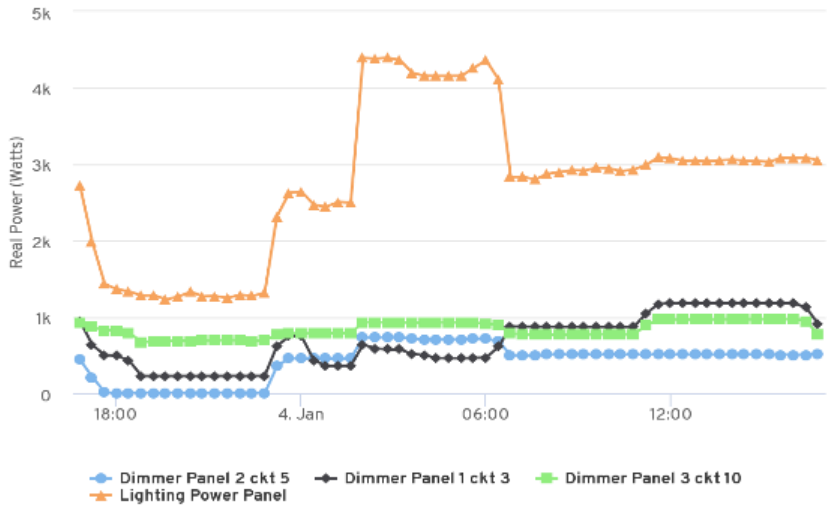
VAEEC Spring 2019 Forum

Blending Technologies to Maximize Building Efficiency

George Barnes, Trane
Rodes Boyd, Siemens
Nick Lange, VEIC
Eric Oliver, 2RW Consultants

Sponsored by Local Energy Alliance Program

leap
local energy alliance program



VAEEC Spring Forum

Continuous Auditing and RTEM

May 9, 2019

Eric Oliver, PE, CEM, LEED^{AP}
Director, Energy Solutions

2RW ENERGY BY DESIGN

RTEM/Continuous Auditing

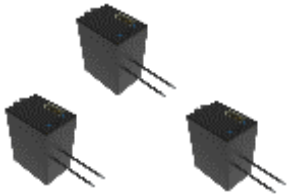
Monitoring a facility in real time over the course of 6-12 months to identify immediate AND ongoing opportunities for Energy Conservation Measures (ECM).

- Perform initial energy audit
- Install circuit-level Real Time Monitoring system
- Track component-level Energy consumption over time
  - Trained energy experts will investigate trends in real time
  - Flag energy waste
  - Identify and quantify new ECMs
  - Track ECMs over time (before/after implementation)

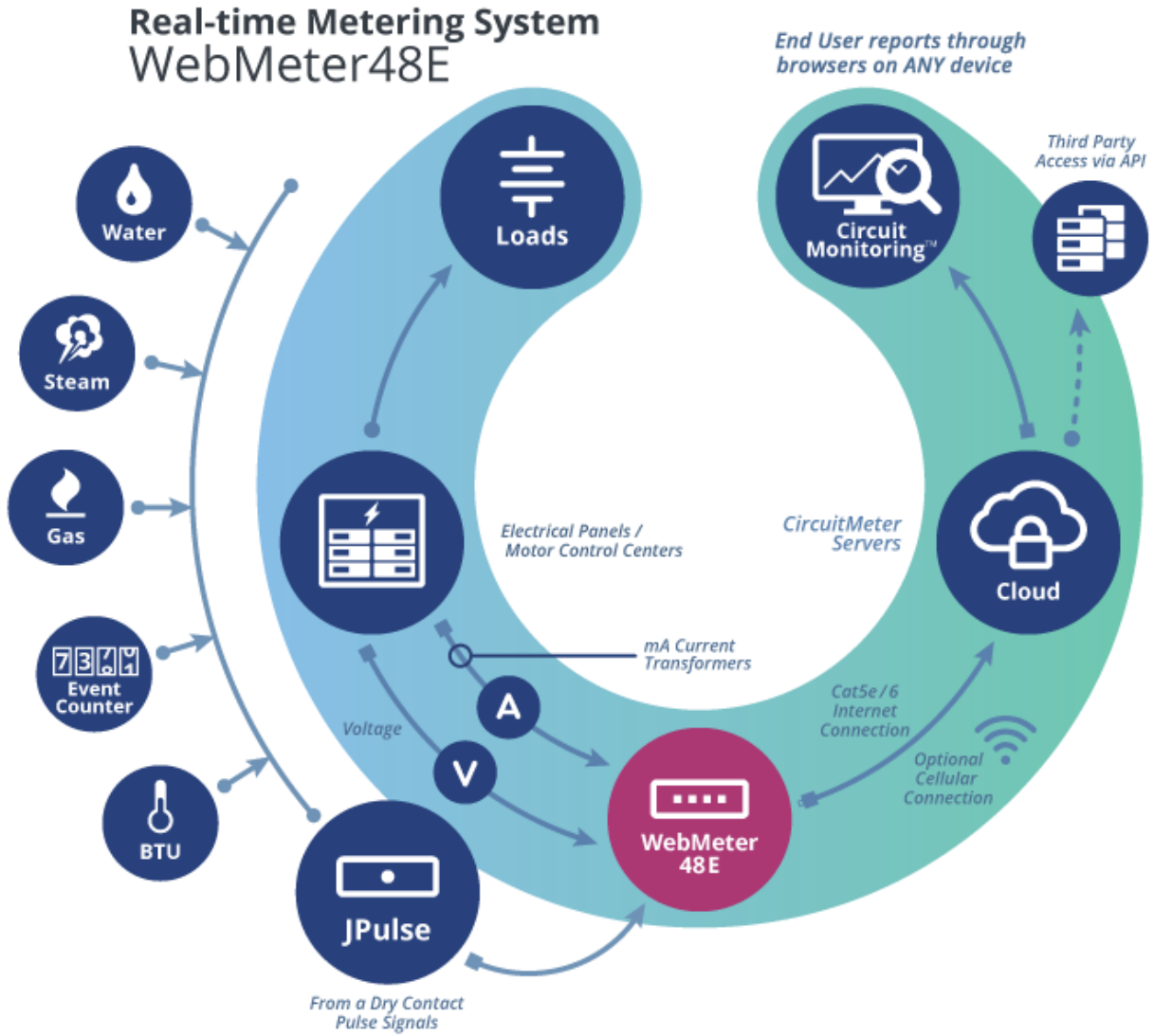
HOW IT WORKS

Intelligent IoT sensors monitor energy usage in real-time

Data Collector
- 48 inputs, fully enclosed
- Accepts pulse data



Circuit-level nodes
- Collect data and transmit to DC
- 10A to 200A capacities

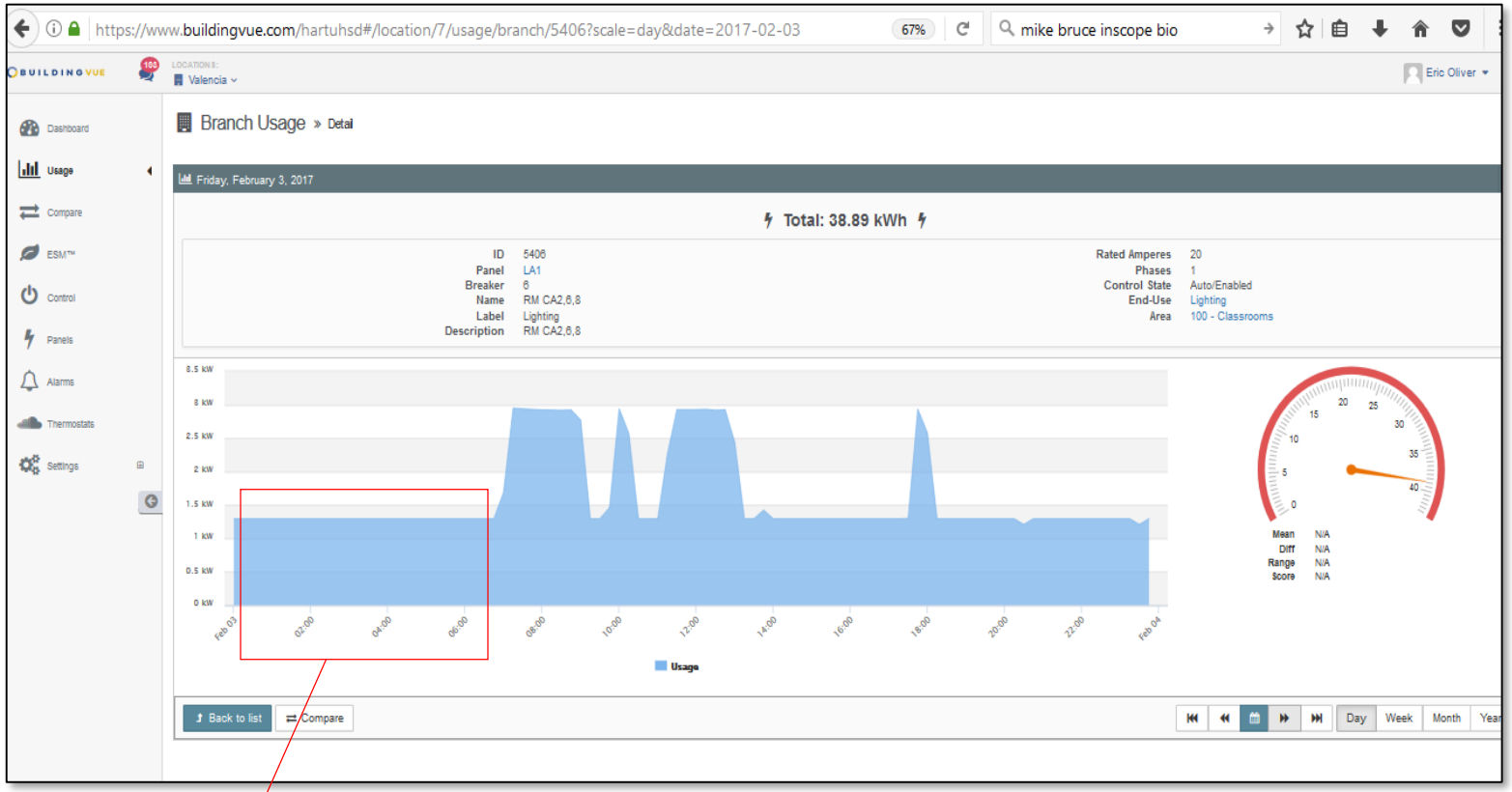


REAL TIME DASHBOARD

Granular visualization into up-to-the-minute energy consumption

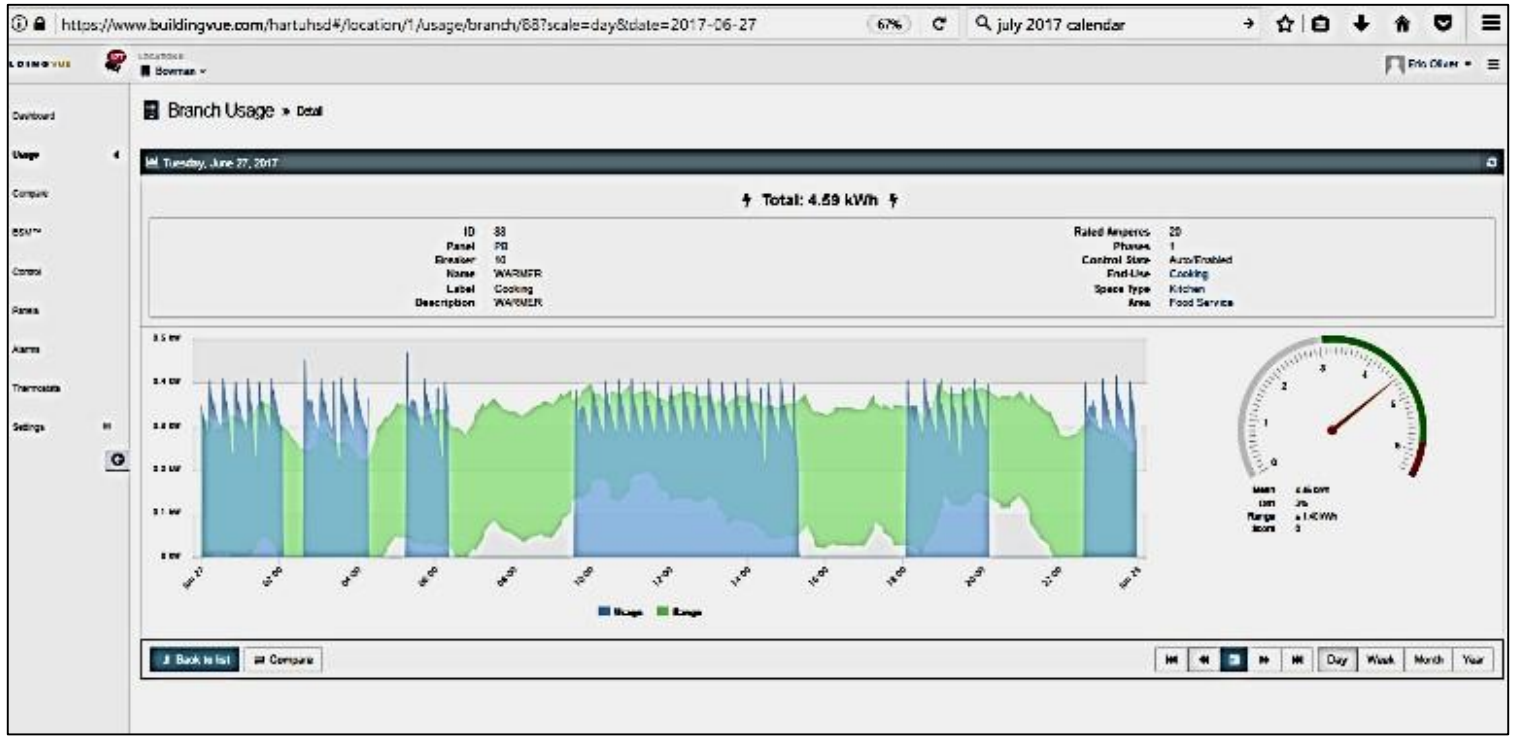
ENERGY-SAVING MEASURES

Real time monitoring exposes energy waste and provides opportunities for automatic or manual energy reduction



