SPOTLIGHT ON VERMONT: MEETING STATE AND INDUSTRY NEEDS

Kathryn Parlin, West Hill Energy, Moderator
Barry Murphy, Vermont Department of Public Service
Pierre van der Merwe, VEIC
Jeff Monder, Green Mountain Power
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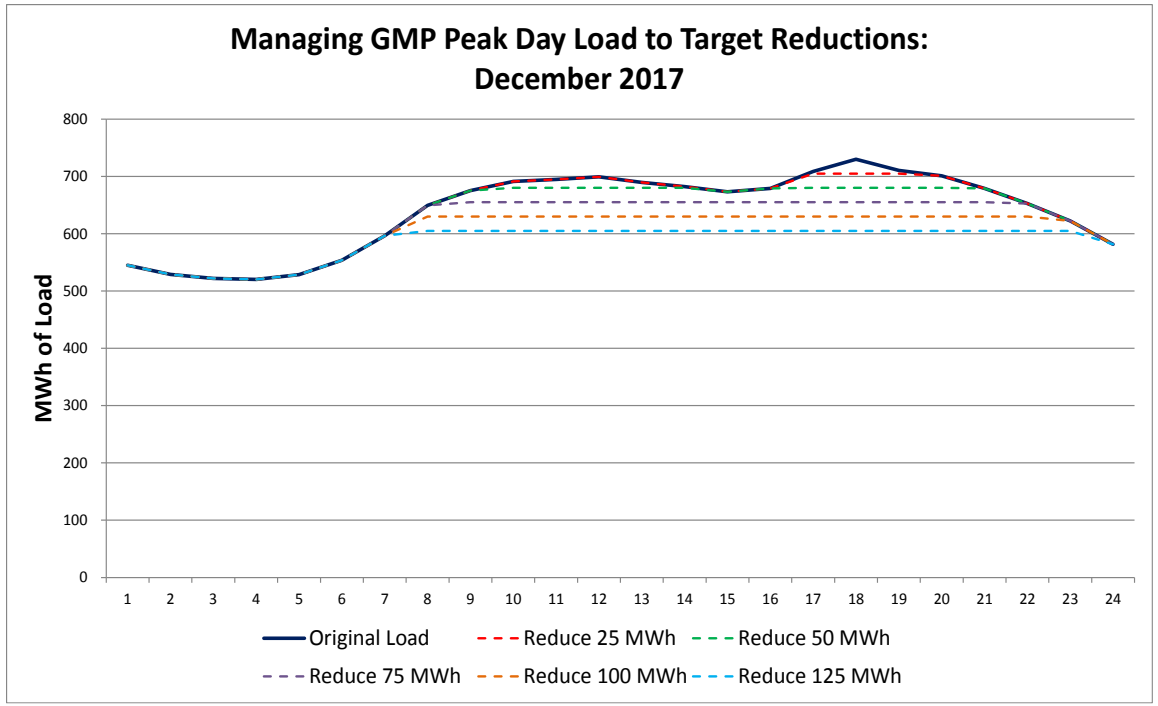
Utility Perspectives in Load Management and M&V

November 7, 2018

Jeff Monder
Green Mountain Power

VERMONT PEAKS

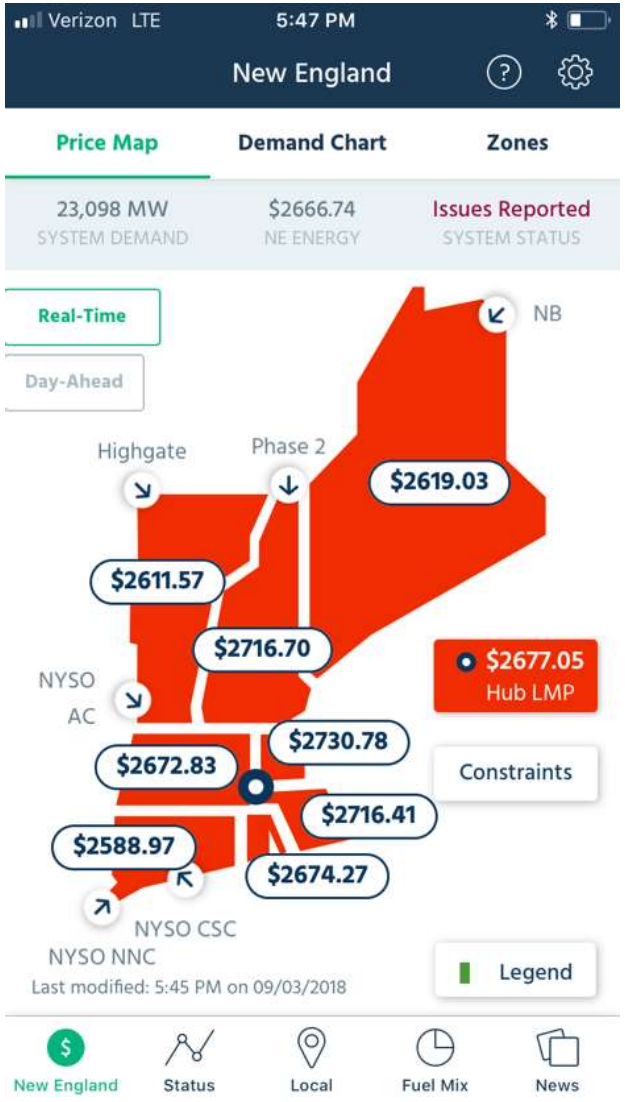


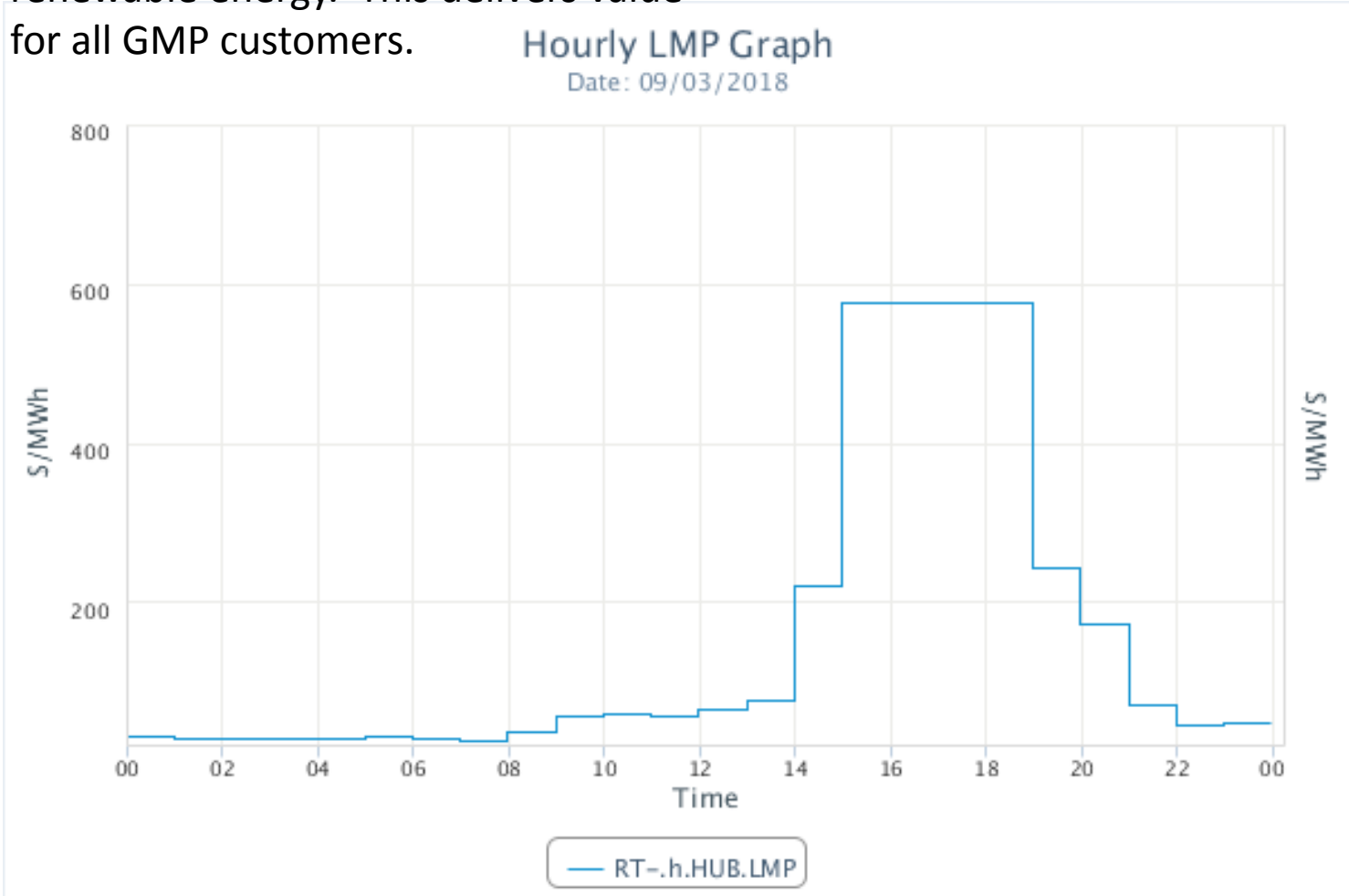
	Reduce 25 MWh	Reduce 50 MWh	Reduce 75 MWh	Reduce 100 MWh	Reduce 125 MWh	Reduce 150 MWh
Required hours of reduction	3	9	13	15	16	18
Required MWh of reduction	34	187	499	866	1,258	1,676

- To reduce GMP's peak to a target level, tools need to handle the peak day(s)
- Deeper reductions require more frequent and longer utilization of storage/DER tools
- The requirements accelerate above roughly 50 MW >> requires new revenues/values to offset
- Some longer-duration resources will be needed

BUY LOW/SELL HIGH

Stored energy can be dispatched to take advantage of fluctuations in market costs, with clean, low-cost, renewable energy. This delivers value for all GMP customers.





