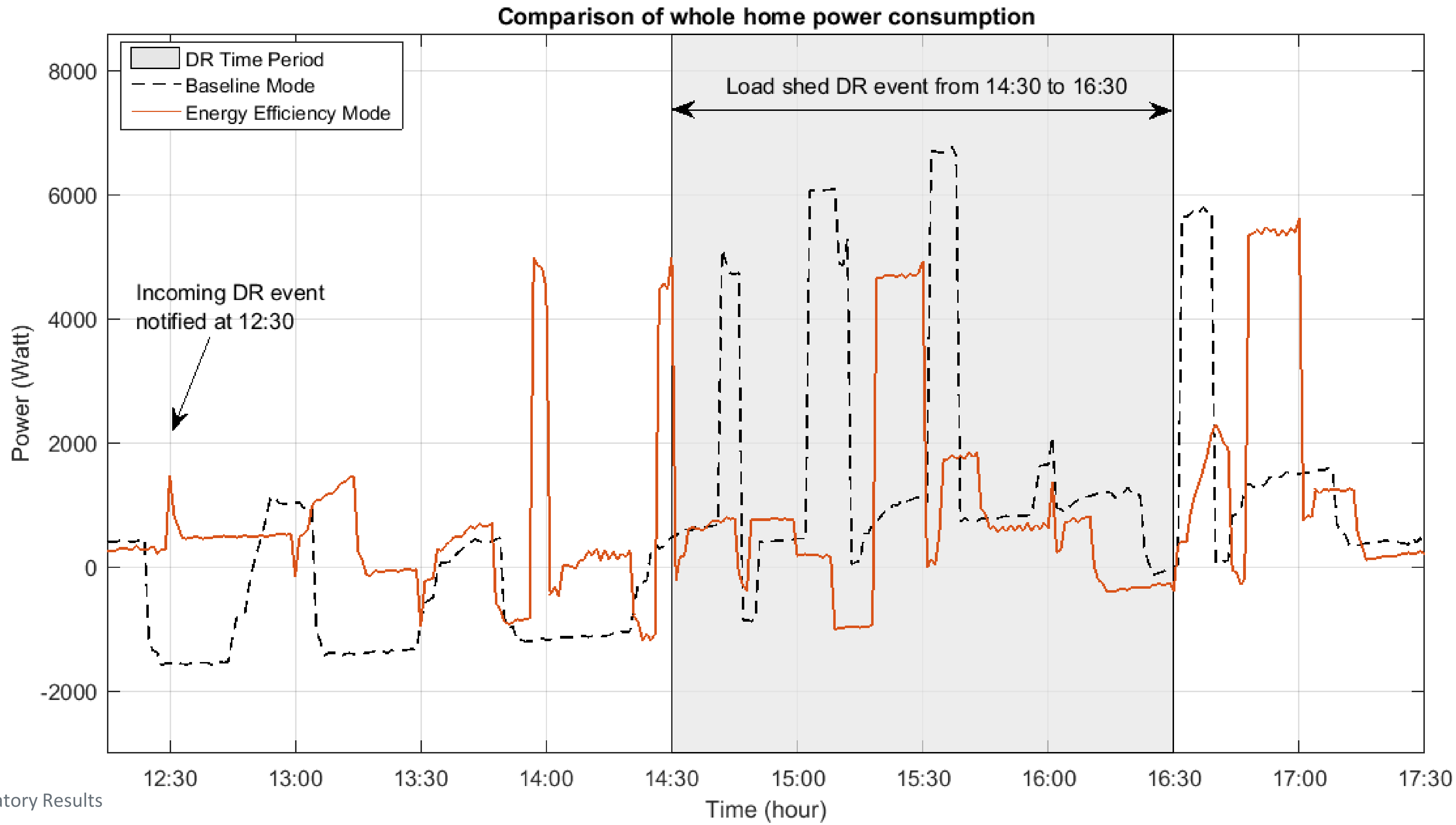

Preliminary Laboratory Results