Classroom lights left on at night

OBSERVE **TRENDS** TO IDENITFY **ENERGY WASTE**

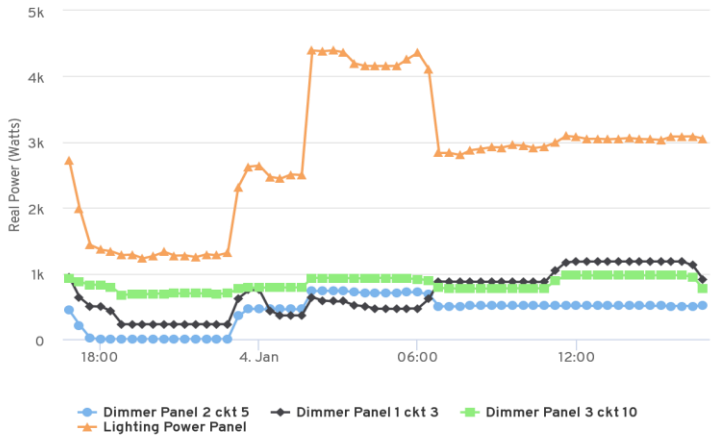


Kitchen food warmer

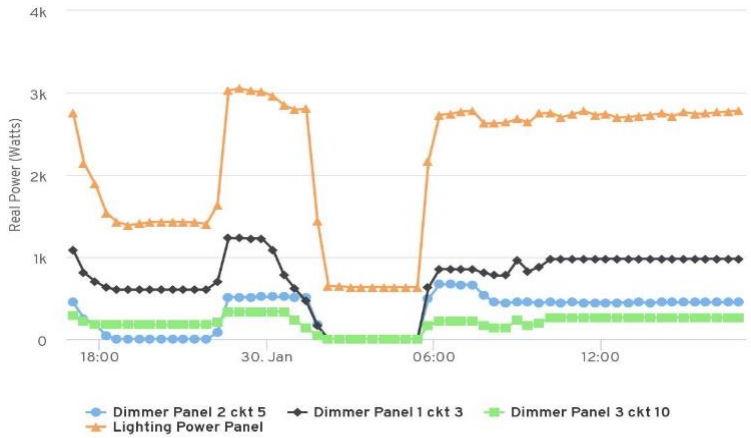
ECM SAVINGS VERIFICATION

ECM: Instruct Cleaning Crew to shut down lights in areas not being cleaned

24-hour Lighting Consumption Before and After



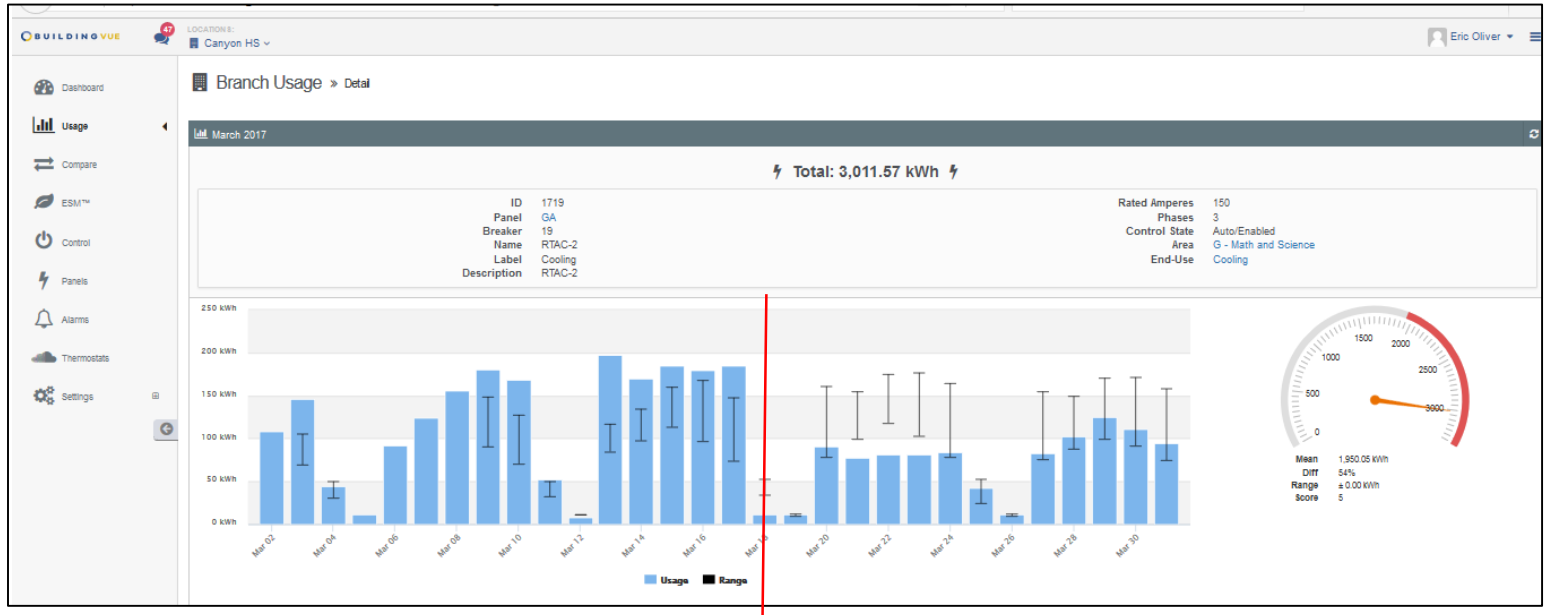
Before Adjustment



After Adjustment

MEASUREMENT & VERIFICATION

Circuit-level RTEM provides automatic M&V for any ECM



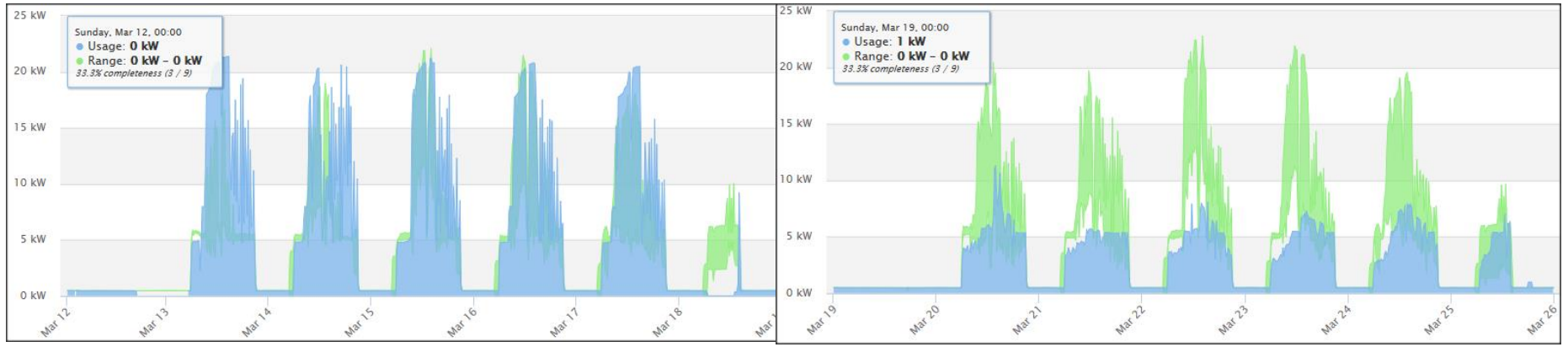
Pre-installation consumption

Post-installation consumption

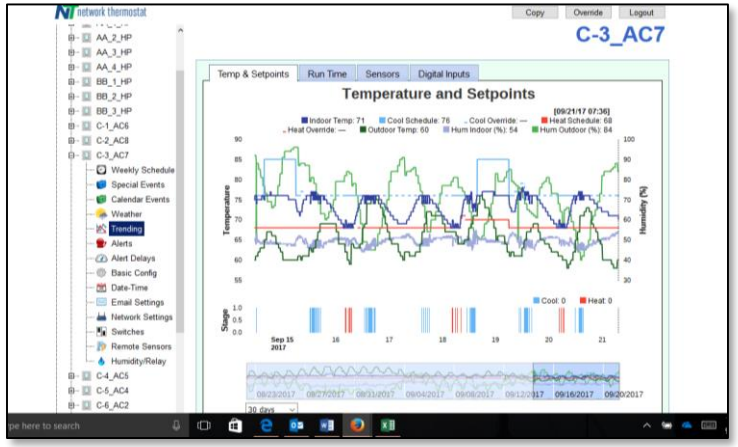
VFD installed on RTAC

ECM SAVINGS VERIFICATION

Circuit-level RTEM provides automatic M&V for any ECM



Energy Data



Temperature Data

average daily kWh	weekdays	weekends	
pre-installation	125.1	28.0	
post-installation	92.5	23.3	
ann. Extrapolated no VSD	32,537	2,940	
ann. Extrapolated w/VSD	24,042	2,450	
annual savings	8,495	490	
		8,985	**kWh**

Weather-normalized annually extrapolated

CONTINUOUS AUDITING SYSTEM BENEFITS

Energy Audit	Continuous Auditing
Facility assessment is a snapshot in time	Ability to analyze the performance of the building across time and seasons
Energy savings based on assumptions and projections for operations	Energy savings based on actual run-hours and performance metrics in real time
	Abnormal energy consumption identified and corrected before it wastes too much money
ECM M&V can be a separate task order	Post ECM-implementation performance measured and verified as part of Data Analytics

QUESTIONS?

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https://vaeec.org/event/spring-2019-forum/

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Smart Buildings

Harnessing the Power of Data to Transform Facilities

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usa.siemens.com/smartbuildings

Smart Building Revolution

Delivering Operational Excellence & Enhanced Occupant Experience

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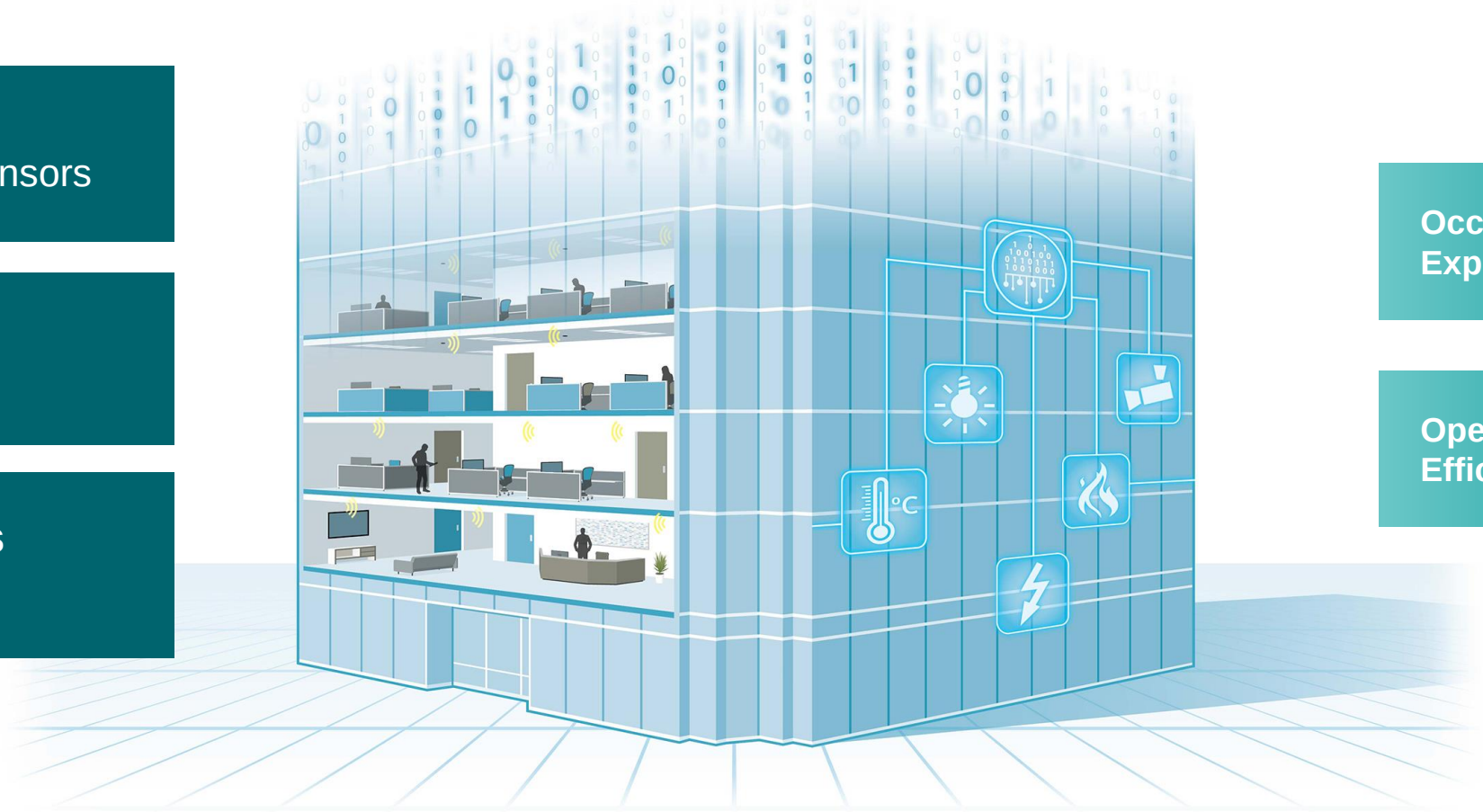
Connecting People
IoT Network of Smart Sensors

Analyzing Data
Data Analytics Platform

Connecting Systems
Integration Platform



Occupant Experience

Operational Efficiency

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Smart Building Sensory System

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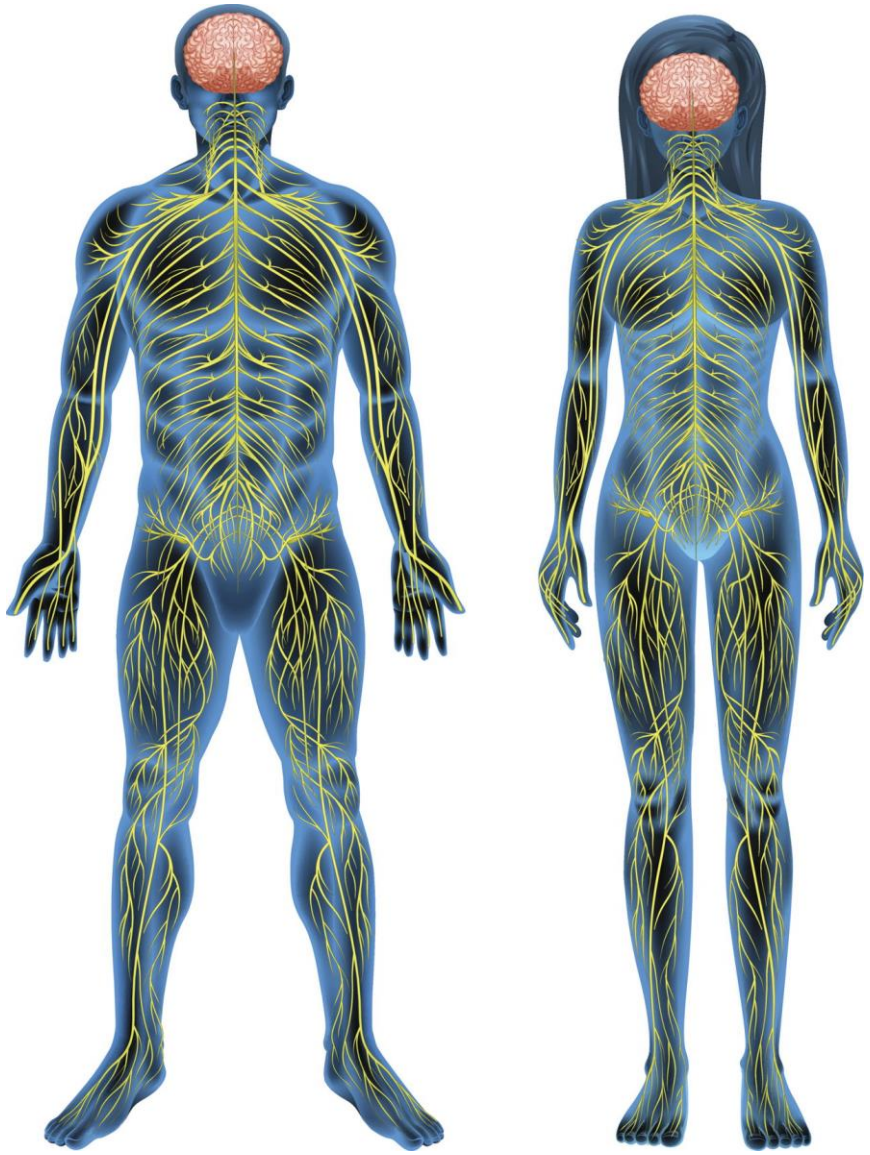

Brain-
Central
Processing/Learning

Spine-
Transmission Backbone

Hands-
Sense of touch

Cloud

Wireless
Backbone

Sensor Unit

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Open, integrated ecosystem leverages the power of data

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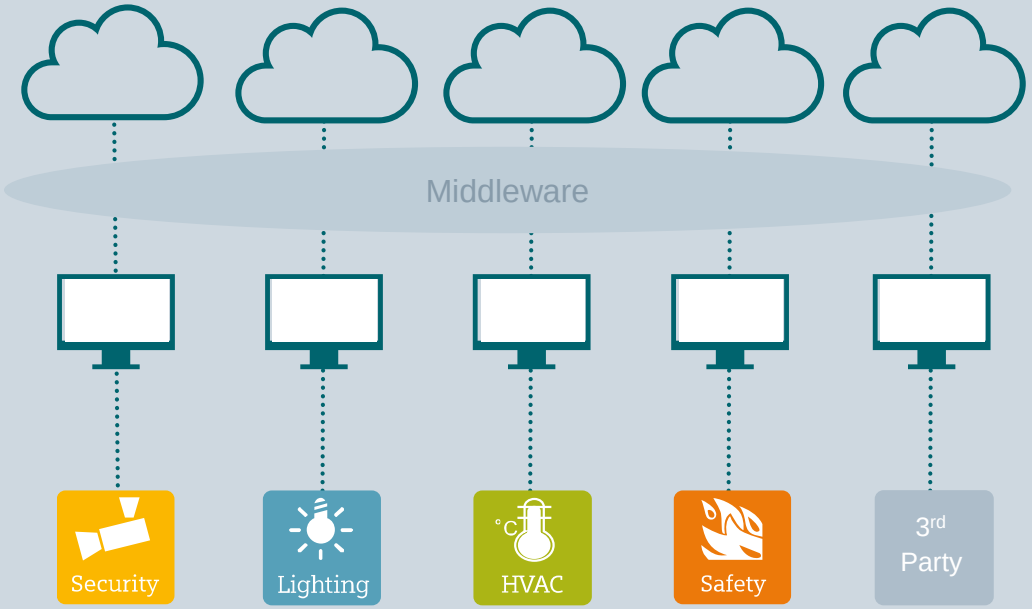
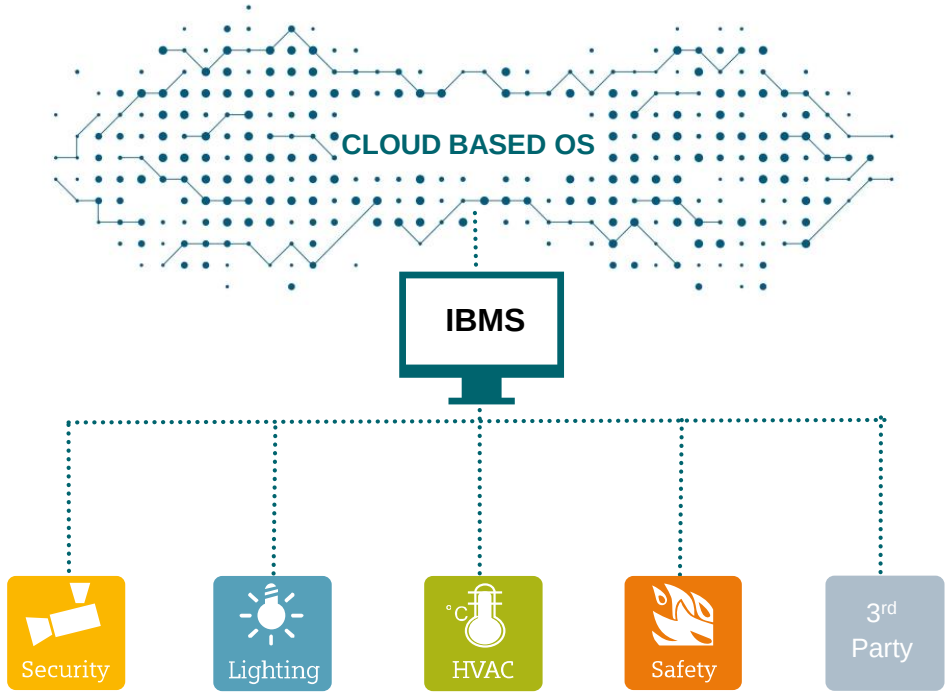
Traditional Approach
Disparate buidling systems increase installation and operating costs and limits connectivity and use of data.