GMP LOAD MANAGEMENT STRATEGY

- Utilize storage and controllable loads to redesign grid management in order to save Vermonters 10's of millions of dollars in the coming decades
- Take GMP VT peak from 730 MW's to no more than 600 MW's year round
- Crush and flatten the peak to lower costs for customers
- Integrate distributed, intermittent generation resources
- Drastically improve the operational efficiency of the grid

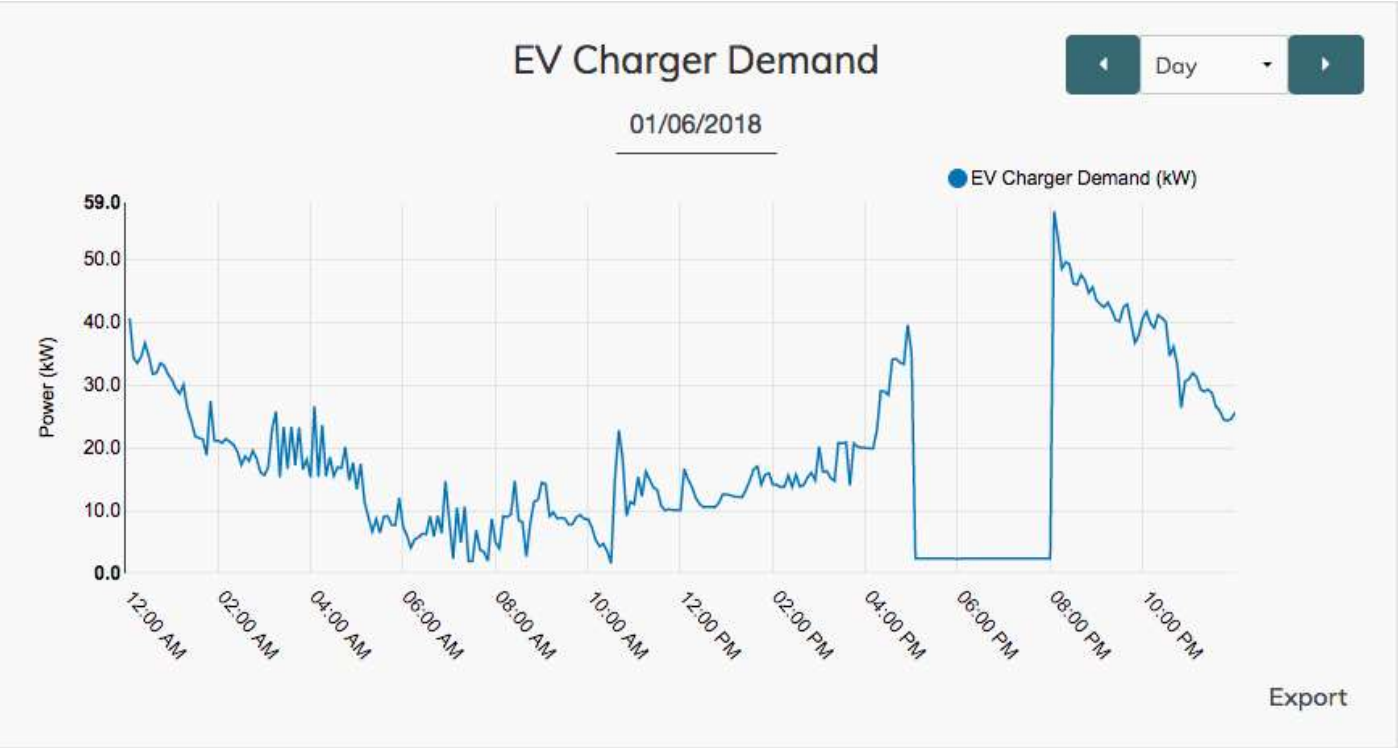
TOU ALTERNATIVE - VOLUNTARY CURTAILMENT

Customers on commercial time-of-use rates can opt into a Curtailment Load Rider

GMP 'shoots for peak' several times every month
Customers agree to shed a % of load during events
Can save on peak demand charges, while tying demand to called peak
M&V is at the AMI meter

DEFERRED LOAD

- Direct management of customer-owned resources, like EV chargers, water heaters, and heat pumps during peak events
- M&V comes from DRMS, the charger, and the AMI meter



STORAGE - BATTERIES

August 29, 2018 – All PowerWalls and Panton Battery (4MW Total)

Combined Value of RNS and FCM
As much as ~$200k / year / MW

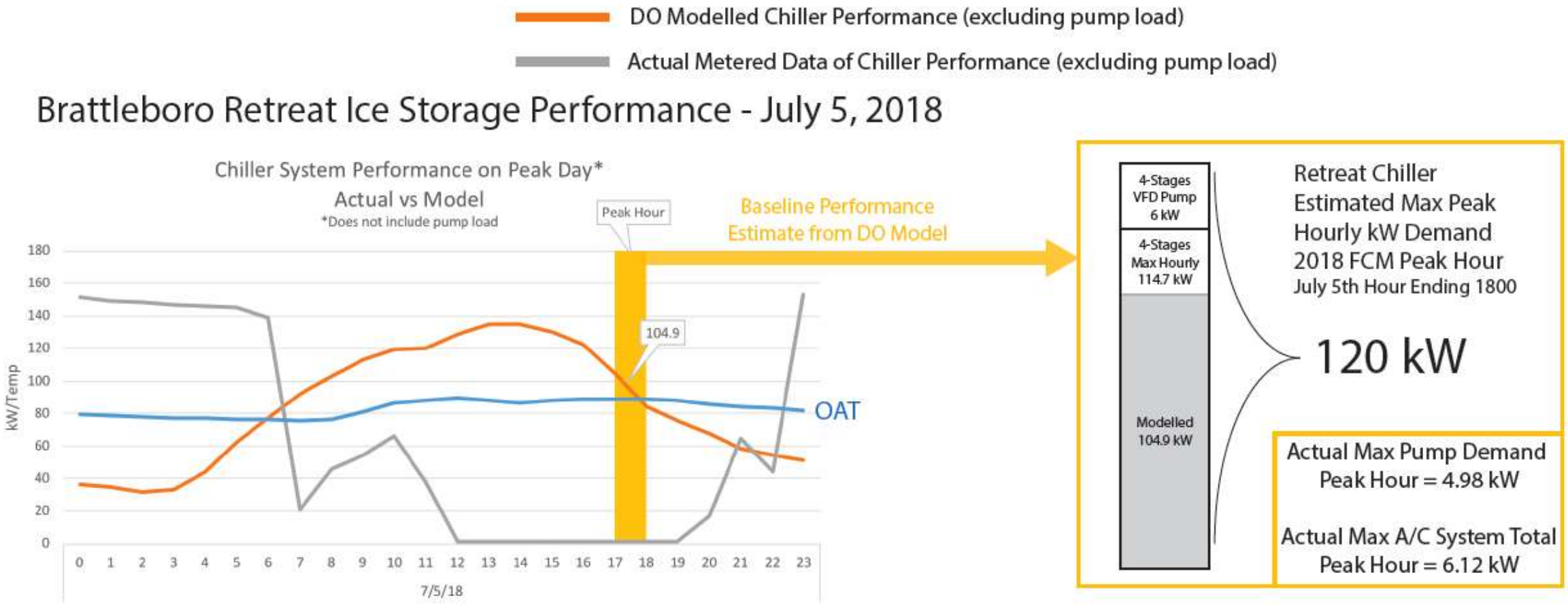
HIDDEN RESOURCES

- What about controllable resources that could support DR, but don't have a tariff that allows for operation?
  - Refrigeration
  - Air and water cooling and heating
  - Industrial processes
  - Multiple fuel sources
- Opportunities for Innovative Pilots

PILOT

- Flexible Load Management Pilot
  - Demonstrate distributed, flexible load management for controllable assets that can ride through curtailments
  - Create downward pressure on cost of service for all customers, while sharing value with customers hosting solutions
  - Establish measurement and verification that feeds upstream operations and accounting systems
  - Demonstrate security and integrity of all systems
  - Work towards automation
  - Work towards more granular, circuit-level action between controllable assets and local generation in the broader context of the regional grid

FLEXIBLE LOAD MANAGEMENT PILOT



THANK YOU!

November, 2018

Building the Infrastructure and Skill Sets to put Advanced M&V into action!

Pierre van der Merwe

VEIC

VEIC

- Mission-driven nonprofit
- Over 30 years reducing economic, environmental costs of energy
- Energy efficiency, renewable energy & transportation
- Consulting & implementation
- 3 energy efficiency utilities

Efficiency Vermont

EFFICIENCY$MART

DC SUSTAINABLE ENERGY UTILITY

Displacing 9,000,000 MT CO2e annually

Major Initiatives

Efficiency Vermont

DC SUSTAINABLE ENERGY UTILITY

EFFICIENCY$MART

BERC Biomass Energy Resource Center

RENEWABLE ENERGY RESOURCE CENTER

Drive Electric Vermont

Commons Energy

Sustainability Benefits

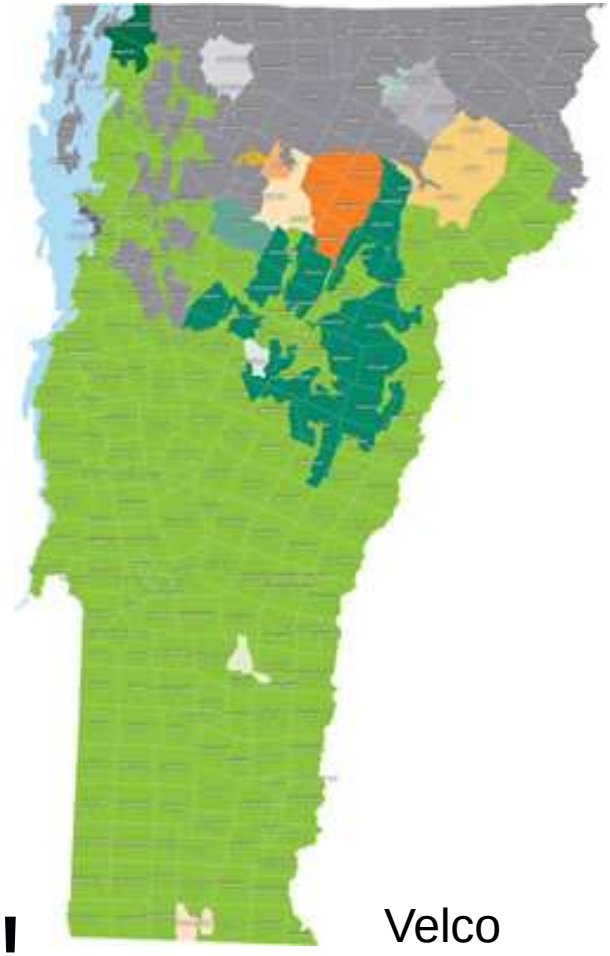
Sun Shares

Efficiency Vermont

- Founded in 2000
- Statewide energy efficiency utility
- Administered by VEIC, under appointment of Public Utility Commission
- Three-year performance cycle