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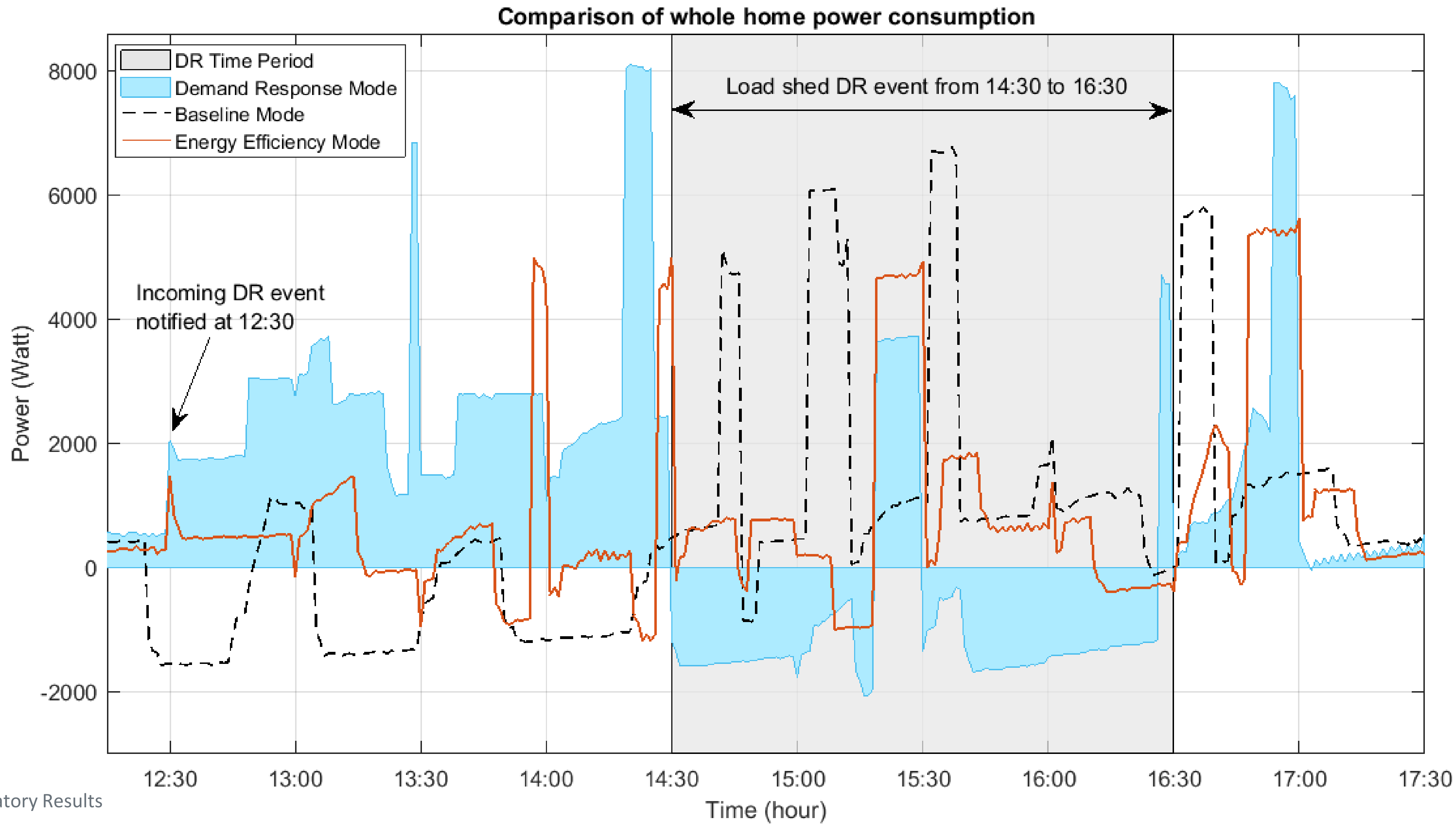
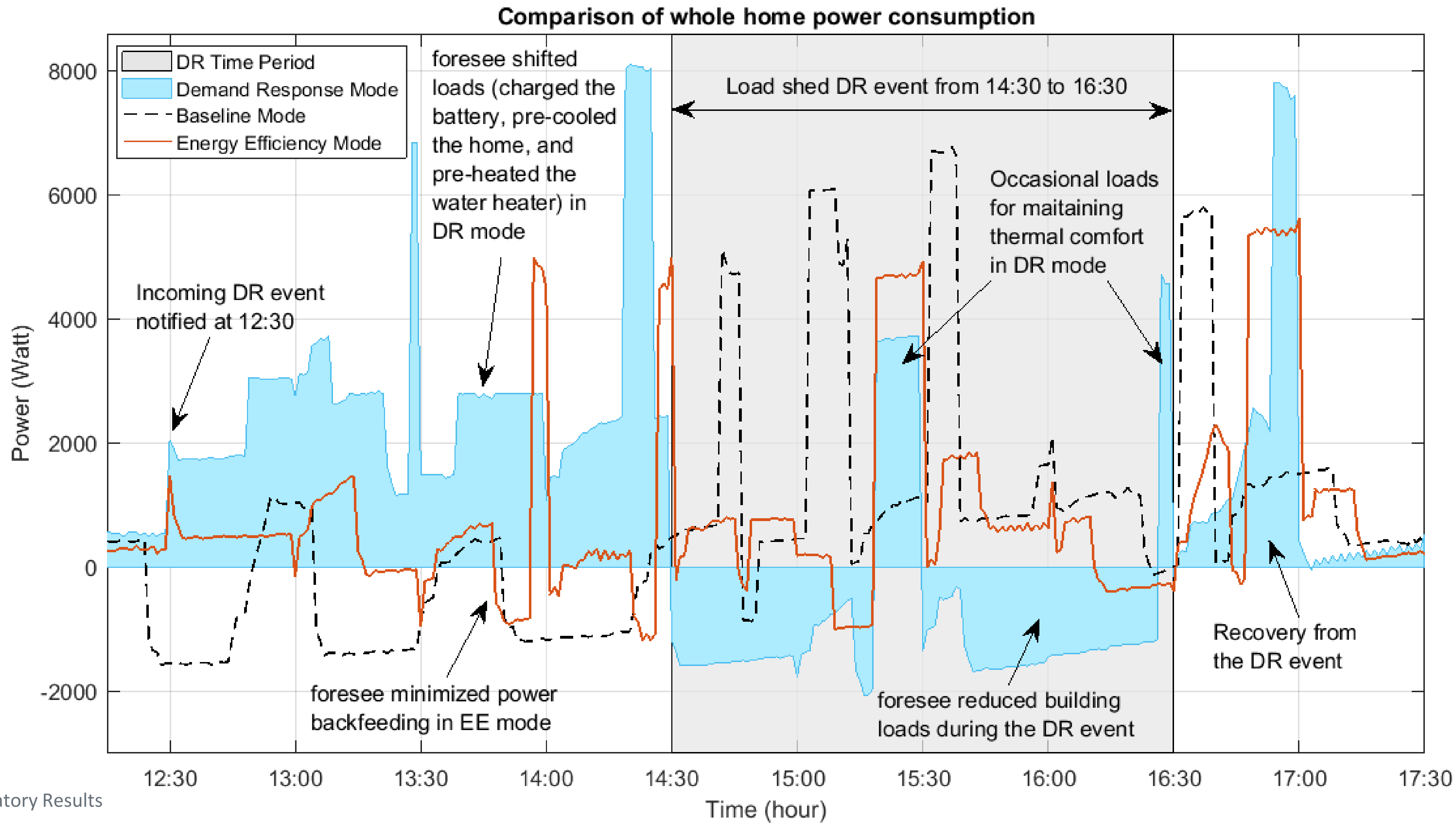