Smart Building Approach
An open, integrated ecosystem with all systems connected via an integrated building management system, fully leveraging the power of data to drive business outcomes. Results in **lower capital and operating expenditures** and **enhanced capabilities**.

Closed, multi-system architecture



Open, integrated ecosystem



IBMS provides the technology backbone for your smart infrastructure

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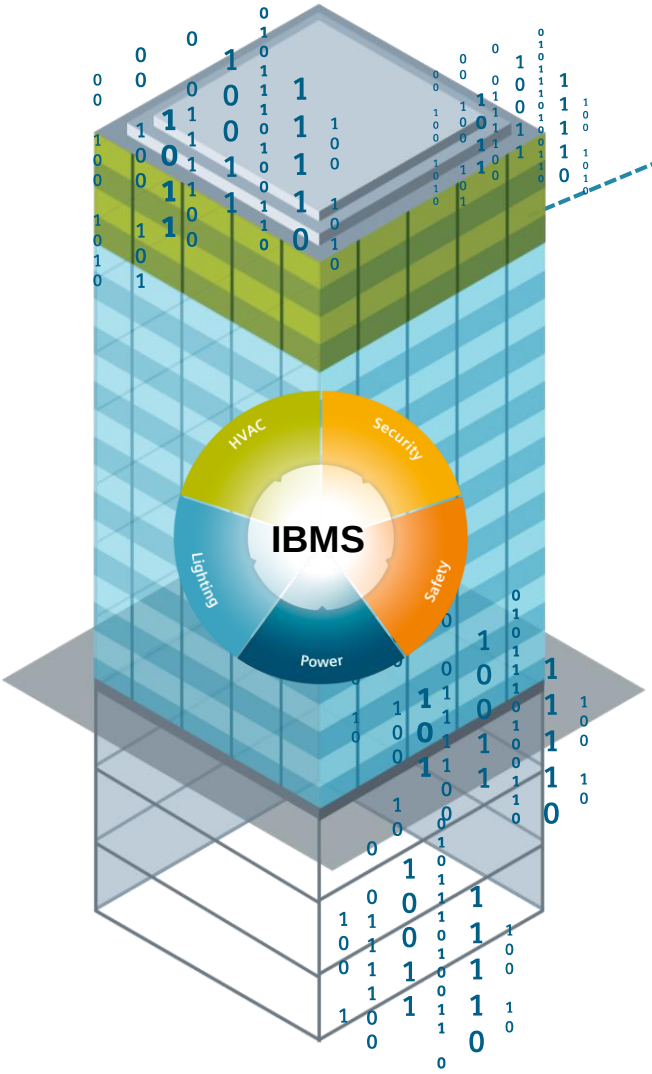

Northbound | Apps and service layer

Ecosystem Apps

Own Apps

Remote Services

Enrich with Apps & services

- Powerful open APIs
- Create own Apps or leverage the Ecosystem
- Platform to provide services

IBMS is an open platform that enables building systems to communicate & interoperate. Centralized access to data provides visibility and drives the right business decisions.

Adapt and tailor

- Flexible and modular system
- Unique user interface
- Powerful building management functionality

Southbound | physical network layer

Security | HVAC | Safety | Lighting | 3rd Party

Integrate all

- Integrate subsystems from multiple disciplines via global standards such as BACnet, Modbus, Zigbee, LoRa, ETC.

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Smart-Connected Building Vision

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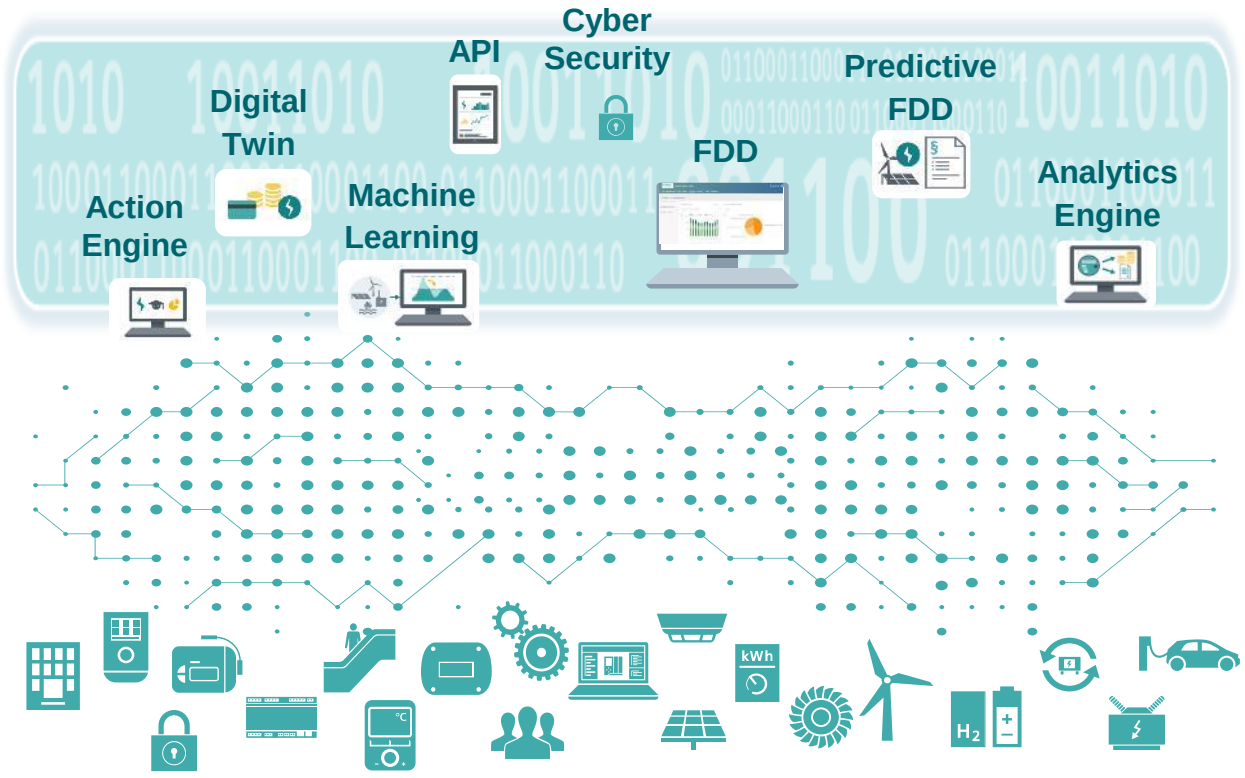
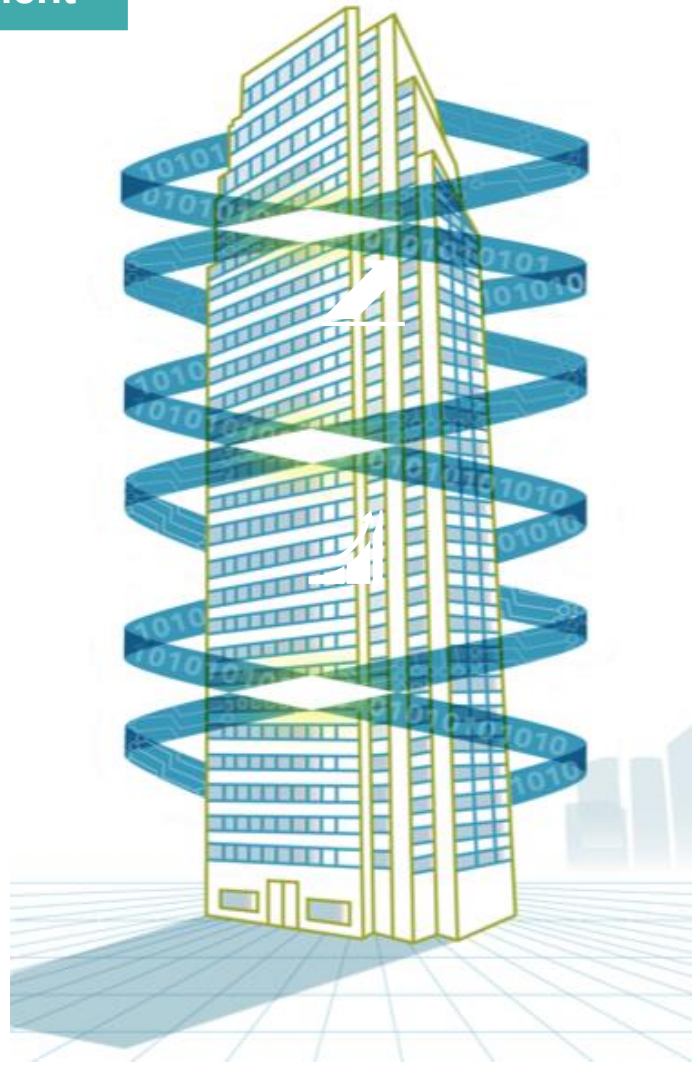
Comfortable & Safe	Energy & Asset Efficient	Space & User Efficient

Digital Applications & Services

Intelligent Infrastructure

Cloud OS
IBMS
IoT Devices





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Occupant Experience + Operational Efficiencies = Increased Energy Efficiency

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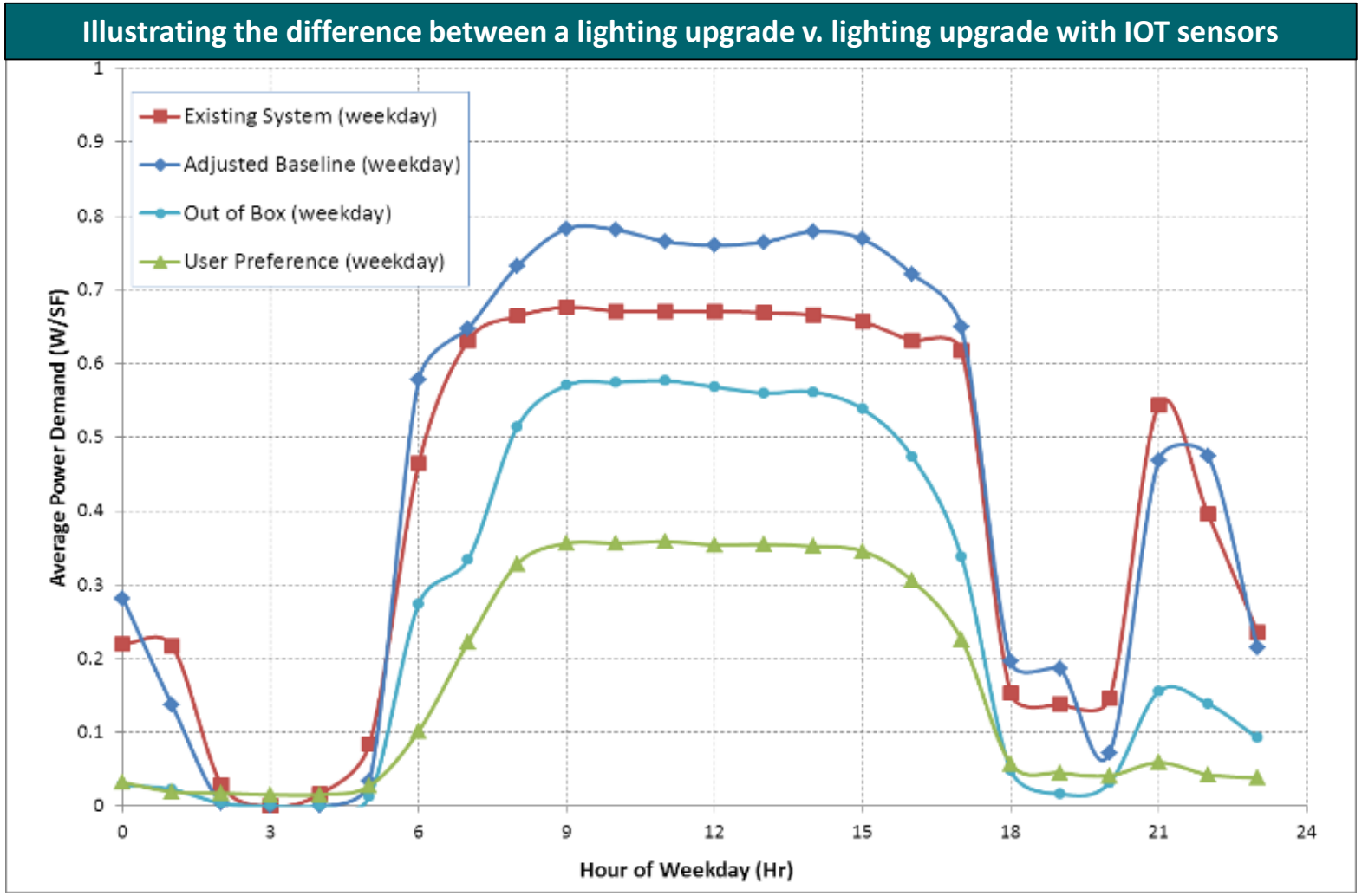

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May 9, 2019

Smarter Smarts

VAEEC Spring Forum

VEIC

What kind of title is that? What's this talk really about?

Today's Topics:	What we've learned (so far) …
Smart Thermostats	*Cautionary Tales from a "Connected Canary"*
Advanced Home Energy Monitors	*Capturing Savings + Hidden Benefits*
Energy Problem "Wickedness"	*Coherency, Contradiction & Change*

“In a world deluged by ever-increasing amounts of complexity and information…
… clarity is power.”