Advanced Meter Infrastructure in Vermont

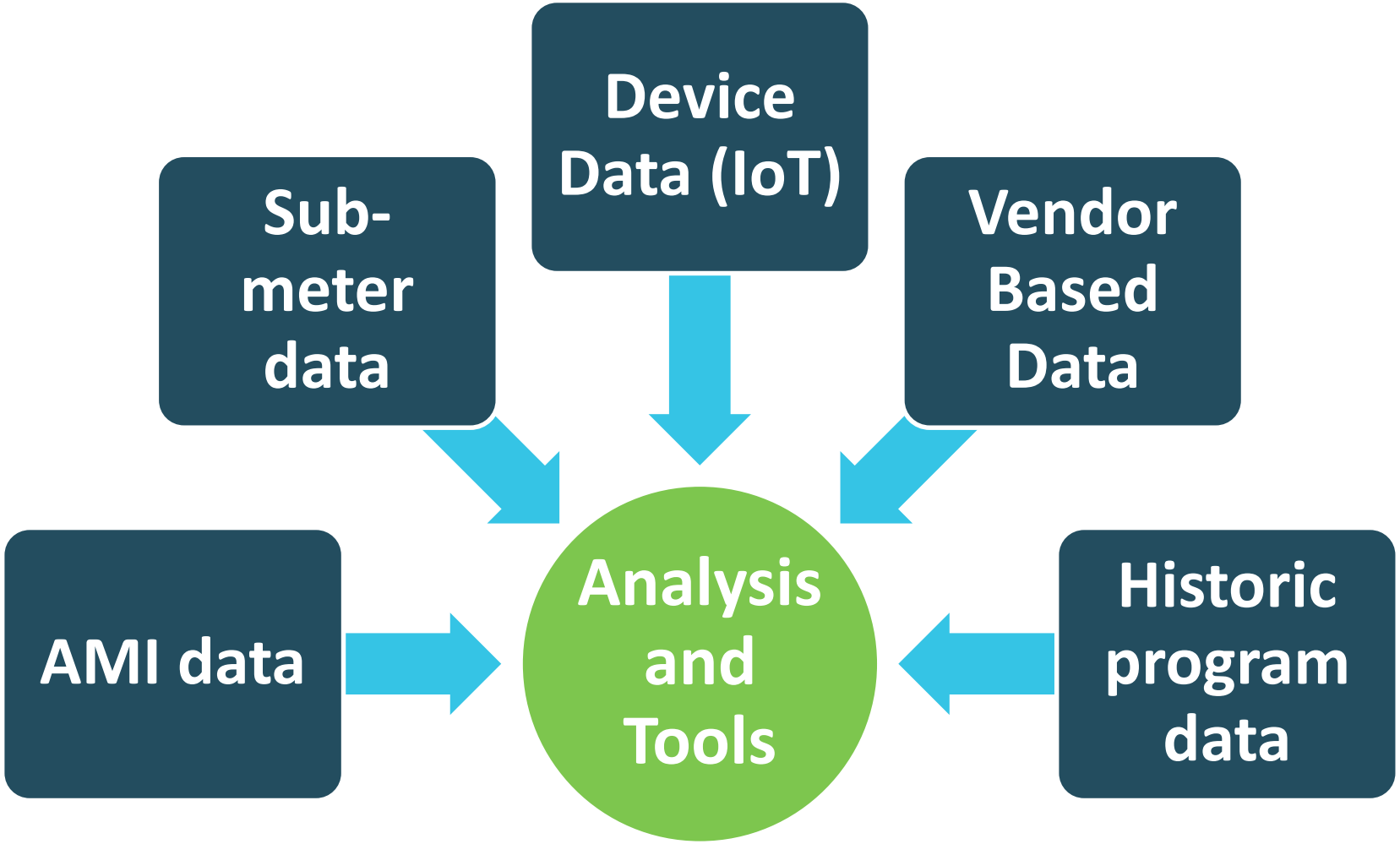
- 2009 ARRA Grant
- 17 utilities – five with AMI
- Over 300,000 meters
- Efficiency Vermont Data Infrastructure
  - Monthly data from all utilities
  - AMI data from Green Mountain Power
  - Supports data analytics tools and customer facing services



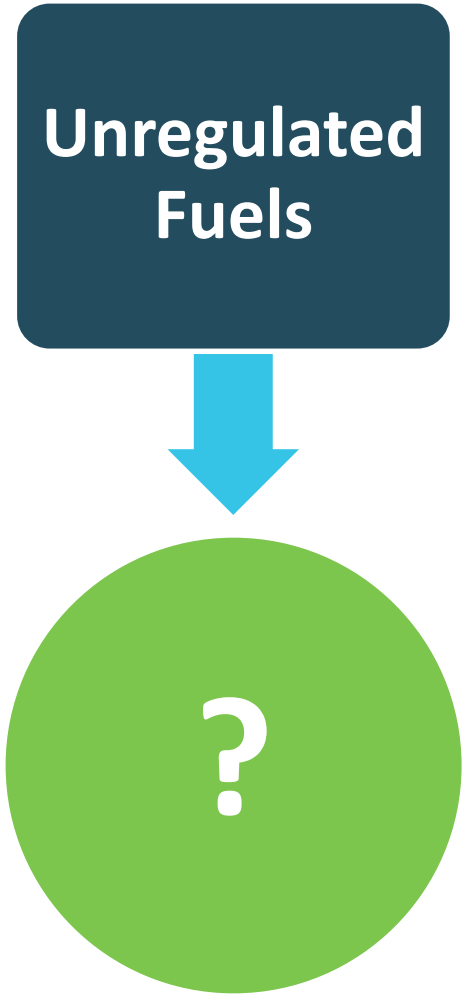
Velco

From 12 data point per home per year to 35040!

Its not just AMI data

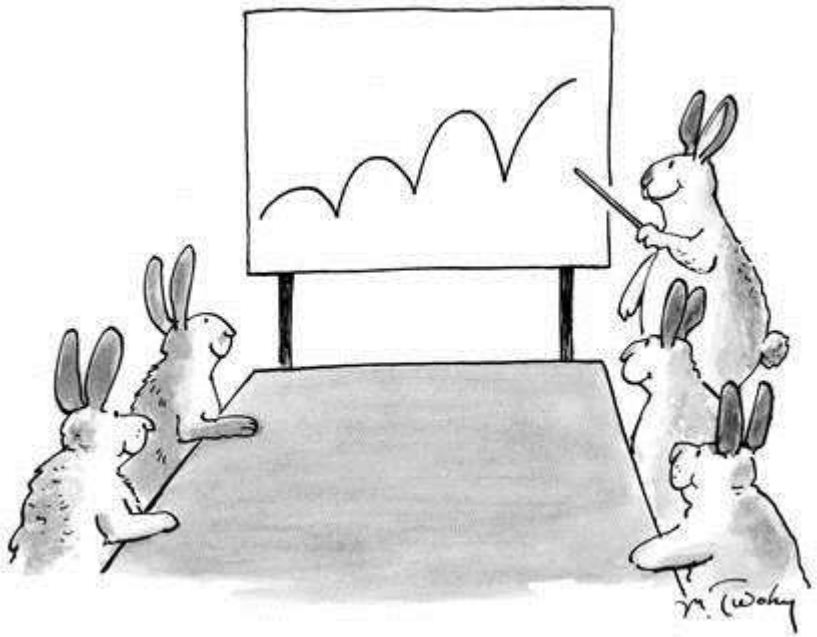


Its not just AMI data… or any data



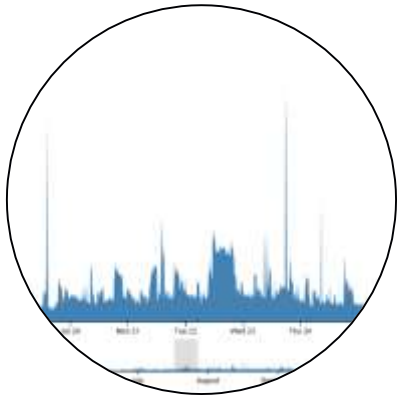
VEIC Data Analytics

- Formed energy analytics support group in 2015
- Specialized expertise in data science, data visualization, software development, and automation
- Python and R
- Data-driven insights
  - Accurate
  - Repeatable
  - Scalable

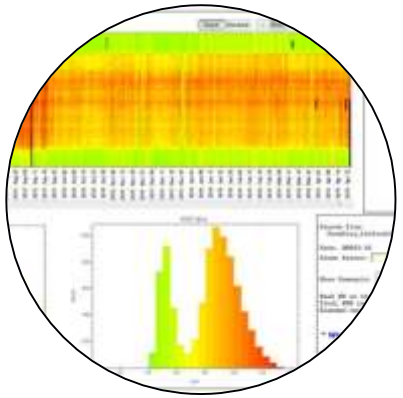


“Squiggle Analysis”

AMI Analytics



AMI Explorer

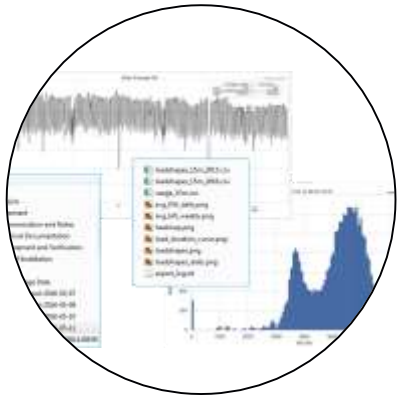


Viper

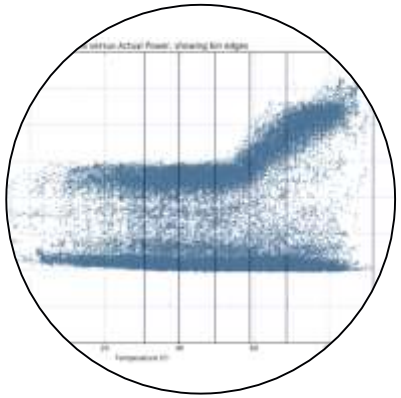
Peak Analysis Tool

Bullseye

Portfolio Level Analytics & Filtering

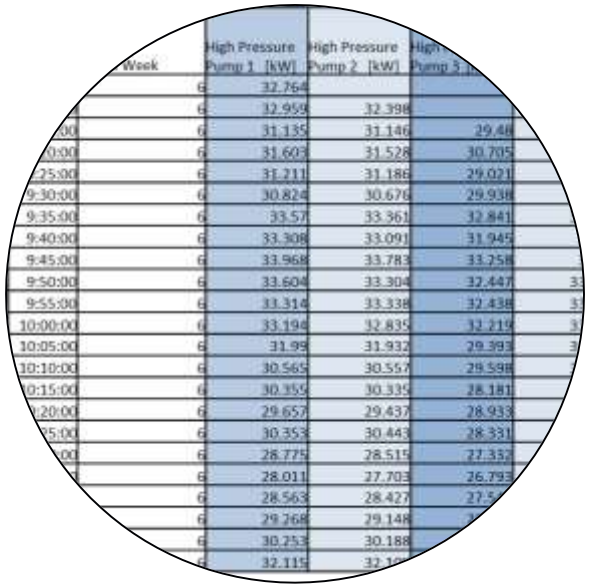


AMI Exporter “Folder 8”