Preliminary Laboratory Results

Example Use Case: Demand Response



Preliminary Laboratory Results

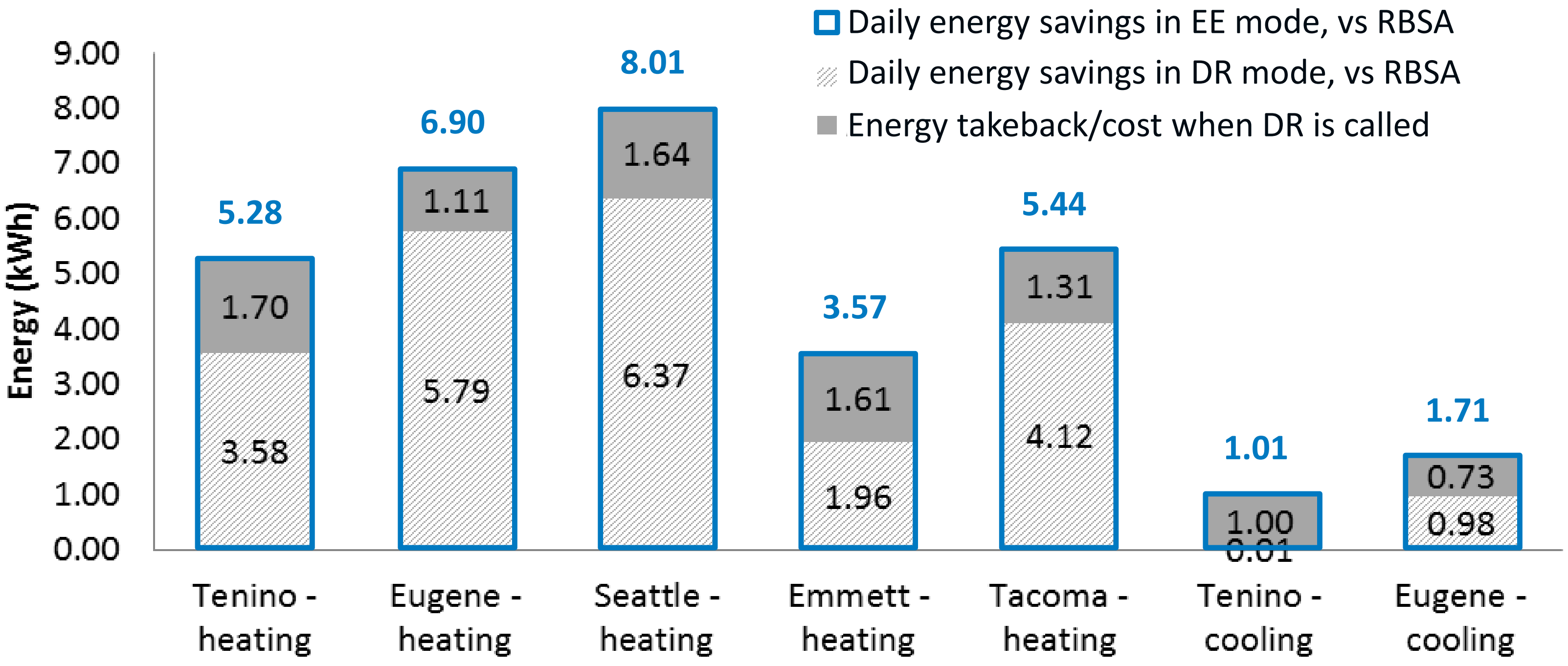
Daily Energy Savings Breakdown by Source

EE vs. baseline

Season	Heating					Cooling	
RBSA Home	Tenino	Eugene	Seattle	Emmett	Tacoma	Tenino	Eugene
Daily Energy Savings (kWh)	5.28	6.90	8.01	3.57	5.44	1.01	1.71
Daily Cost Savings ($)	0.58	0.76	0.88	0.39	0.60	0.11	0.19
Daily CO2 Reduction (lbs)	1.90	3.15	2.89	0.49	2.06	0.85	0.69

DR vs. baseline

Season	Heating					Cooling	
RBSA Home	Tenino	Eugene	Seattle	Emmett	Tacoma	Tenino	Eugene
Daily Energy Savings (kWh)	3.58	5.79	6.37	1.96	4.12	0.01	0.28
Daily Cost Savings ($)	0.39	0.64	0.70	0.22	0.45	0.00	0.11
Daily CO_2 Reduction (lbs)	0.82	2.09	0.55	-0.27	0.66	0.76	0.53