~ Yuval Noah Harari
21 Lessons for the 21st Century

VEIC

Always consider the source

BASIS:

32 years of “full stack” energy services

8 years of deep work with AMI & device data

4 principles clarify + drive our connectivity efforts

BIAS:

find & fix market failures

in strategic support of partners

show results & benefit for all

Smart Thermostats:

Cautionary tales from a "connected canary"

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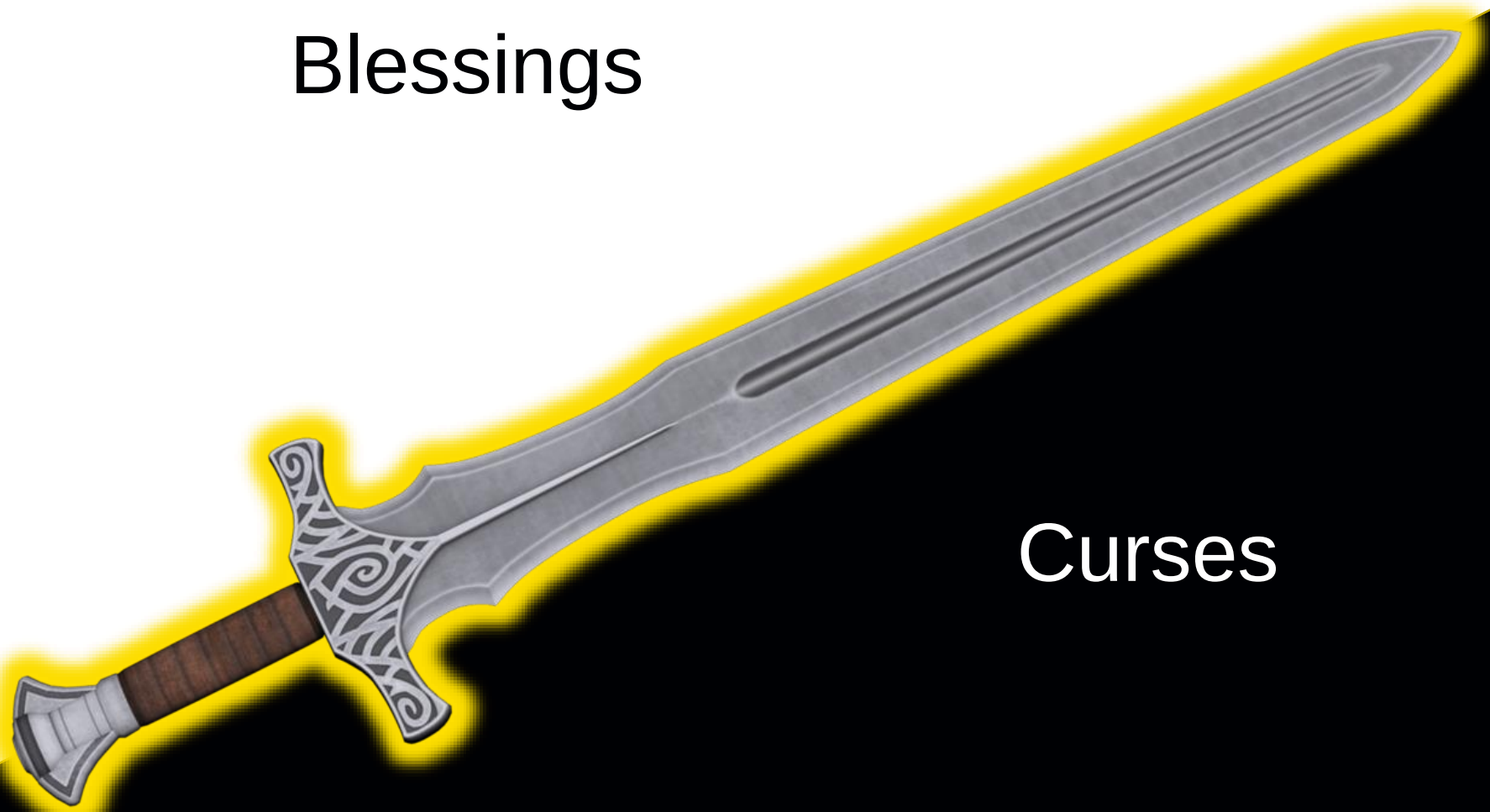
DID YOU EMBRACE INNOVATION, CONNECTIVITY, AND DATA?
YES
WHAT DID IT COST?
EVERYTHING

Now what?

Blessings



Curses

Connectivity is a double-edged sword…

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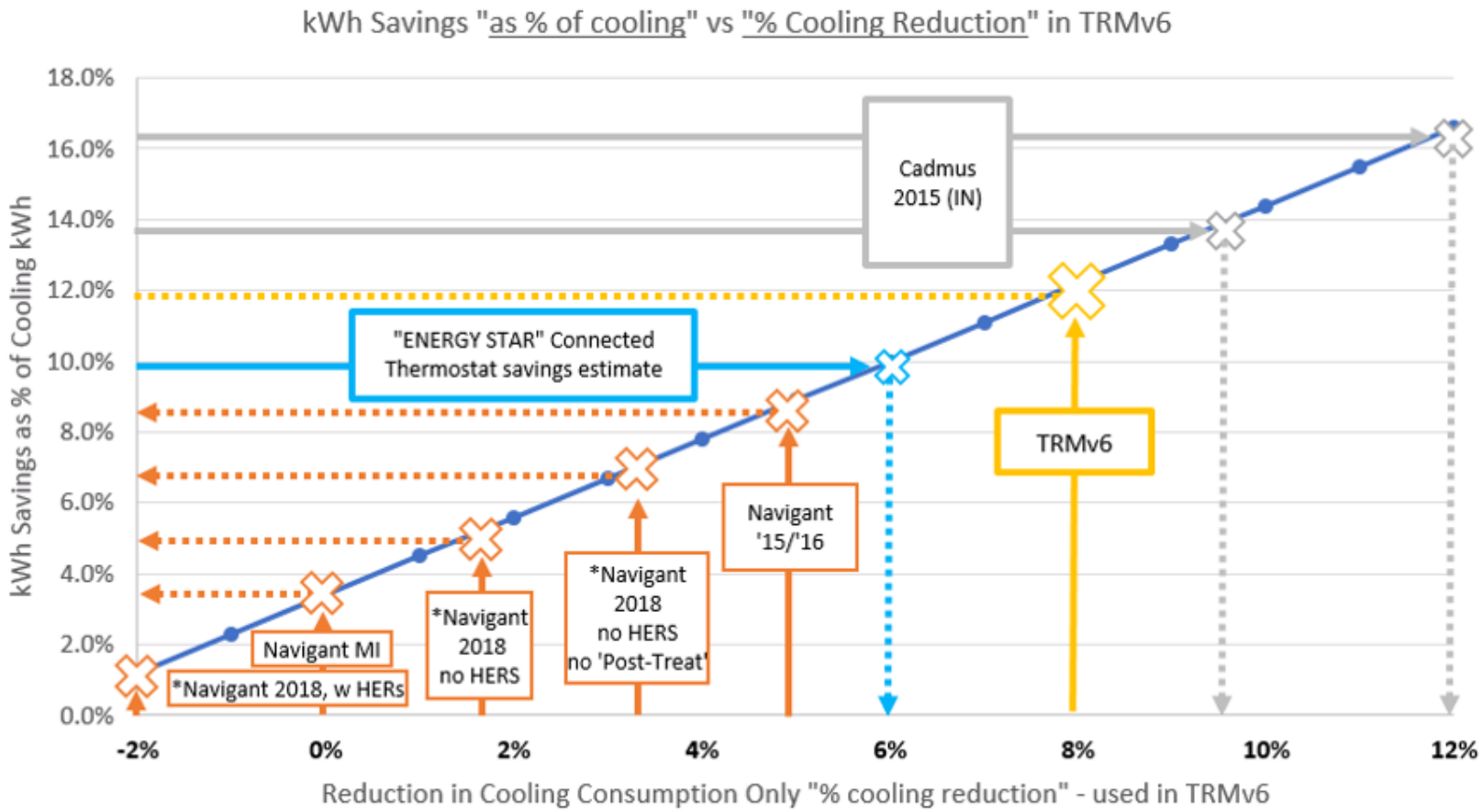
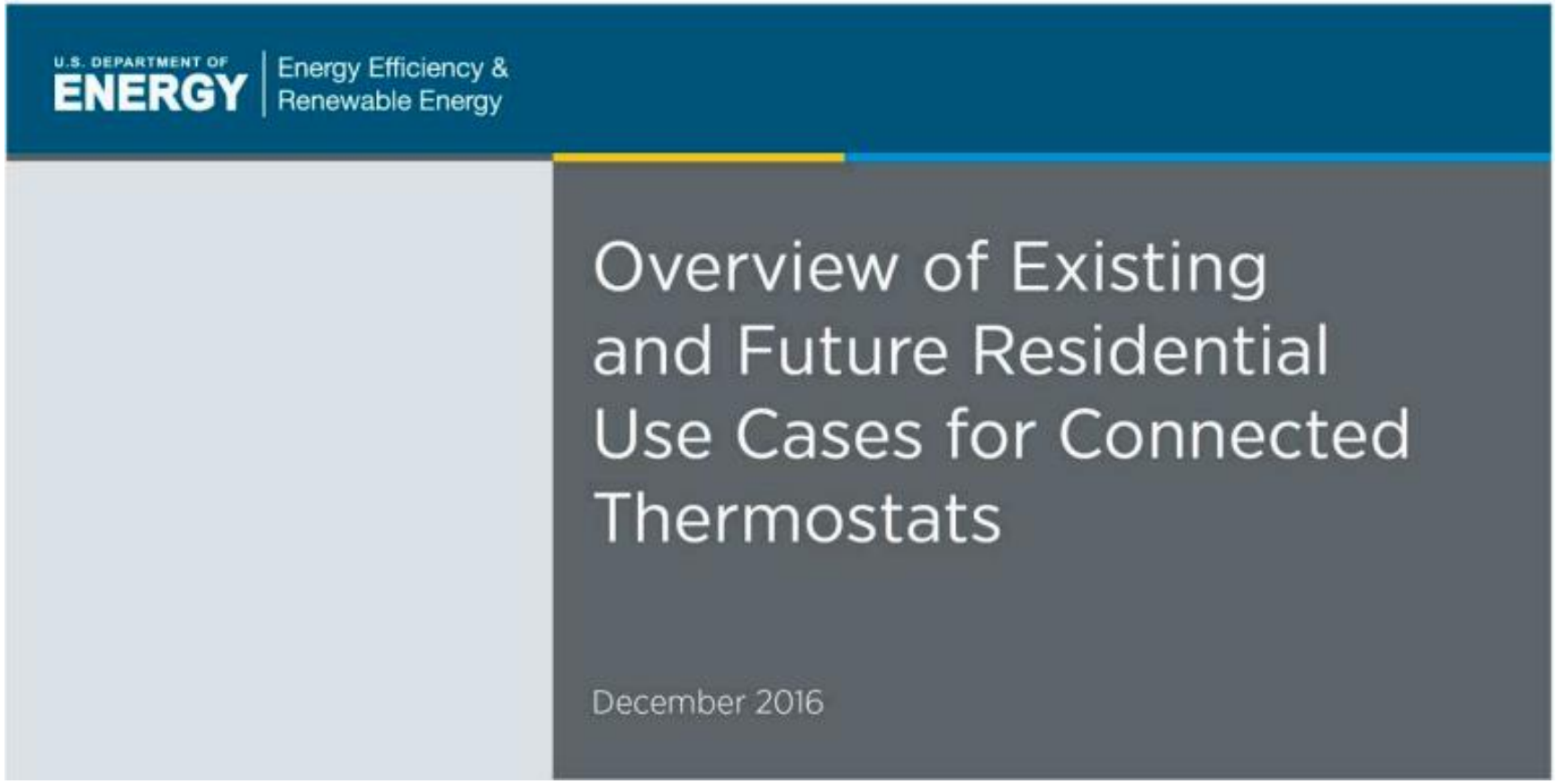
Problem: What does a Smart Thermostat Save?

What's a _____ to do?

1. Program Administrator
2. Evaluator
3. Regulator
4. Manufacturer
5. Customer



ca. 2015


U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
Overview of Existing and Future Residential Use Cases for Connected Thermostats
December 2016
BUILDING TECHNOLOGIES OFFICE
Prepared for:
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office
energy.gov/eere/buildings

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Market Transformation

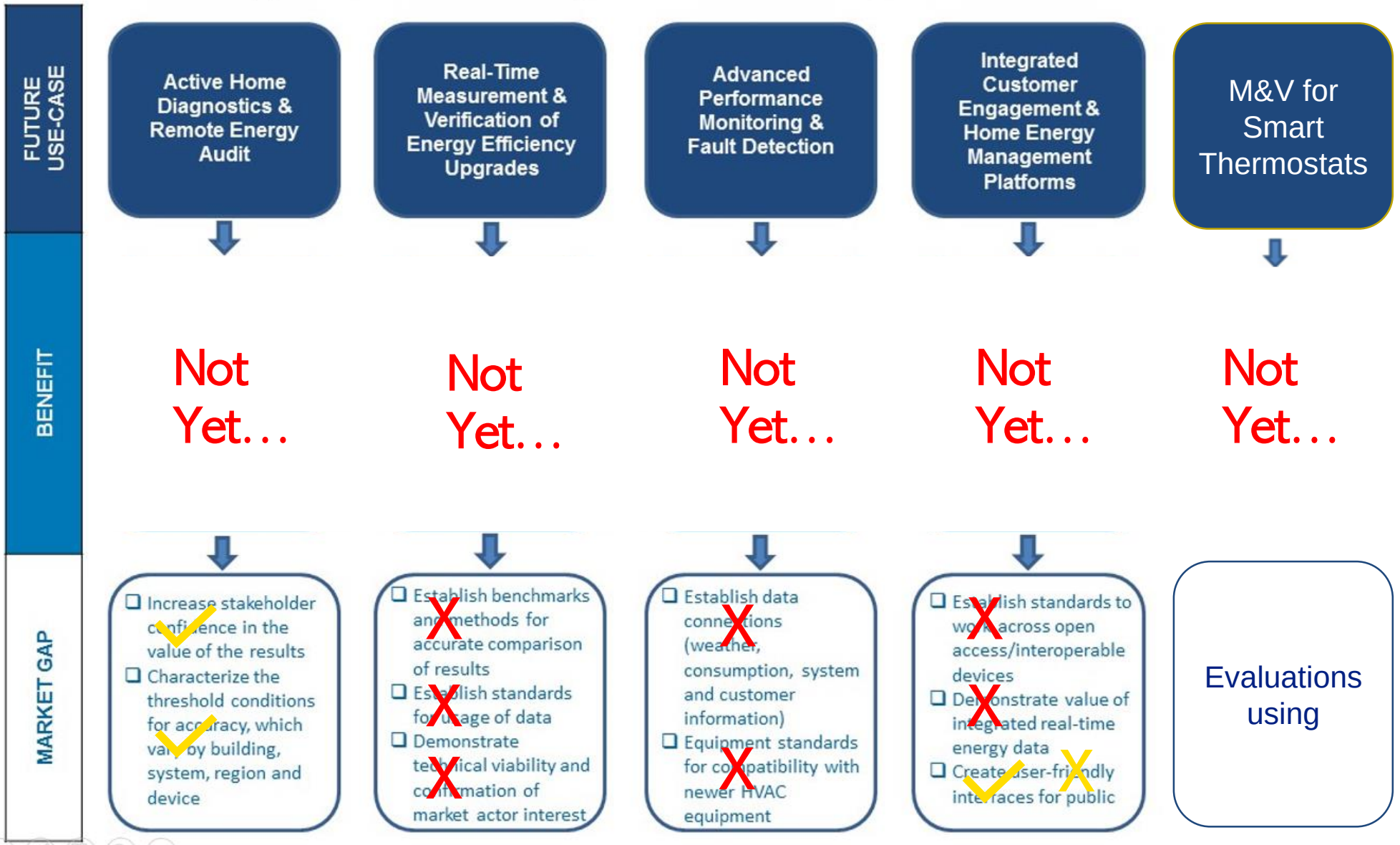
Opportunities and Gaps for Future CT Use Cases

FUTURE USE-CASE				
	Active Home Diagnostics & Remote Energy Audit	Real-Time Measurement & Verification of Energy Efficiency Upgrades	Advanced Performance Monitoring & Fault Detection	Integrated Customer Engagement & Home Energy Management Platforms

Update on "the future"

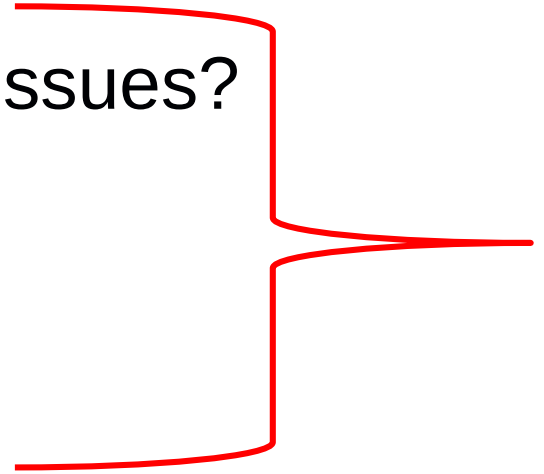
Benefits realized?

Market gaps addressed?



Cautionary Tales from a Connected Canary

1. Privacy, security and logistics issues?
2. Business constraints?
3. Science and research needs?
4. True market transformation?



How can we get there?