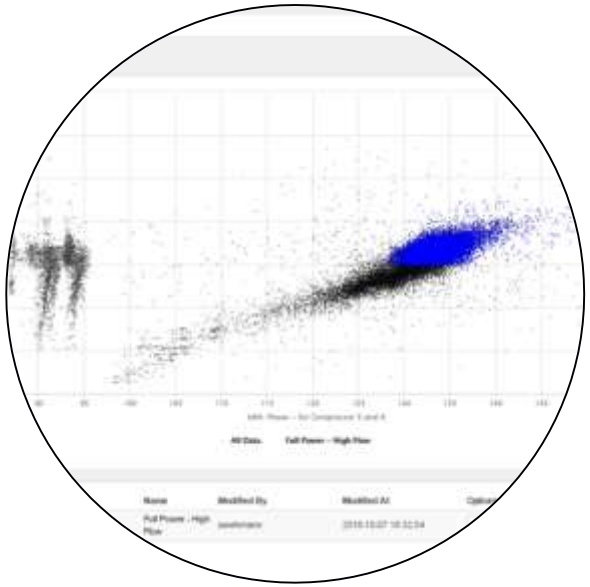


Standard Weather Modeling Algorithms

Submetering Platform



Week	High Pressure Pump 1 [kW]	High Pressure Pump 2 [kW]	High Pump 3 [
6	32.764		
6	32.959	32.398	
6	31.135	31.146	29.48
6	31.603	31.528	30.705
6	31.211	31.186	29.021
6	30.824	30.676	29.938
6	33.57	33.361	32.841
6	33.308	33.091	31.945
6	33.968	33.783	33.258
6	33.604	33.304	32.447
6	33.314	33.338	32.438
6	33.194	32.835	32.219
6	31.99	31.932	29.393
6	30.565	30.557	29.598
6	30.355	30.335	28.181
6	29.657	29.437	28.933
6	30.353	30.443	28.331
6	28.775	28.515	27.332
6	28.011	27.703	26.793
6	28.563	28.427	27.5
6	29.268	29.148	
6	30.253	30.188	
6	32.115	32.1	



Meter Plan

Document Projects

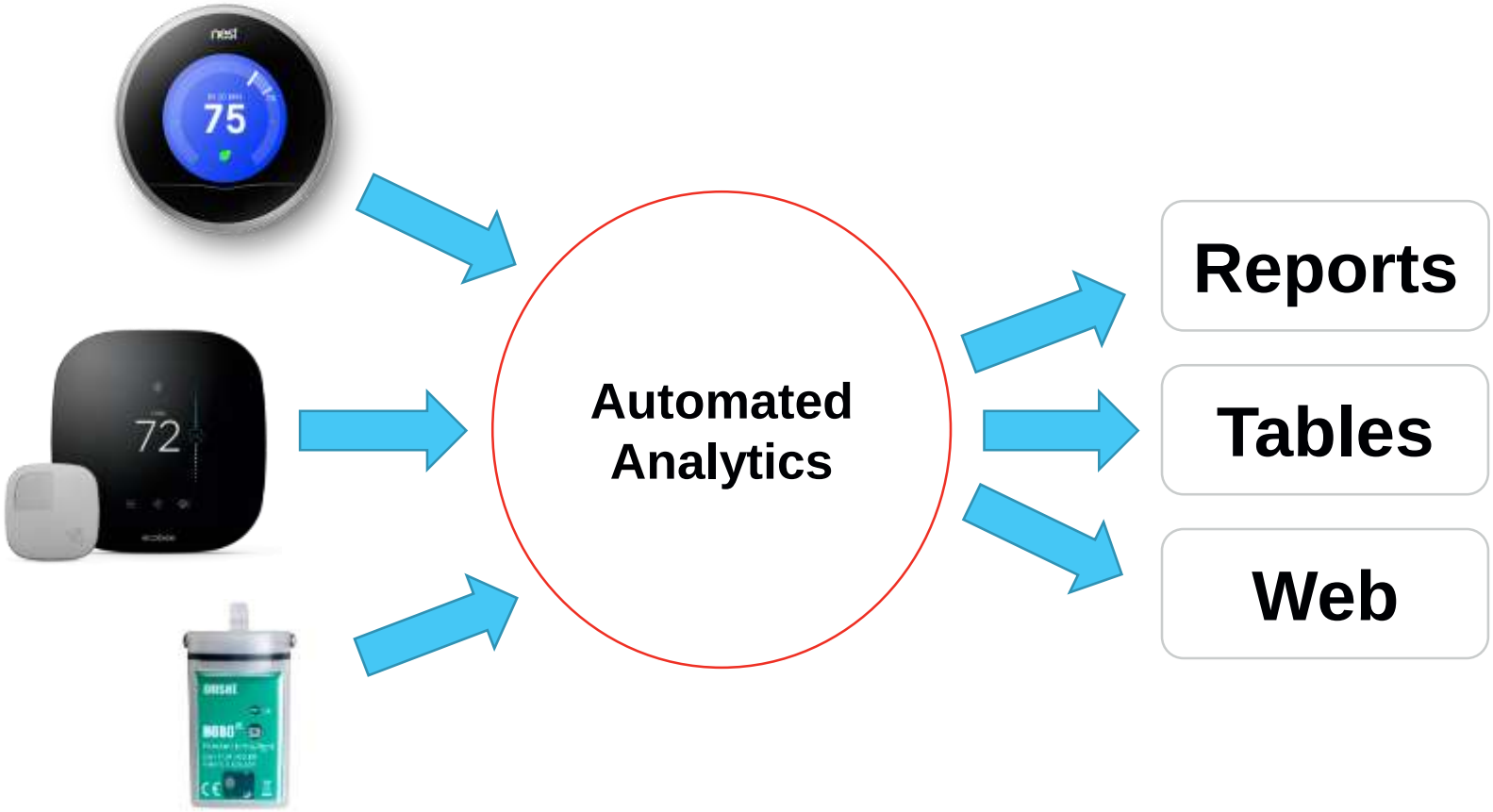
Data Warehouse

Acquire, Organize & Store Data

Analytics Tools

Calculate Performance

Device Data – Smart Thermostats

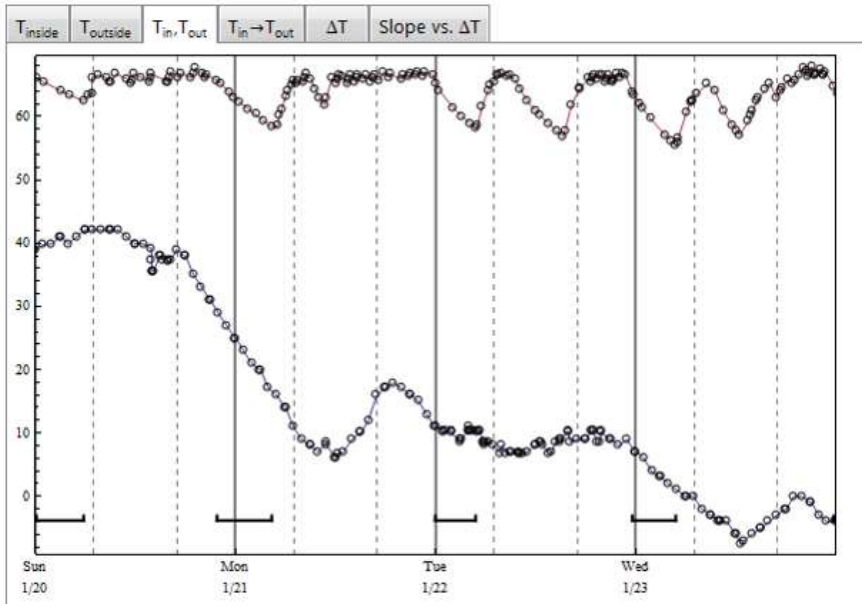


STAT - Smart Thermostat Analytics Toolkit

Device Data – Smart Thermostats

How it works

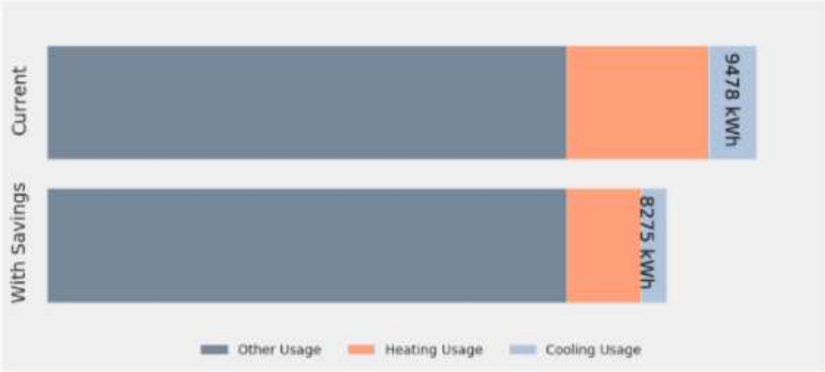
- “SCHWOOP” analysis correlating outside air temp against how often the home is heating or cooling
- Provides targeting opportunities for insulation, heating, and cooling



Device Data – Smart Thermostats

Annual Savings Potential

Estimated savings potential is based on the weather-modeled heating and cooling energy use as well as the percent savings calculated from the thermal transmission rate.