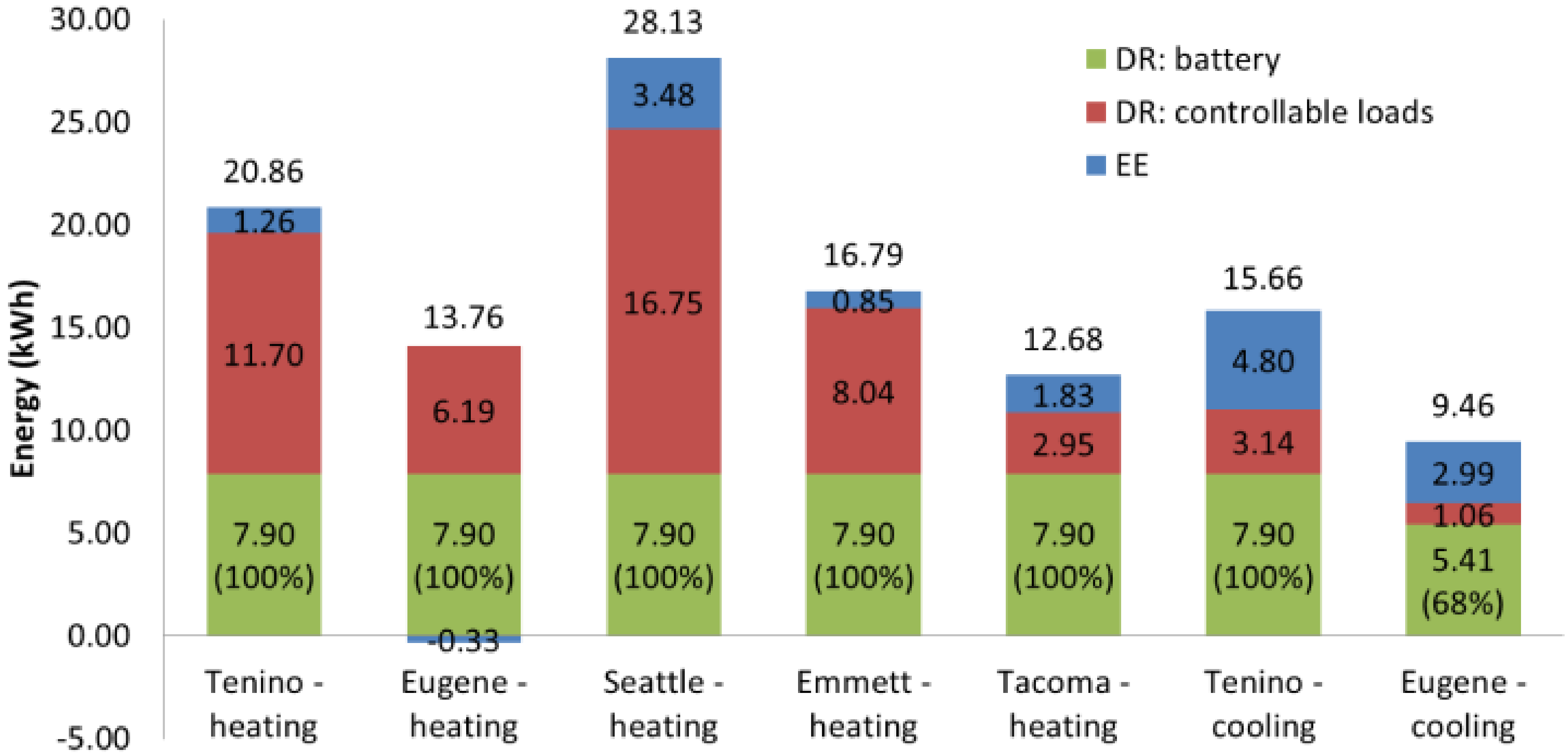


(Simulated INC Event: 4-hour load-shed DR)

DR Load Reduction Breakdown by Source

DR vs. baseline

Season	Heating					Cooling	
RBSA Home	Tenino	Eugene	Seattle	Emmett	Tacoma	Tenino	Eugene
DR Forecast Error	8.08%	10.01%	2.10%	10.68%	-4.23%	9.29%	7.69%
DR Grid Energy Reduction (kWh)	20.86	13.76	28.13	16.79	12.68	15.66	9.46
DR Average Power Reduction (kW)	5.22	3.44	7.03	4.20	3.17	3.91	2.37



- Batteries were fully utilized except one low-load home
- Significant contributions from reduction of controllable loads

(Simulated INC Event: 4-hour load-shed DR)

Summary of Findings… so far:

- Interoperability is maturing across the smart buildings market very quickly
- Unified operation of multiple devices has numerous benefits
- Win-win solutions can exist for homeowners, utilities, and society to mutually benefit
- Rate structures have strong influence on how the equipment will be operated under automation
- Cybersecurity is an emergent barrier:
  - *Protect consumers & utilities*
  - *Manage aggregated devices as Critical Infrastructure*

Thank you!

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