Advanced Home Energy Monitors

Capturing Savings + Hidden Benefits

Today's Topics:	**What we've learned (so far) …**
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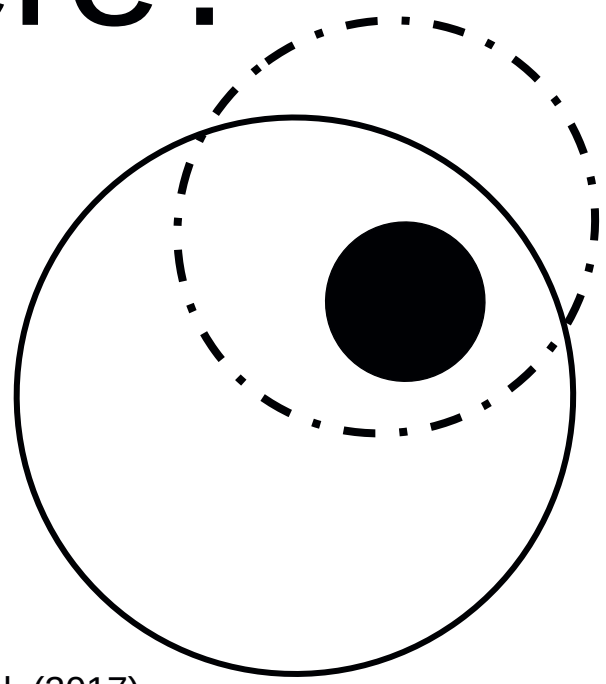
Advanced Home Energy Monitors	*Capturing Savings + Hidden Benefits*
Energy Problem "Wickedness"	*Coherency, Contradiction & Change*

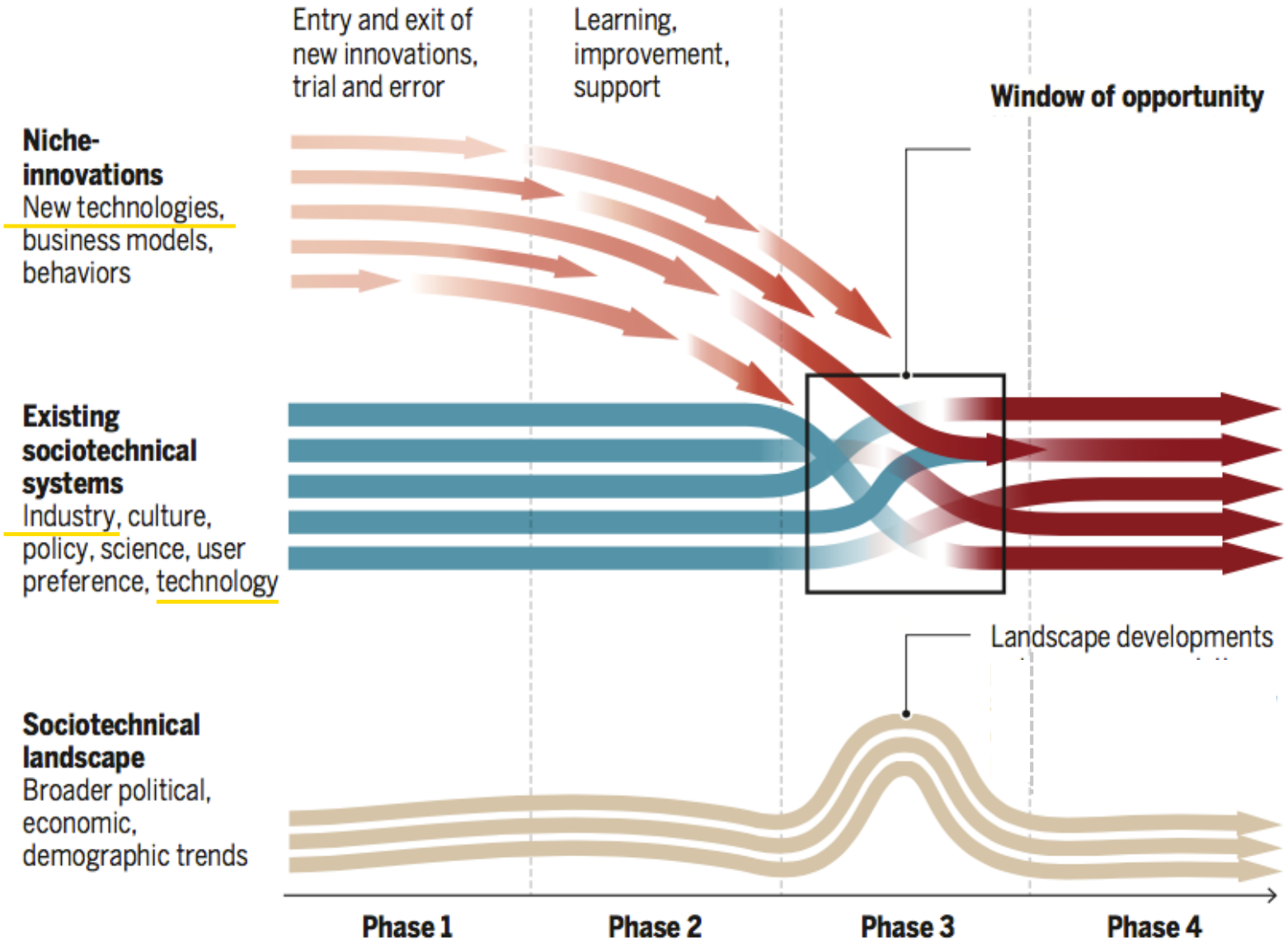
Home Energy Monitors

- A class of technology – whole home + devices
  - Stand-alone and connected to a smart grid – ***or not***
  - Real-time – ***or not***
  - Robust feedback systems & controls – ***or not***
  - Low-friction UI/UX (e.g. voice, phone app) – ***or not***

What are we doing here?



Geels et al. (2017)



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The Vision

Measurable:

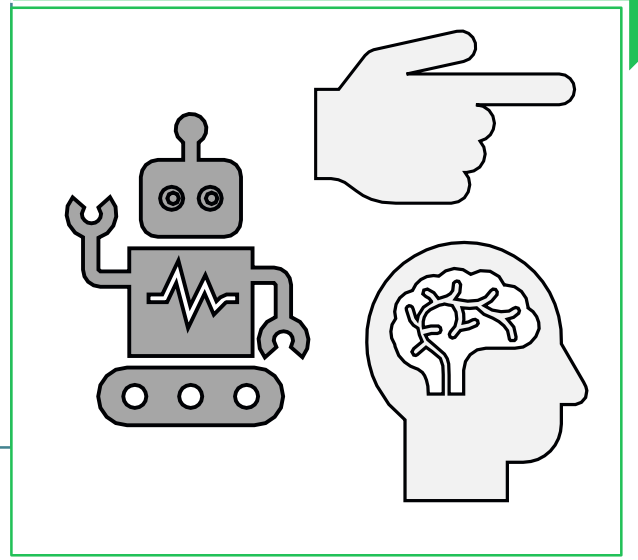
Monitor Energy [Technology]

- Accurate
- Precise
- Reliable
- Appropriate
- Affordable

Deliver Feedback [Information]

- Clear
- Compelling
- Frictionless

Change [Behavior]

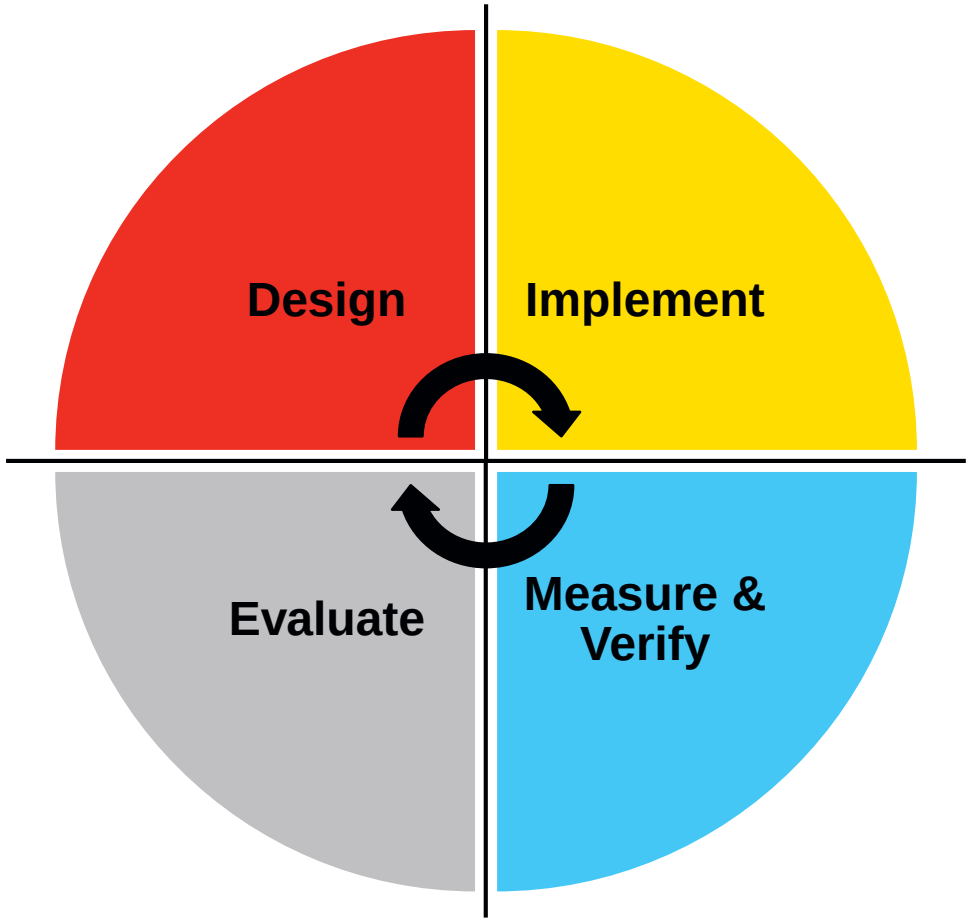


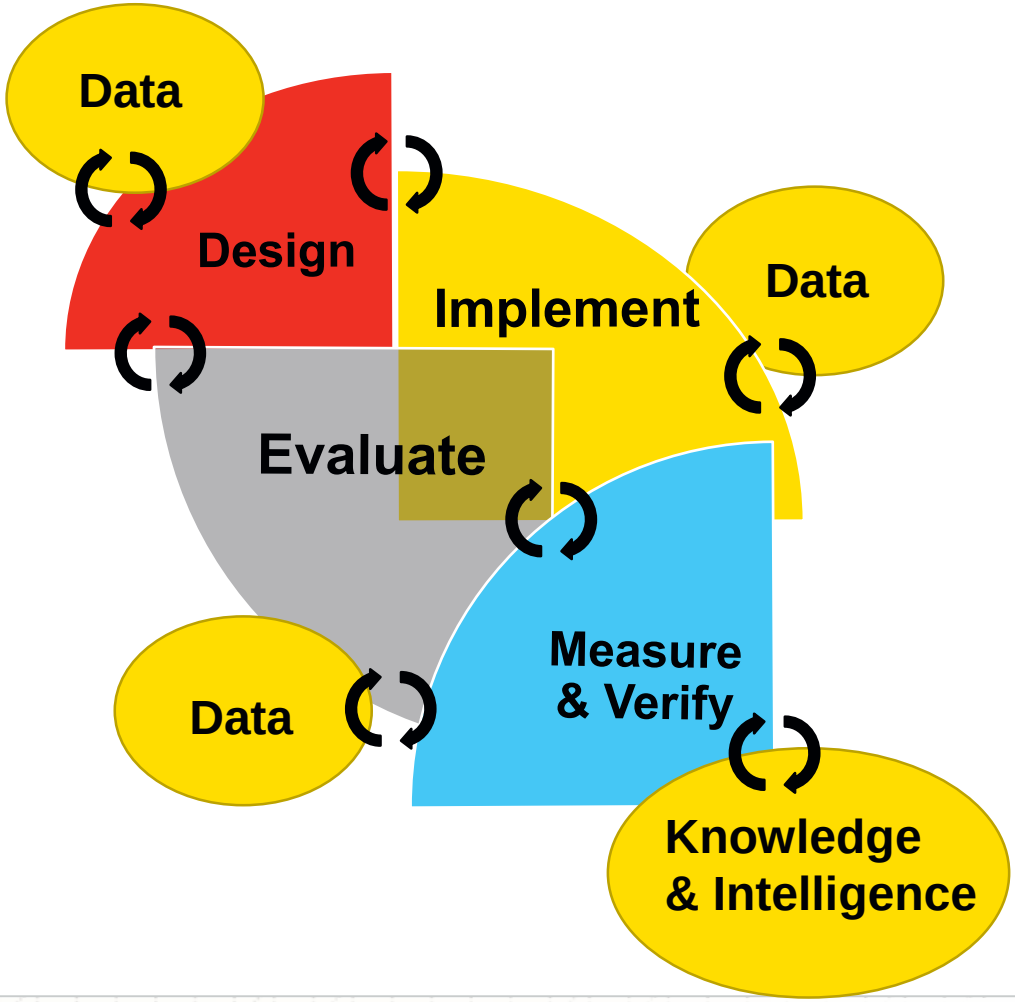
Experience
(Happy End-Users)

Actions
(Behaviors & Projects)

Savings
(Performance)

The Efficiency Program Lifecycle





The Efficiency Program Lifecycle

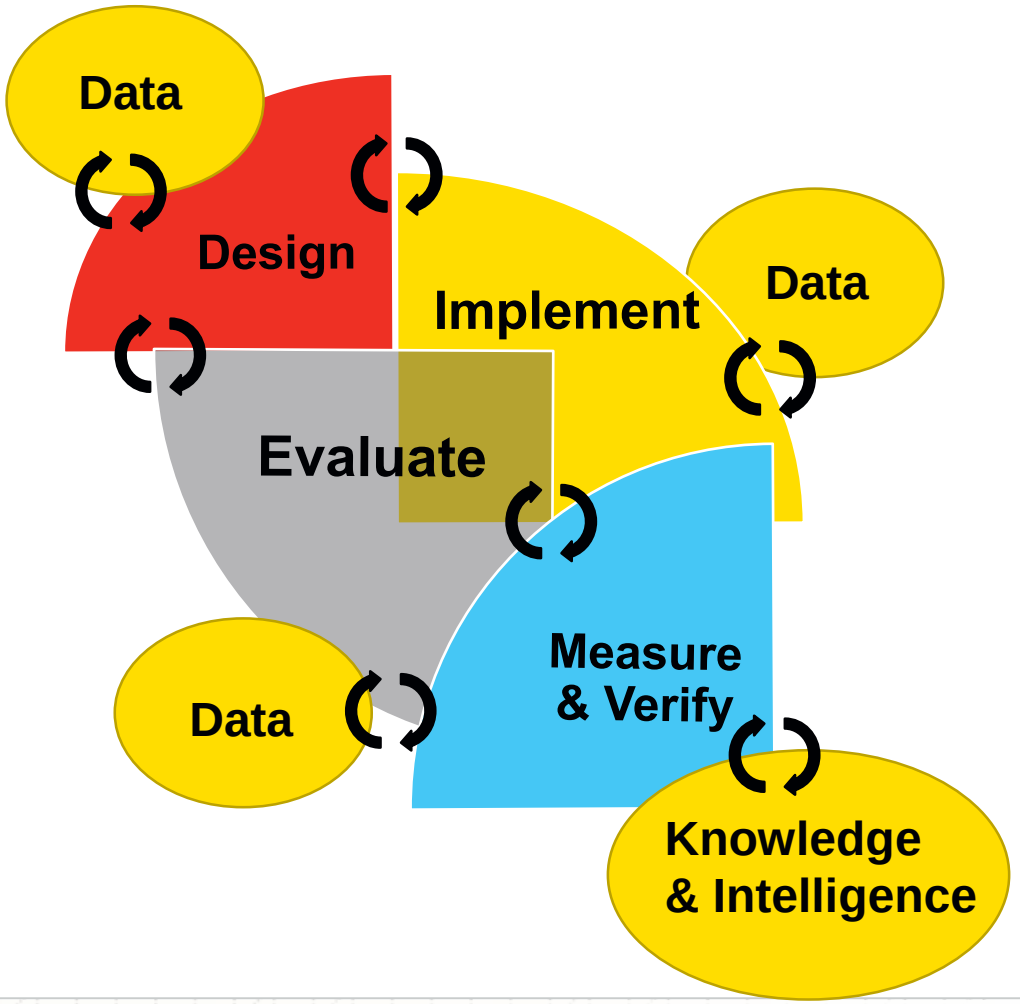
Advanced

Residential

Integrated (Intelligent)

Energy (Efficiency)

Study → Services (Systems)



ARIES: A hybrid path to savings?

home screen

power meter

trends

Off-the-shelf "virtual sub-metering"

In-panel hardware + App + 'cloud'