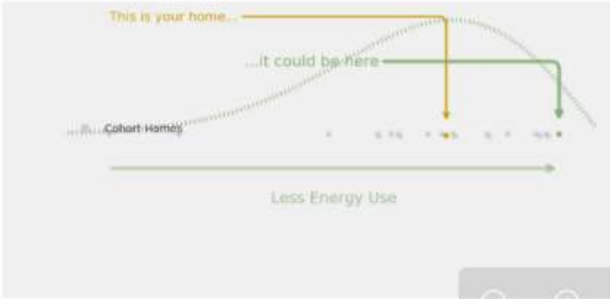


	Current Modeled Use		Estimated Savings	
	kWh	$	kWh	$
Heating	1,895	$236	901	$112
Cooling	637	$79	302	$37
Other	6,946	$868	0	$0
Total	9,478	$1,183	1,203	$149

Total Savings: 48%

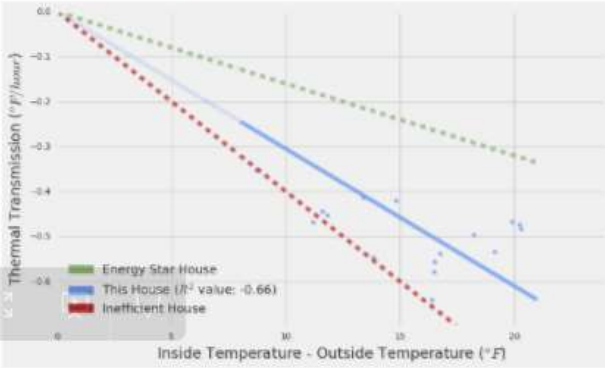
Relative Envelope Performance

Compared to other homes in this group, there is **minimal savings potential** by improving this house's envelope.



Thermal Transmission Benchmarks

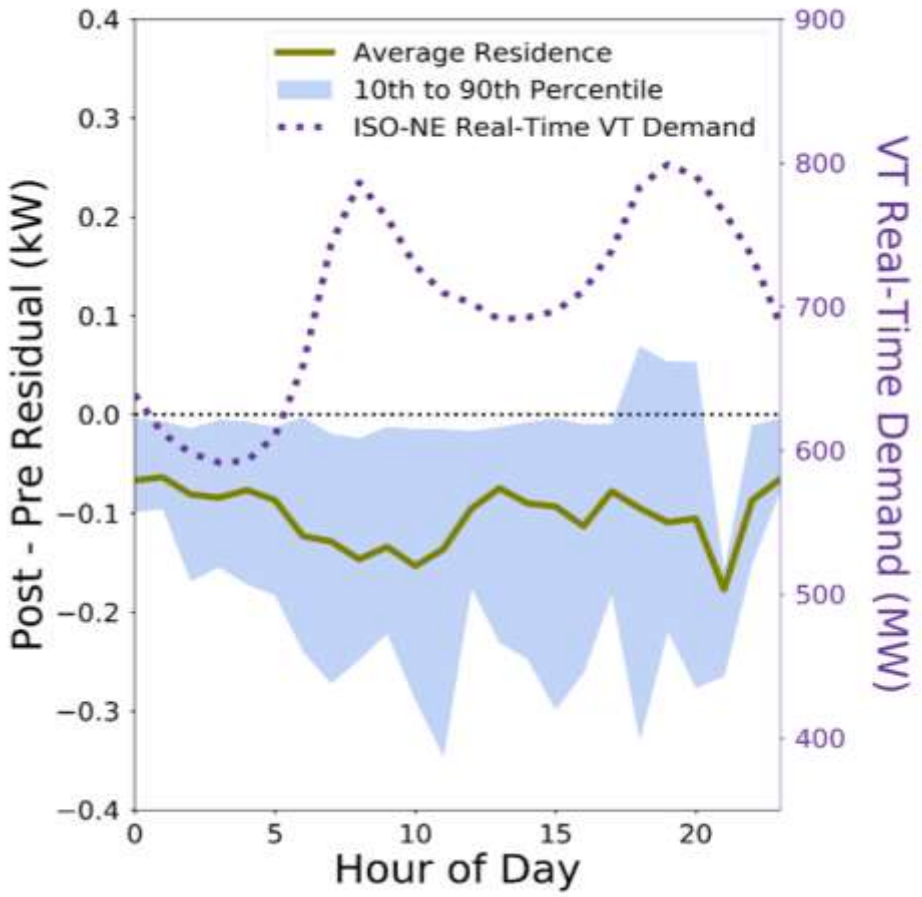
Each point represents a period of passive temperature drift. The rate of temperature change is plotted against the indoor-outdoor delta-T at that time. The linear regression model for this house is compared to benchmarks.



Vermont Duck Curve

AMI Data
+ Program Tracking Data

- EE impacts on loadshape
- Seven individual measures tested
  - Cold-climate Heat Pump
  - Efficient Refrigerator
  - Efficient Freezer Early Replacements
  - LED Lighting
  - Efficient Clothes-Dryer
  - Efficient Clothes-Washer
  - Heat Pump Hot Water Heater



Common Themes & Challenges

- Access – privacy and availability
- Quality – errors, formatting, definitions
- Scalable – standardized methods
- Skillset – data science and software
- Value – new & improved programs, process efficiency
- Evaluation – coordination needed with existing evaluation processes and intended policy outcomes
- Traditional M&V is Summative and needs to shift to a Formative approach leveraging data in a dynamic real-time approach

Doing things differently!

ANALYTICS -ENABLED EFFICIENCY

EFFICIENCY PAST	EFFICIENCY PRESENT/FUTURE
• Limited customer/building targeting	• Data-driven, segmented opportunity targeting
• Time-intensive, costly on-site assessments	• Remote assessments at low cost/time
• Emphasis of capital-intensive retrofits	• Equal focus on retrofits and operational
• Measure-by-Measure action	• Holistic, “whole building driven” EE
• Savings persistence unclear	• Savings persistence ensured

Credit: Dian Grueneich

“Insights using just your own data are just that, “insights”. They fail to put your operations, your situation, or your future into the global context where it belongs. Even more valuable are “outsights” - Microscopes are great for diagnosing, but telescopes provide the ability to anticipate and plan”

Douglas B. Laney

Gartner, Inc

Thanks!

Pierre van der Merwe
VEIC
Director, Data and Technology
pvandermerwe@veic.org

November 7, 2018

Advanced M&V Methods to Drive Real-time Customer Feedback

Jeffrey Hullstrung, PE
Sandra LaFlamme, PE

VEIC

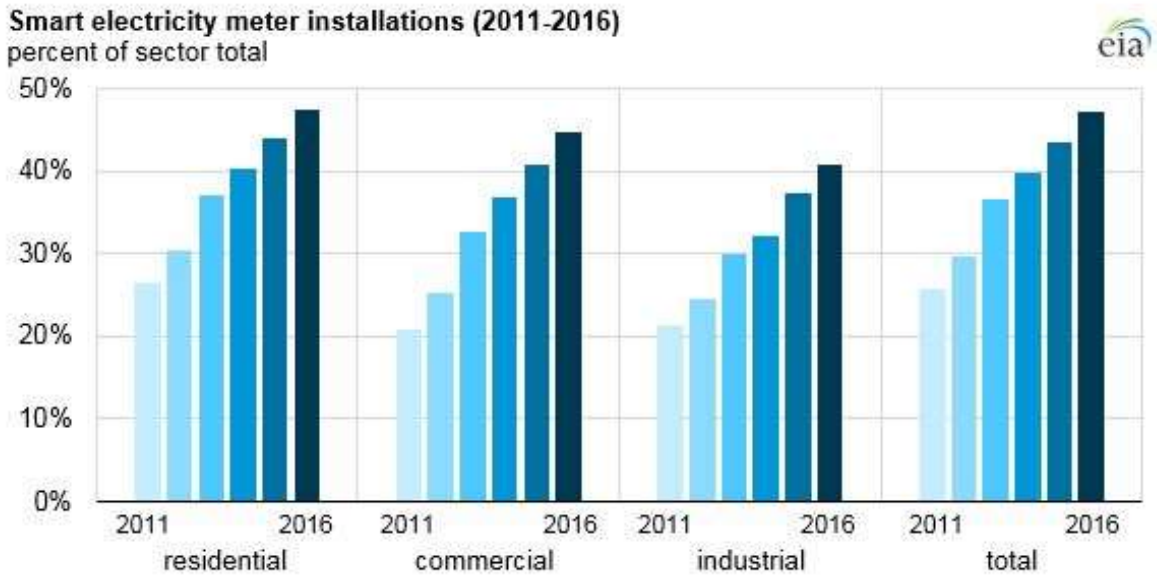
Topics

- Vermont AMI & What VEIC Has Done
- Monthly Data Limitations
- 5 Schools Case Study Summary
- Our New Approach
- Resources We Use
- Customer Benefits
- Sample Output with Charts

Advanced Meter Infrastructure (AMI)

DECEMBER 6, 2017

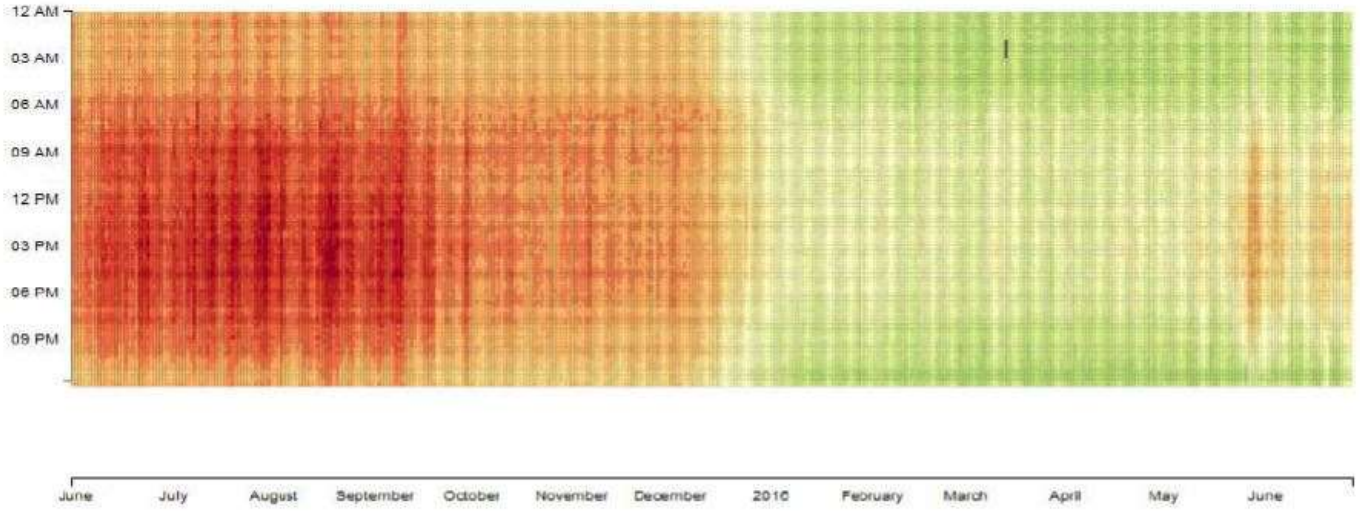
Nearly half of all U.S. electricity customers have smart meters

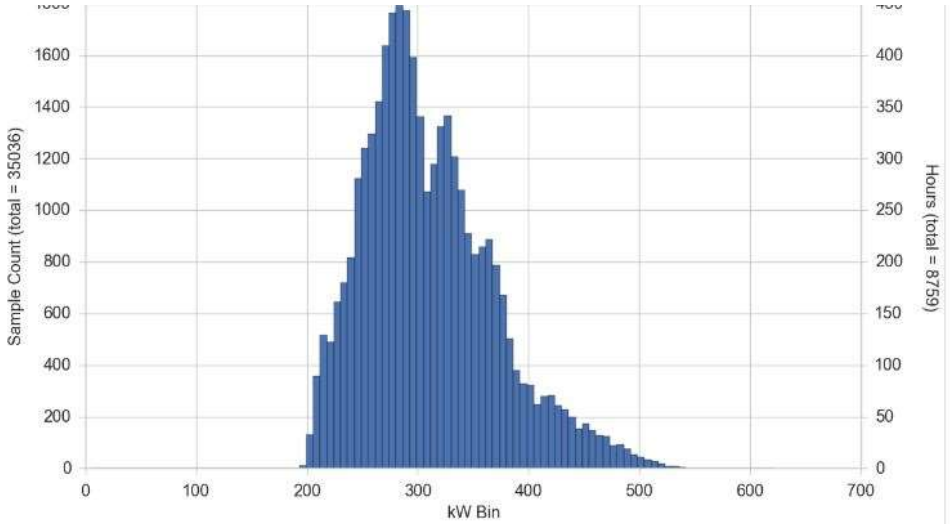


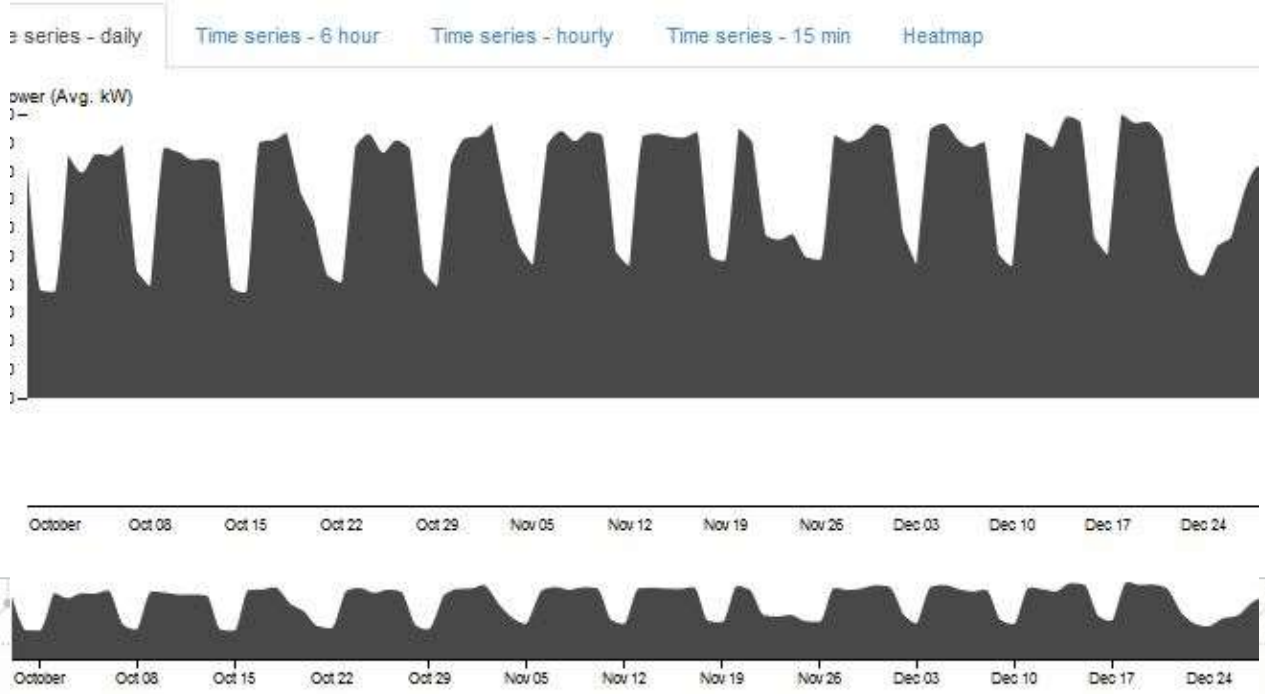
- In Vermont, > 80%
- >300,000 total installed
- 15-minute or 60-minute data intervals available

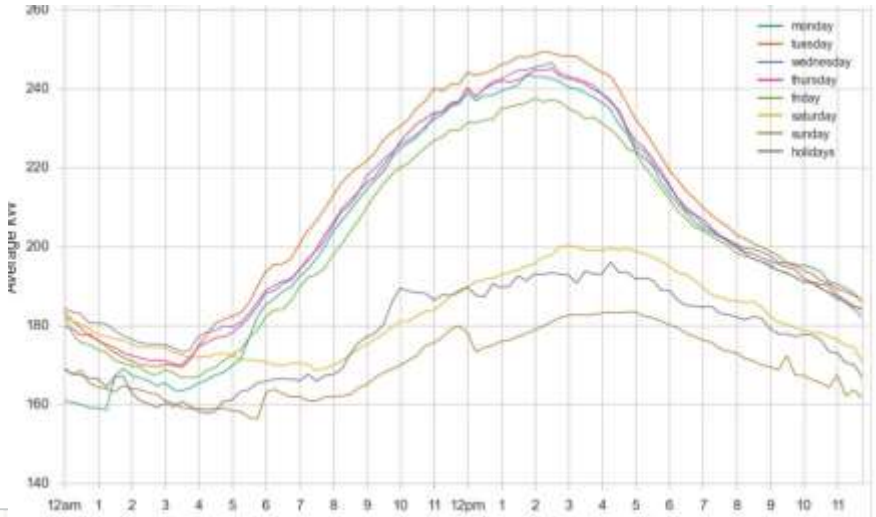
Source: U.S. Energy Information Administration "Annual Electric Power Industry Report" https://www.eia.gov/todayinenergy/detail.php?id=34012#