Measure mains current and voltage

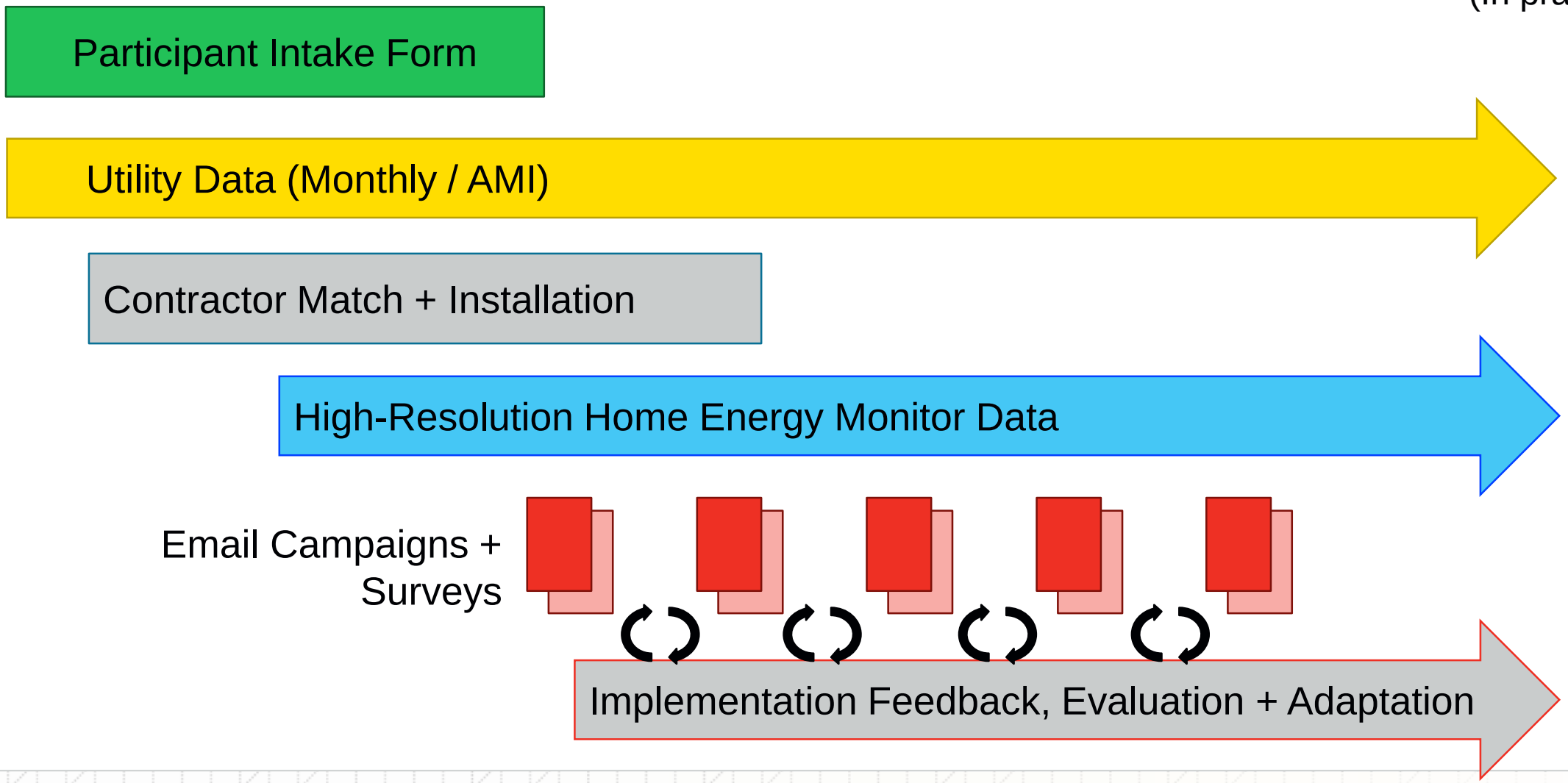
Very high frequency sensing (Mhz)

Pattern recognition → device detection

'Edge' Computing + Human-aided Machine Learning

ARIES: How it works

(In practice)



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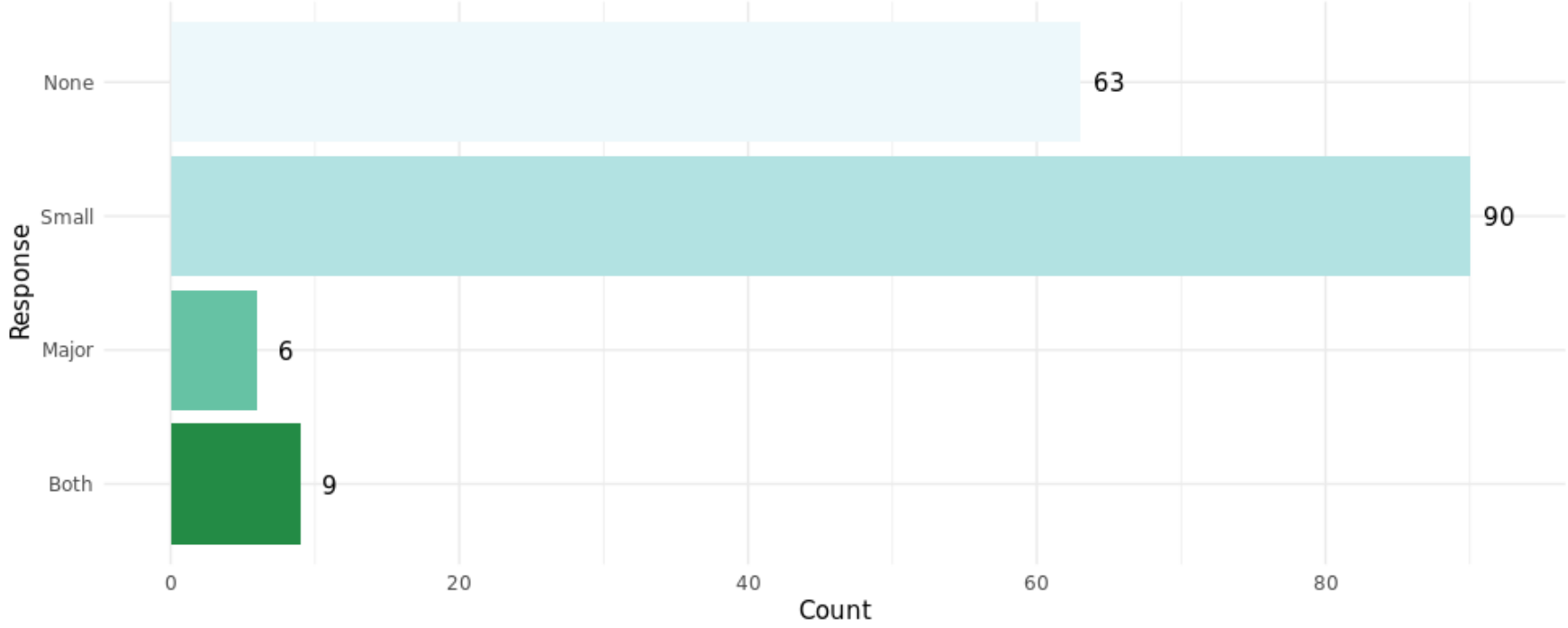
Promising Results & Insights

VEIC

Energy-saving changes at home since monitor installation



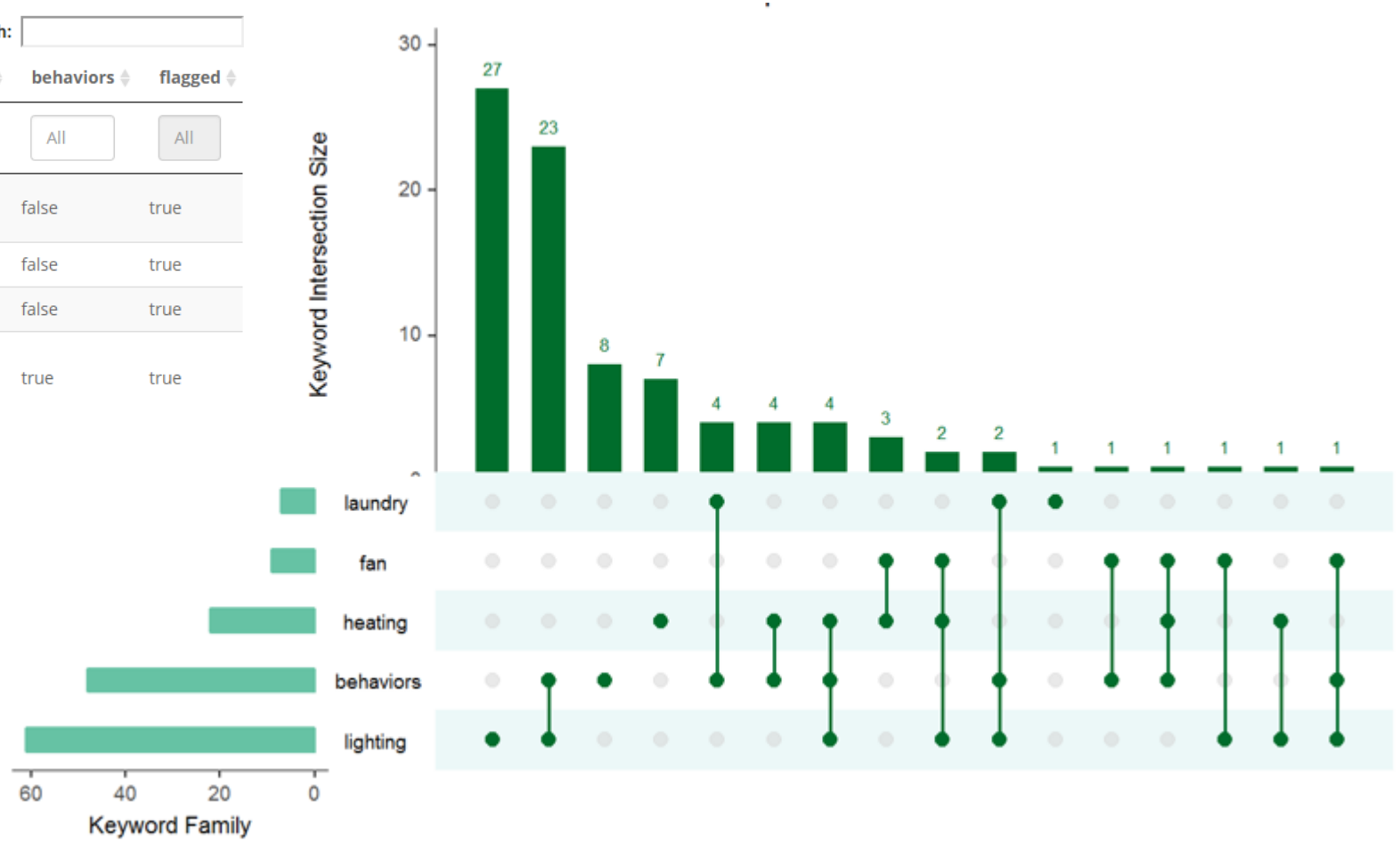
Small Changes
Open text response → NLP
Could be anything: e.g. “Behavior”
Focus of communications

Major Changes
Structured responses (checkbox)
Weatherization, solar, EV, heat pump, etc.
Drives non-routine event (NRE) handling in savings assessments

Open Response → Structured data

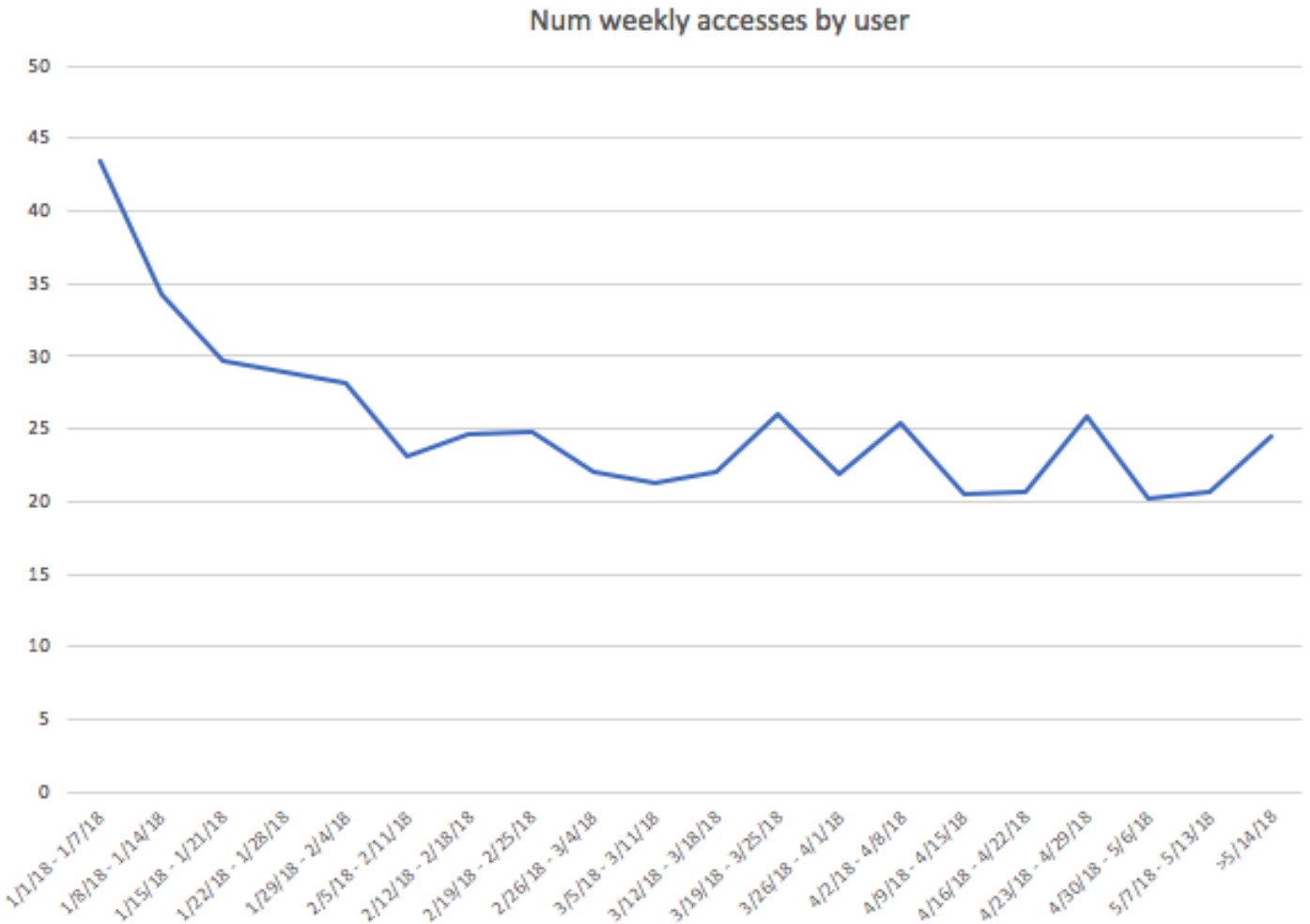
Show 10 entries Search:

	answer	lighting	fan	heating	laundry	behaviors	flagged
	All	All	All	All	All	All	All
1	new thermostats and hot water heater	false	true	true	false	false	true
2	smart bulbs	true	false	false	false	false	true
3	replaced light fixtures	true	false	false	false	false	true
4	LED bulbs, more mindful of appliance usage such as dryer	true	false	false	true	true	true