VEIC: Tools to Leverage High Frequency Data





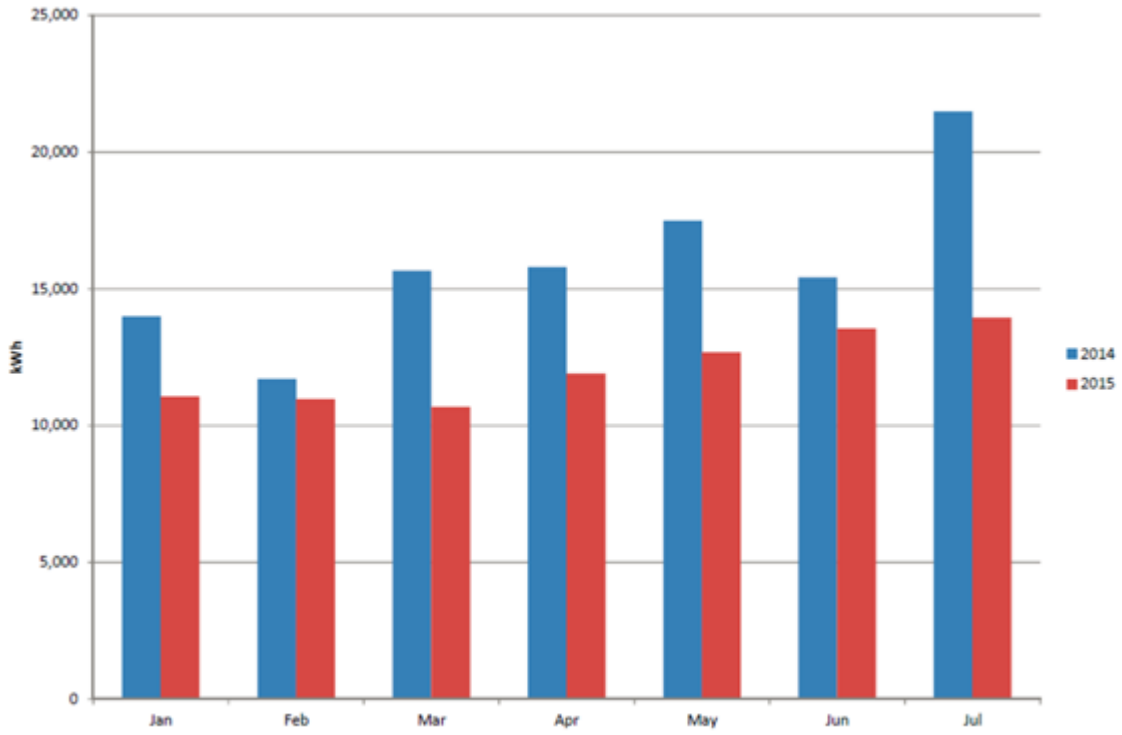




VEIC

Limitations with Monthly Electricity Data

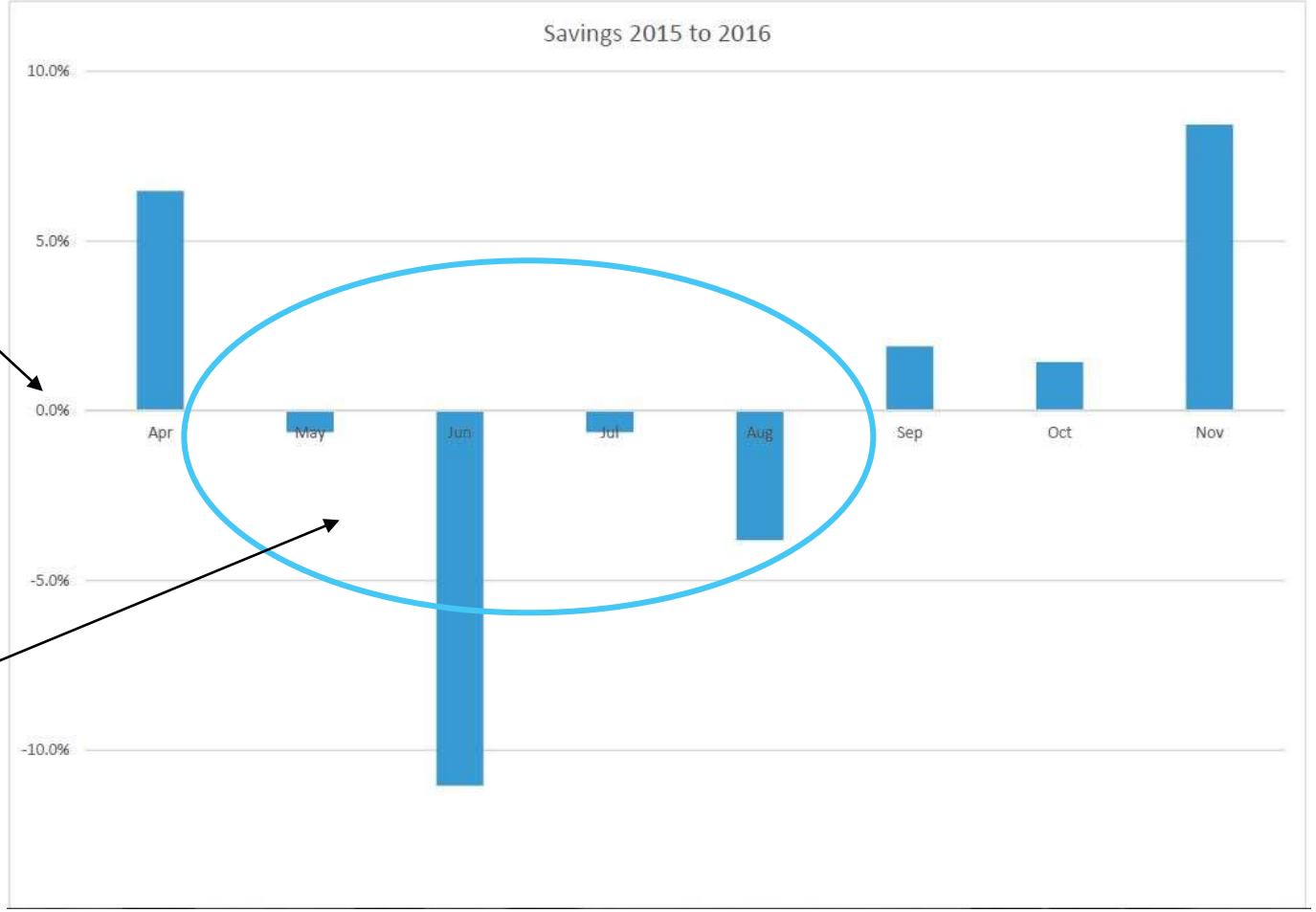
Monthly energy models typically find savings only when they are greater than 10%



More Than a Month to See Possible Increase in Energy Use

6% savings at end of project

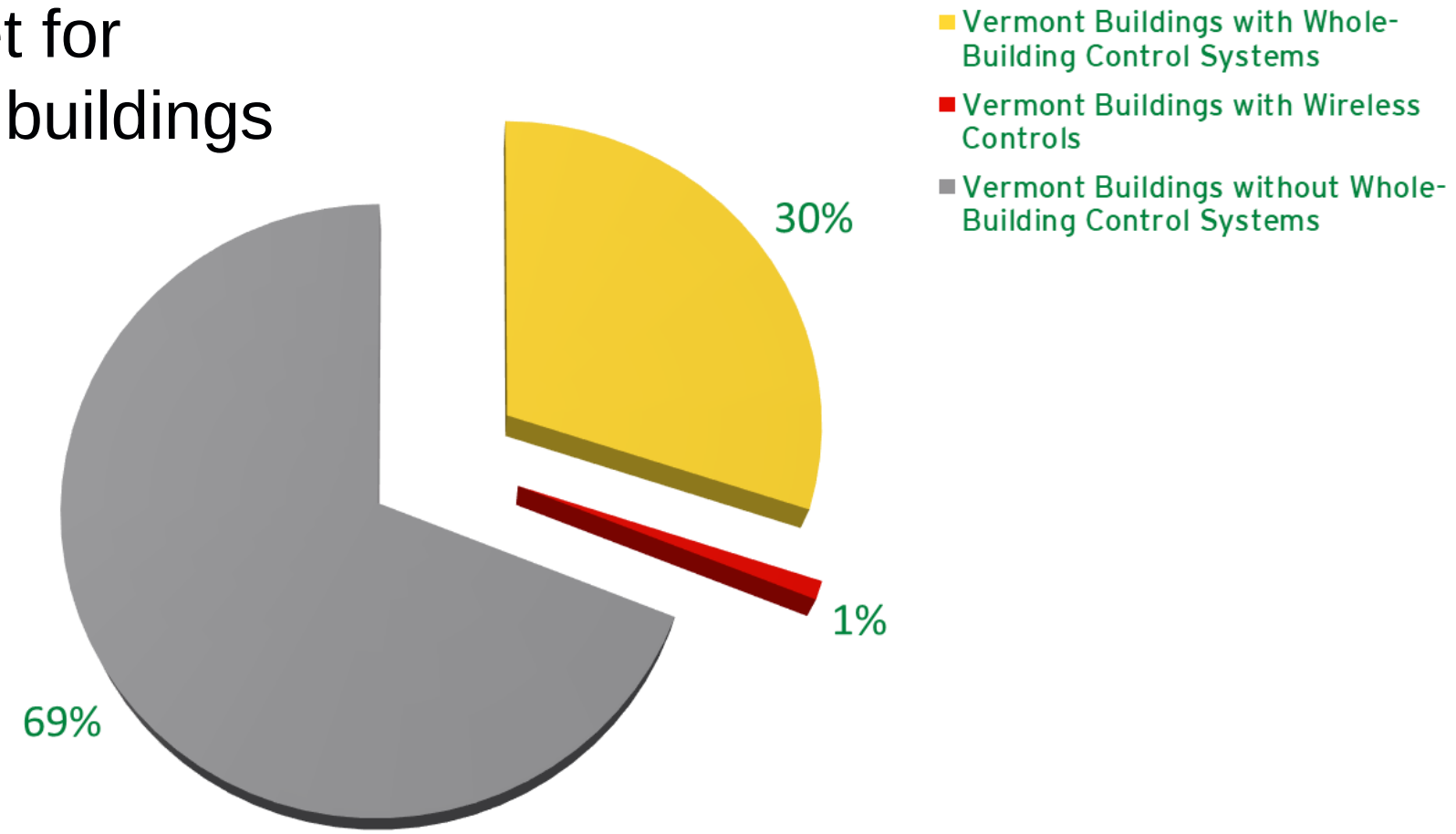
0% savings here



Energy use increases during summer so savings disappear until the fall

Other Ways to Obtain Data, But…

Vermont market for existing commercial buildings



High Frequency Data is a Game Changer!

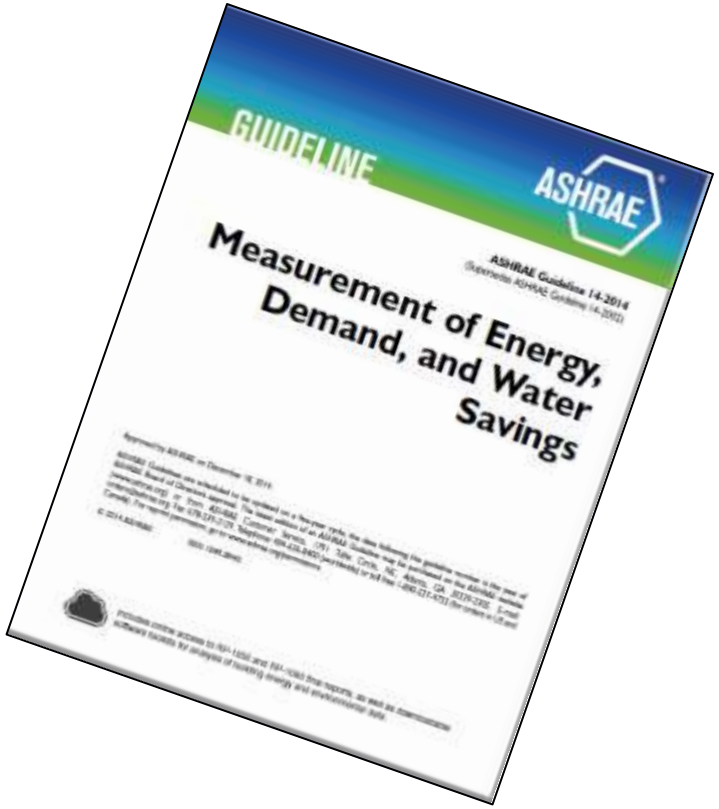
5 Schools in Mt. Mansfield Modified Union School District

	Brown's River Middle School	Camel's Hump Middle School	Richmond Elementary School	Jericho Elementary School	Smilie Memorial School
School floor area (sf)	88,760	88,760	40,800	49,500	17,400
Electricity savings (kWh /y)	30,000	15,650	33,680	10,800	12,580
Savings as percent of total site electricity	7.0%	5.2%	12.1%	5.3%	13.6%
RCx cost	$7,125	$0	$0	$3,207	$5,078
Annual savings	$4,400	$2,300	$3,000	$1,600	$1,800
Simple payback (years)	1.6	0	0	2.0	2.8
Average savings	8.6%				