VEIC

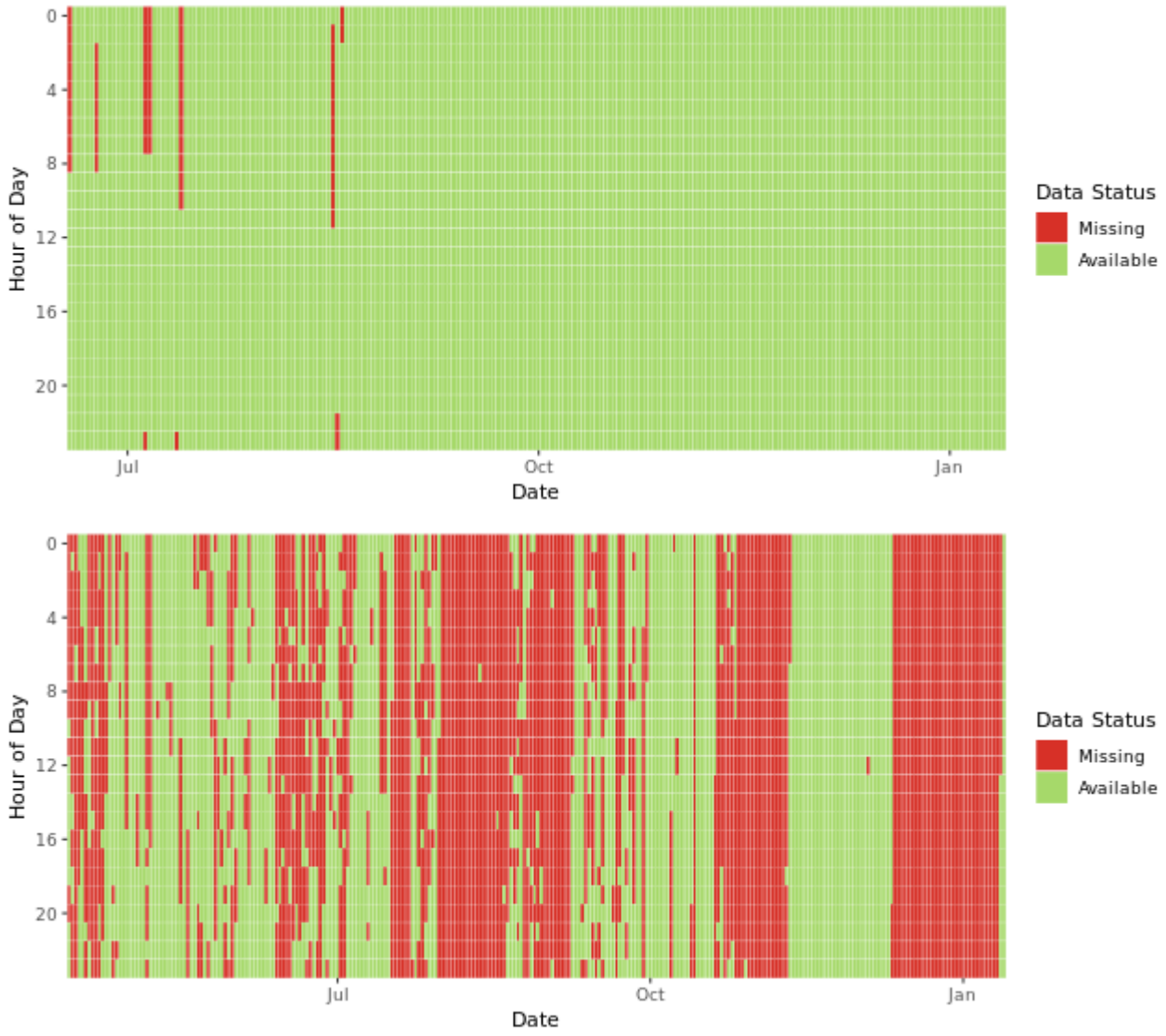
Sustained Engagement

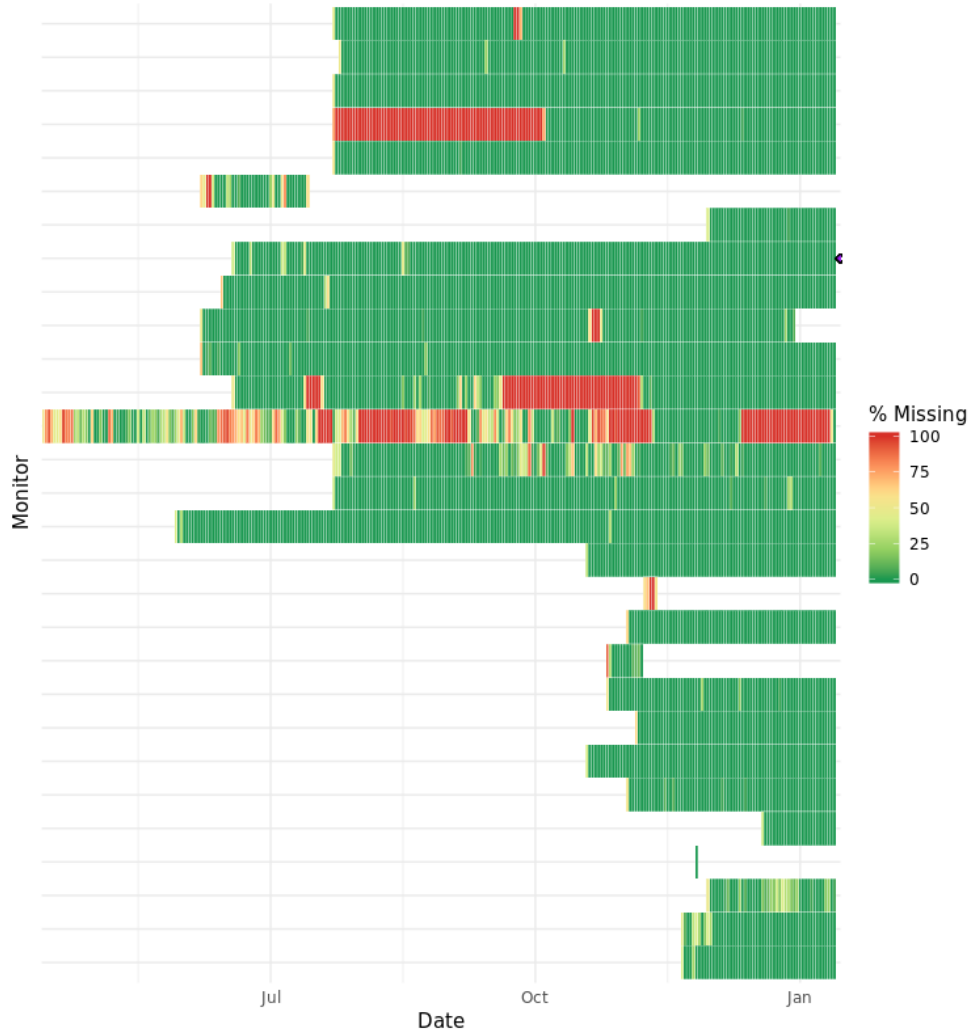


Cohort 1: First 6 months
20 to 25 app sessions per week
Spikes align with e-mails/surveys
Similar to customers who bought the product (i.e. not given for free)

VEIC

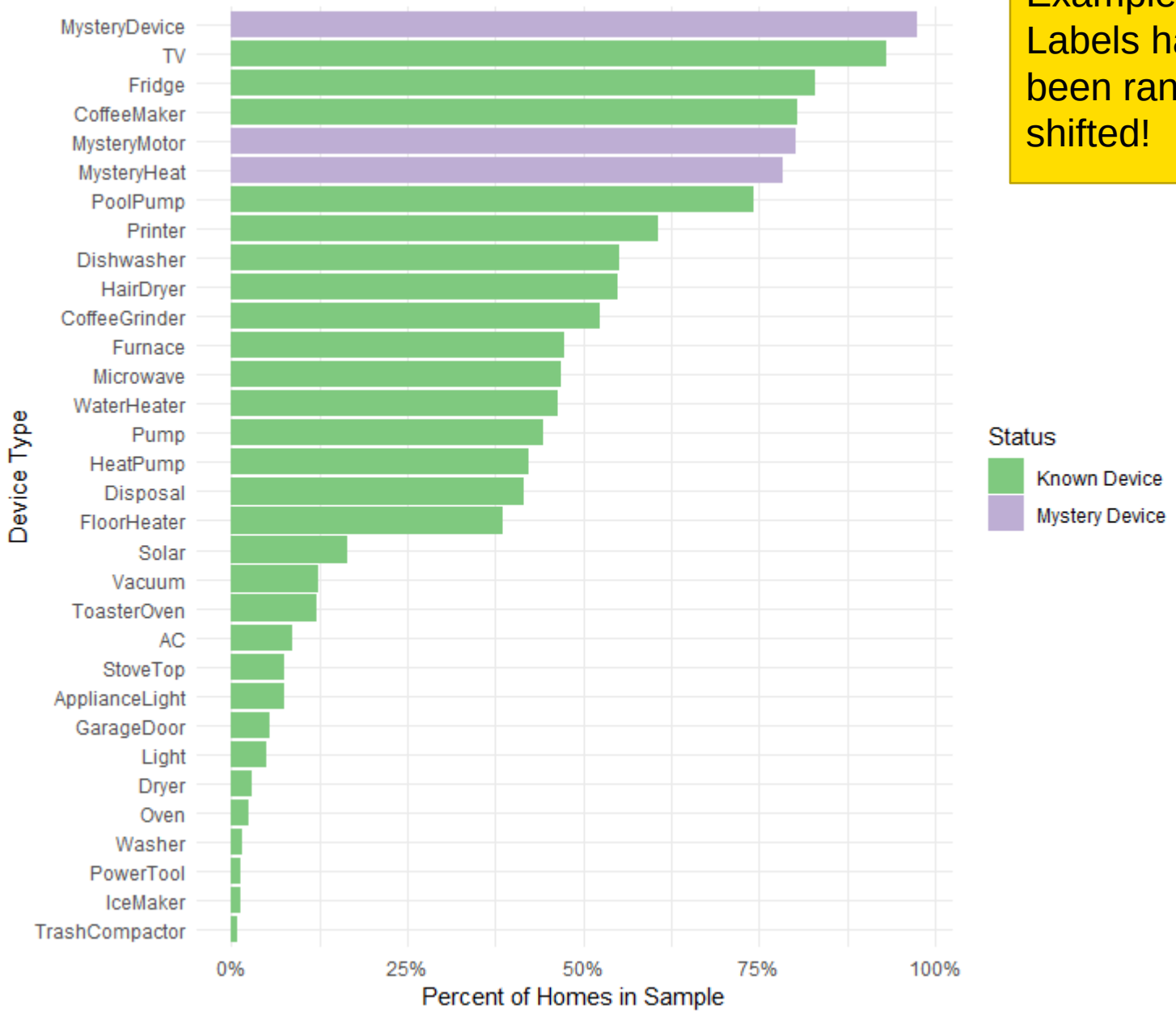
Ensure Monitor Uptime (Data Quality)





Fleet Device Diversity

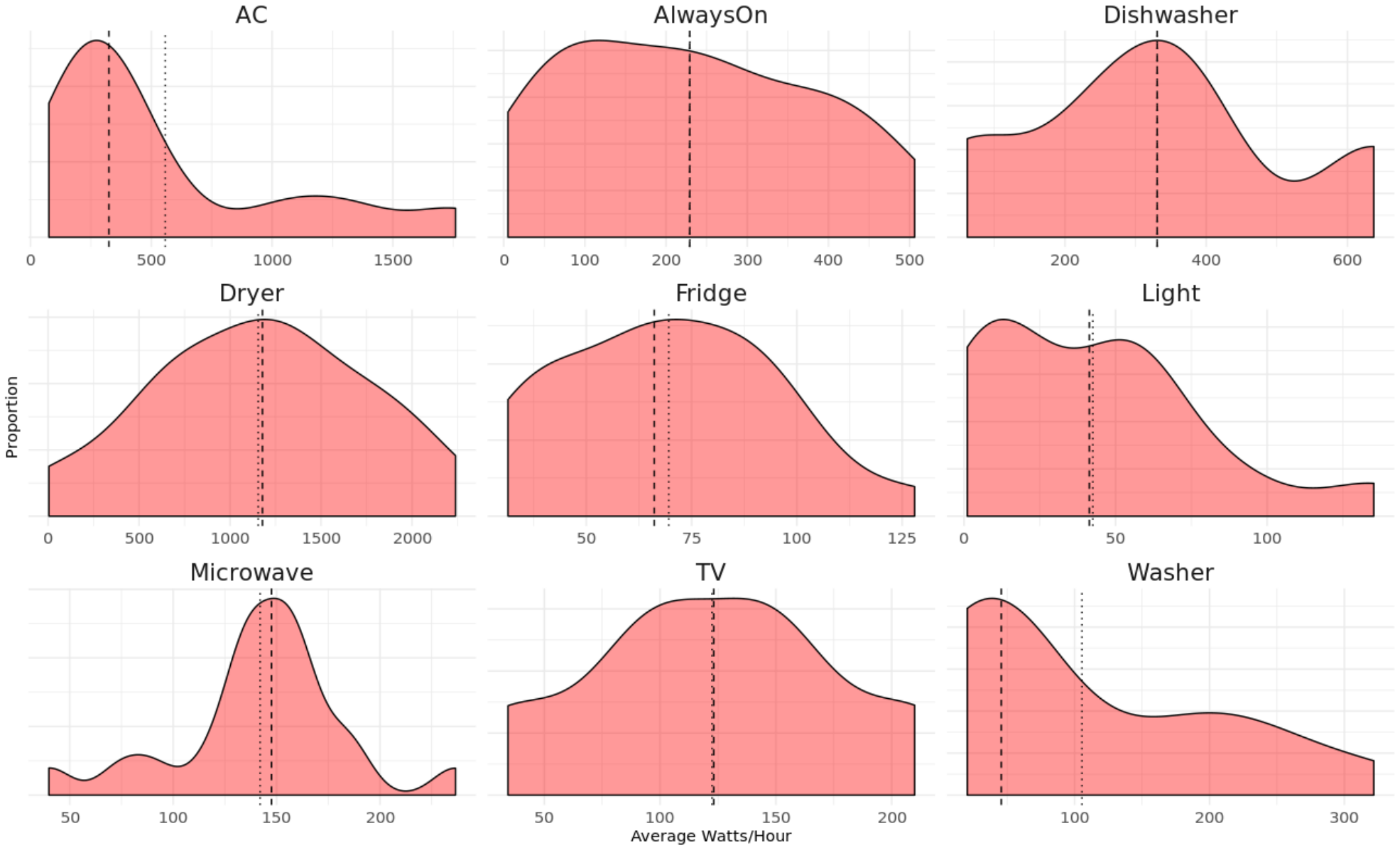
More precise market characterization and segmentation



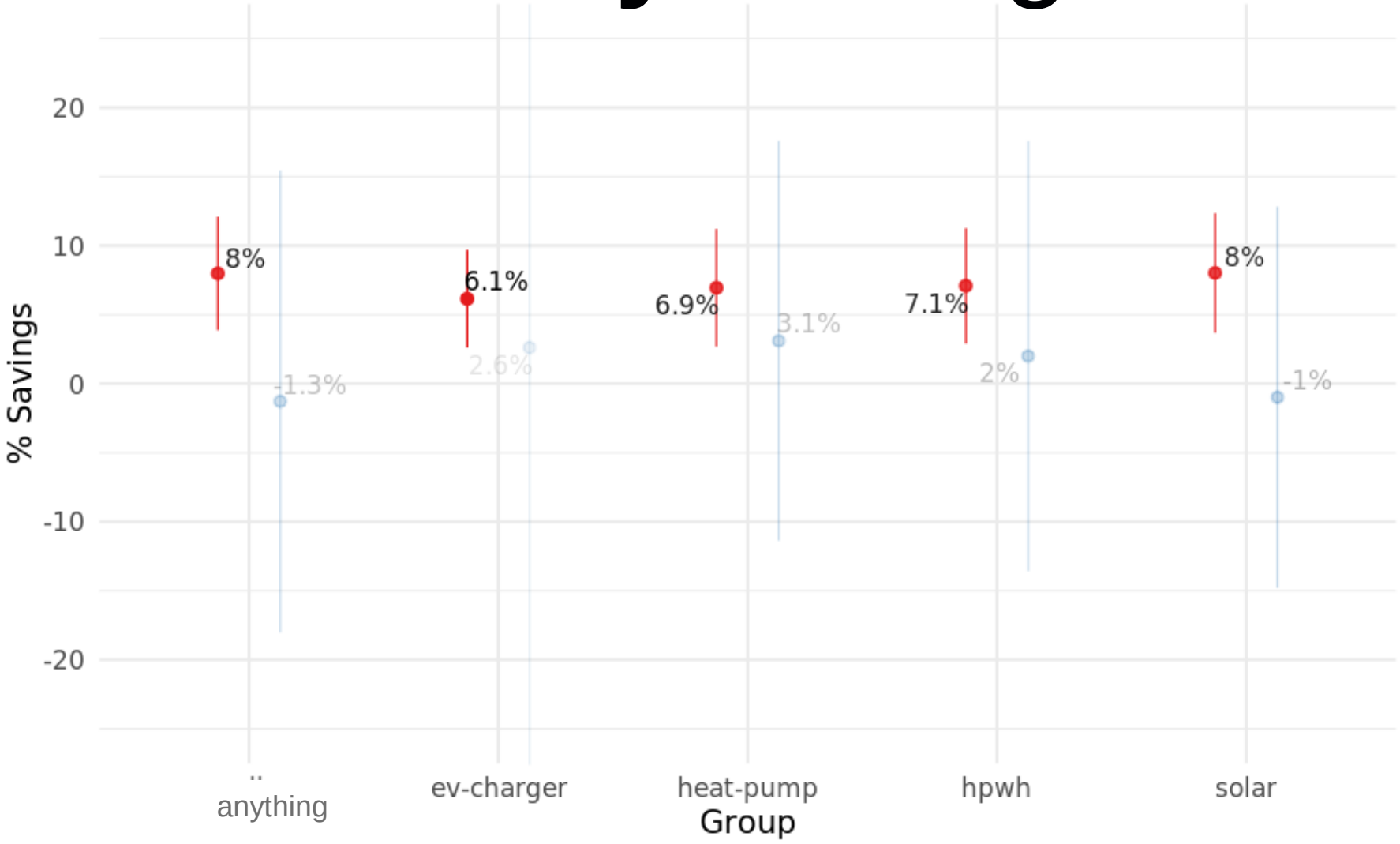
Example only. Labels have been randomly shifted!

Identify Performance Opportunities

Which devices are operating with normal ranges?



VERY Early “Savings” Estimates?



- M&V 2.0 methods
- Segmenting on ‘anomalies’ revealing
- Passes “is something here?” pilot test

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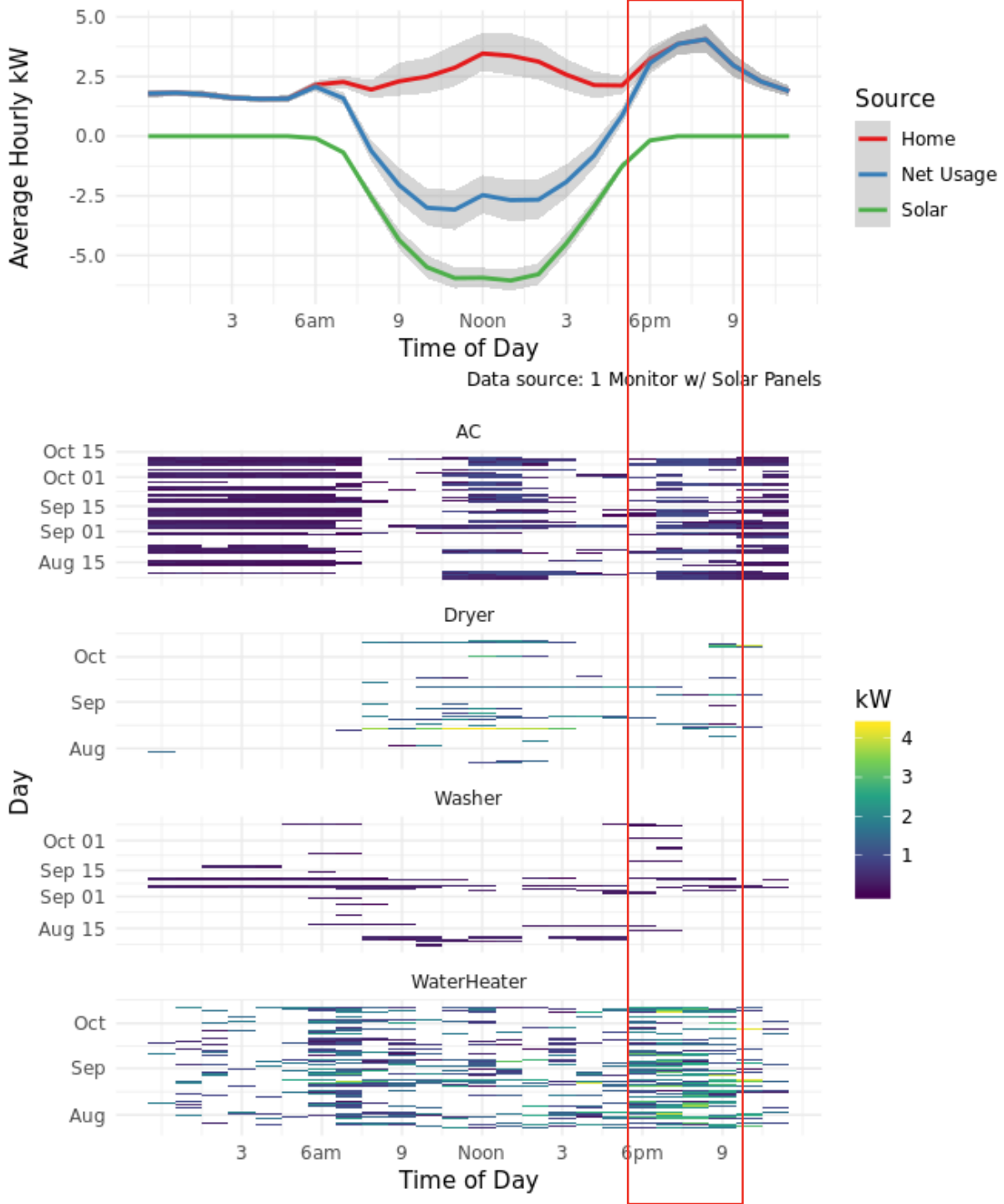

Grid Impacts?

- Demand response + flexible loads
- Rate guidance
- P4P & BYOD Programs
- Custom messaging
- Anomalous loads

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The Vision: Realized?

Measurable:

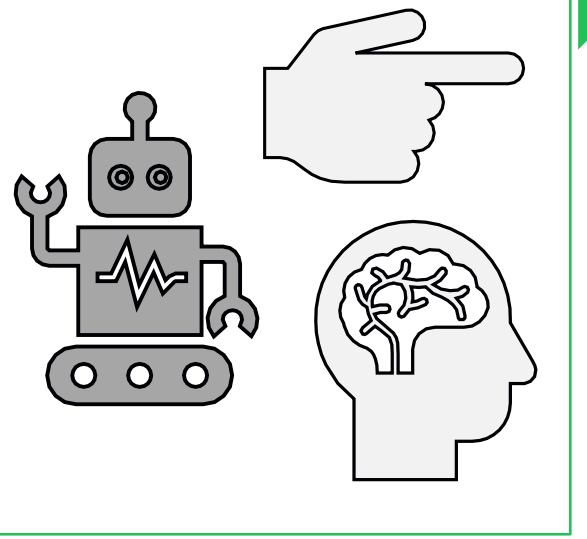
Monitor Energy [Technology]

- ✓ Accurate
- ✓ Precise
- ✓ Reliable
- ✓ Appropriate
- ✓ Affordable

Deliver Feedback [Information]

- ✓ Clear
- ✓ Compelling
- X Frictionless

Change [Behavior]



Experience (Happy End-Users) ✓

Actions (Behaviors & Projects) ✓

Savings (Performance) ✓

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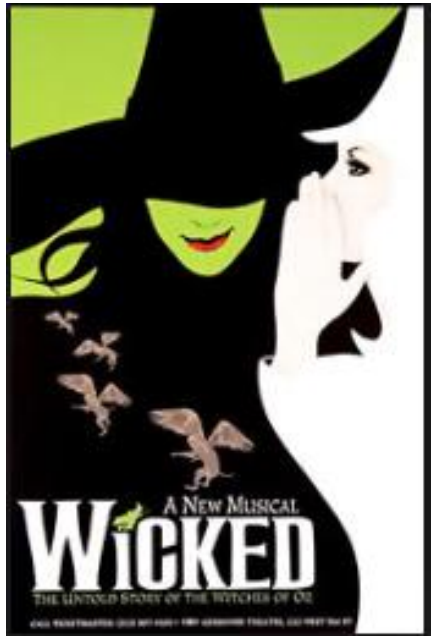
Energy Problem *Wickedness* :

Coherency, Contradiction & Change

Today's Topics:	**What we've learned (so far) …**
Smart Thermostats	*Cautionary Tales from a "Connected Canary"*
Advanced Home Energy Monitors	*Capturing Savings + Hidden Benefits*
Energy Problem "Wickedness"	*Coherency, Contradiction & Change*

When is a problem “Wicked?”



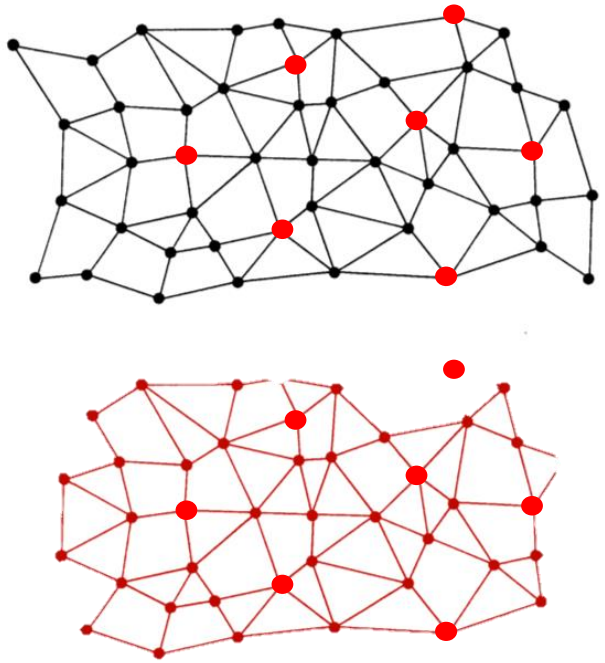
When it is difficult or impossible to solve because of:

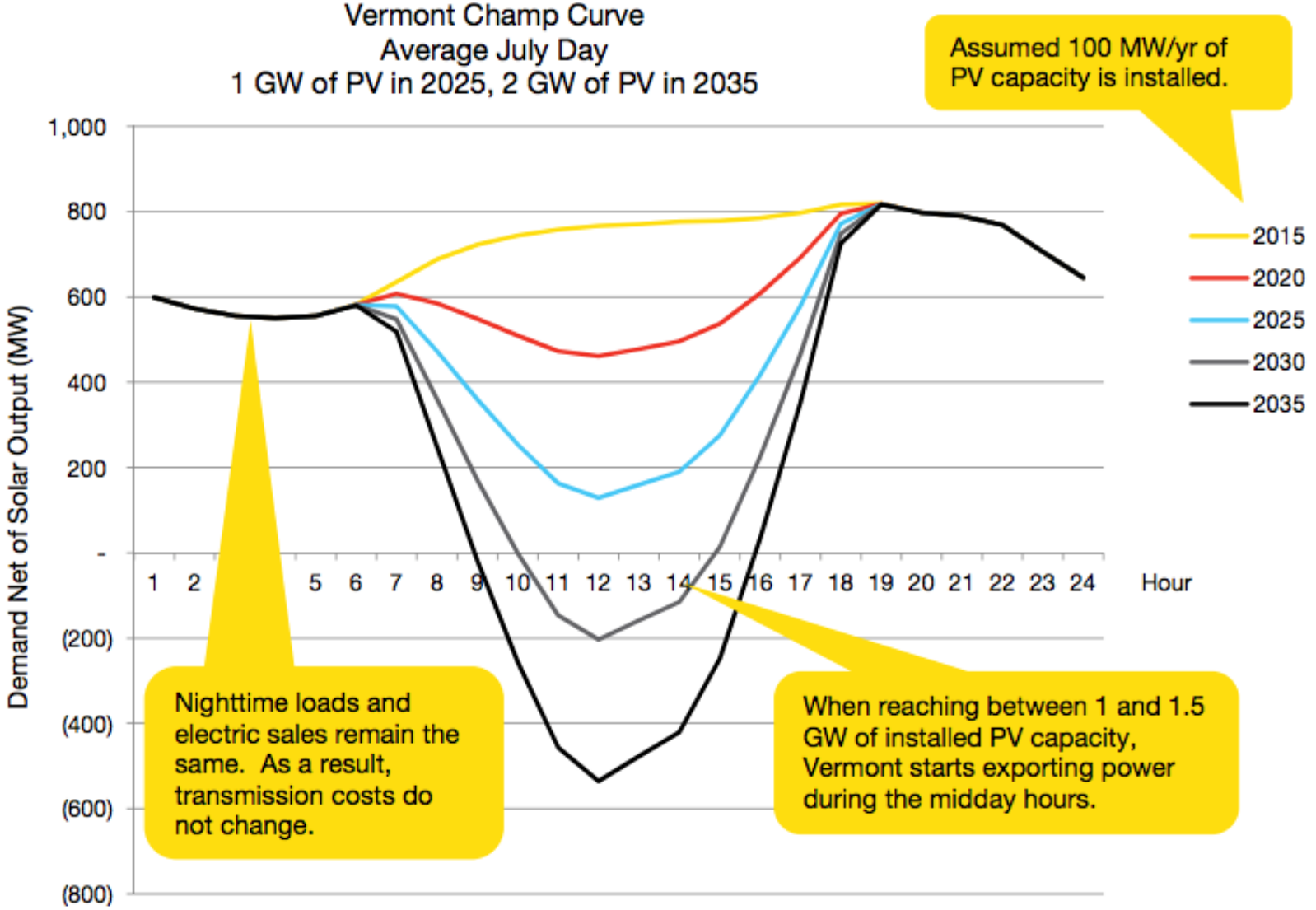
- incomplete, contradictory, and changing requirements that are often difficult to recognize

AND

- efforts to solve one aspect of a wicked problem may reveal or create other problem due to complex interdependencies

Wicked!




Vermont Champ Curve
Average July Day
1 GW of PV in 2025, 2 GW of PV in 2035
Assumed 100 MW/yr of PV capacity is installed.
Demand Net of Solar Output (MW)
1,000
800
600
400
200
-
(200)
(400)
(600)
(800)
1 2 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
2015
2020
2025
2030
2035
Nighttime loads and electric sales remain the same. As a result, transmission costs do not change.
When reaching between 1 and 1.5 GW of installed PV capacity, Vermont starts exporting power during the midday hours.

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Integrating Flex:

Planning and Advising

- Advising on Grid Modernization Proceedings
- Program Design & Best Practices Advising on IDER

Modeling and Forecasting

- Integrated Distribution Planning (Model Impacts of Demand Resources)
- LEAP Modeling: Pathways to Achieve Climate Goals
- Electrification Roadmaps
- Rate & Bill Analysis

Implementation

- Pivot EE Program to Passive Demand Focus
- Residential Active Demand Mgmt (Partner w/ DERMS)
- C&I Load Management
- NWA Design/Delivery
- Bundle Controls into Midstream Programs

Data, Analytics + M&V

Sense
(Load Disagg)

STAT
(Validate HVAC Savings)

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Discussion of a "Wicked" Problem:

"How to *optimally* provide cleaner, more reliable energy services at lower costs?"

1. Rapid changes in grid value through EE, RE, connected… uncertain foundations for cost and returns; roles of stakeholders (utilities, manufacturers, policies, rates, etc.)
2. Role for Govt, Researchers, Vendors, Utilities, Implementers
3. When to lean into market interventions, when to lean back? (unhealthy markets, deadweight losses, customer "bill of rights")
4. Strategies for wicked solutions: → Agile/Design+Systems Thinking

Thanks!

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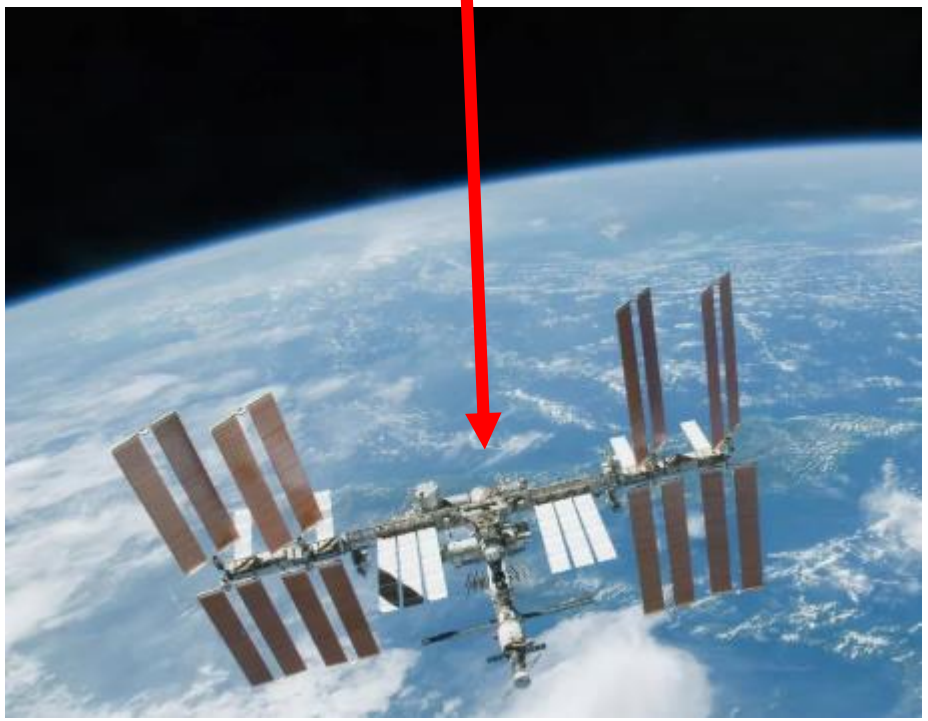

Questions?

- **George Barnes**, Trane
- **Rodes Boyd**, Siemens
- **Nick Lange**, VEIC
- **Eric Oliver**, 2RW Consultants

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