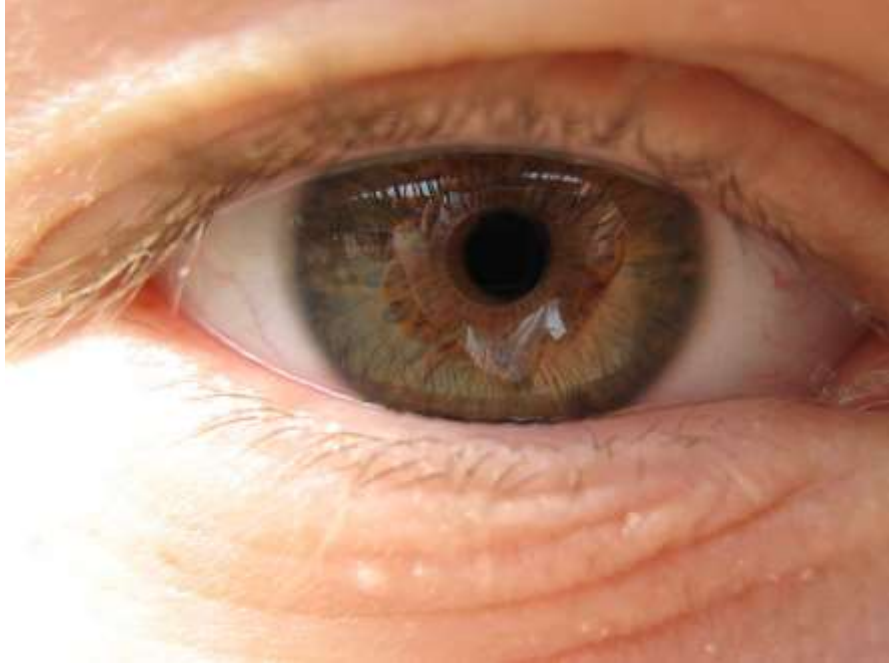
Information used with permission from Jeff Forward, Facilities Coordinator and Project Manager for Mt. Mansfield Modified Union School District. Project team also included Cx Associates and Temperature Controls of Vermont.

All We Needed Was Already out There

- LBNL weather modeling guidance
- OpenEEMeter open source code
- Bonneville Power Administration model validation guidance
- ASHRAE Guideline 14-2014 *Measurement of Energy, Demand, and Water Savings*



Higher resolution



- Small savings can be identified
  - As low as 2% of total usage
  - Scales down to cover small projects
- Higher confidence in large savings
  - Reduces uncertainty

Customer Benefits

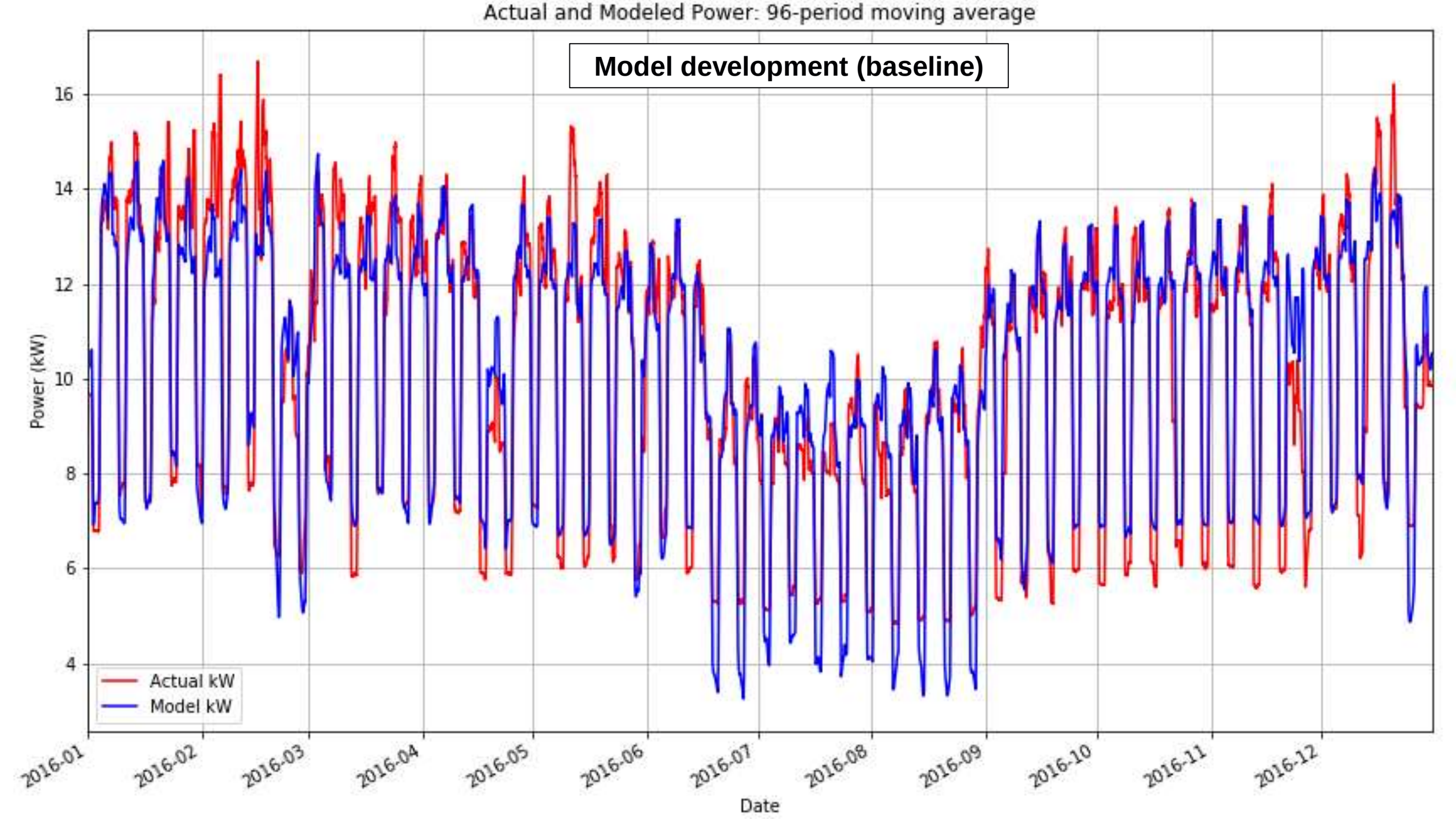
- Provide faster feedback
  - Monthly data takes 6+ months
  - ENERGY STAR® Portfolio Manager takes 12 months
- Contractors & customers can celebrate or troubleshoot quickly
- Become an engagement tool
- Provide motivation for future projects
- Save customer time through less data requests & on-site visits

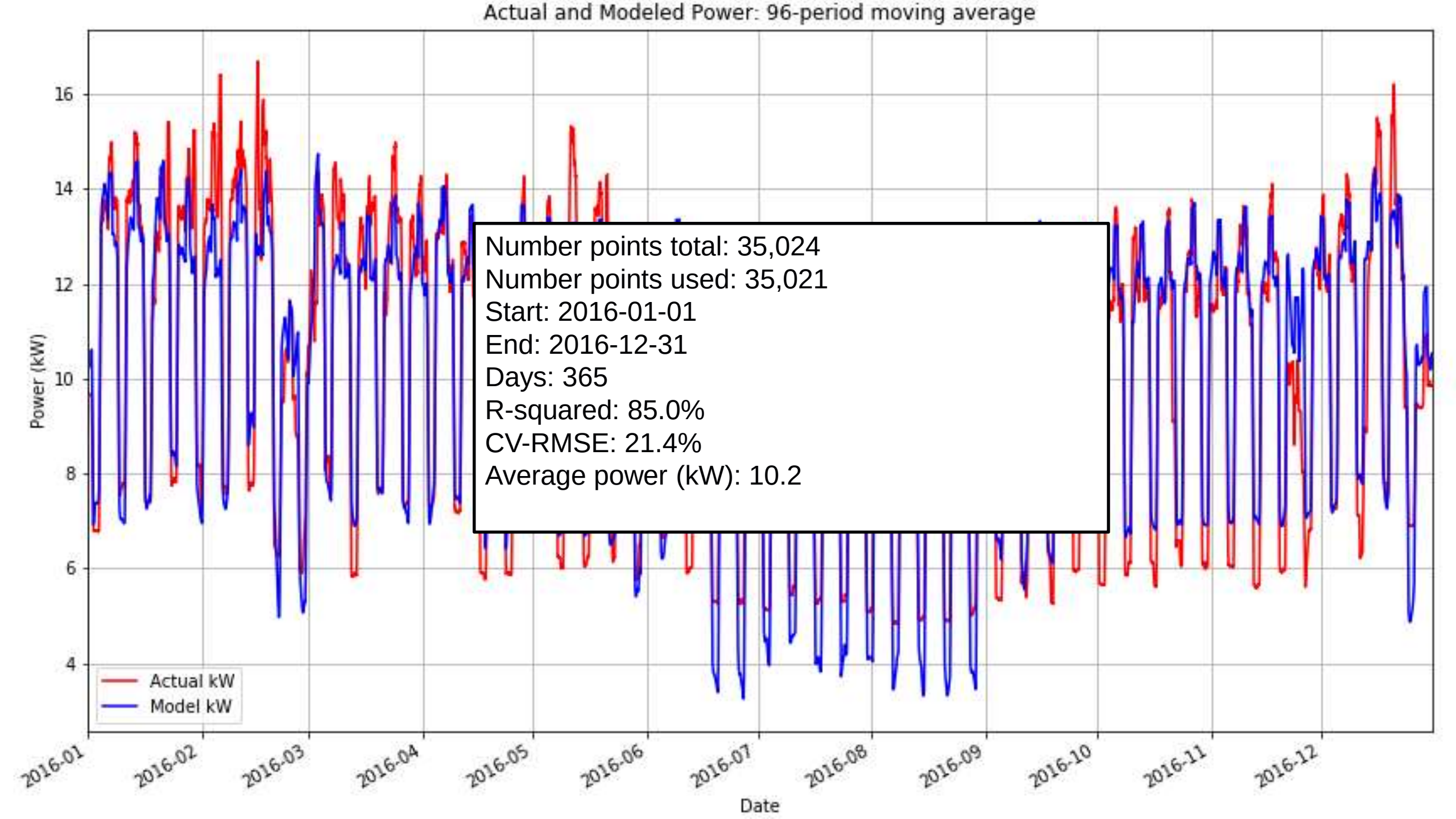
Pre-Screening Tool

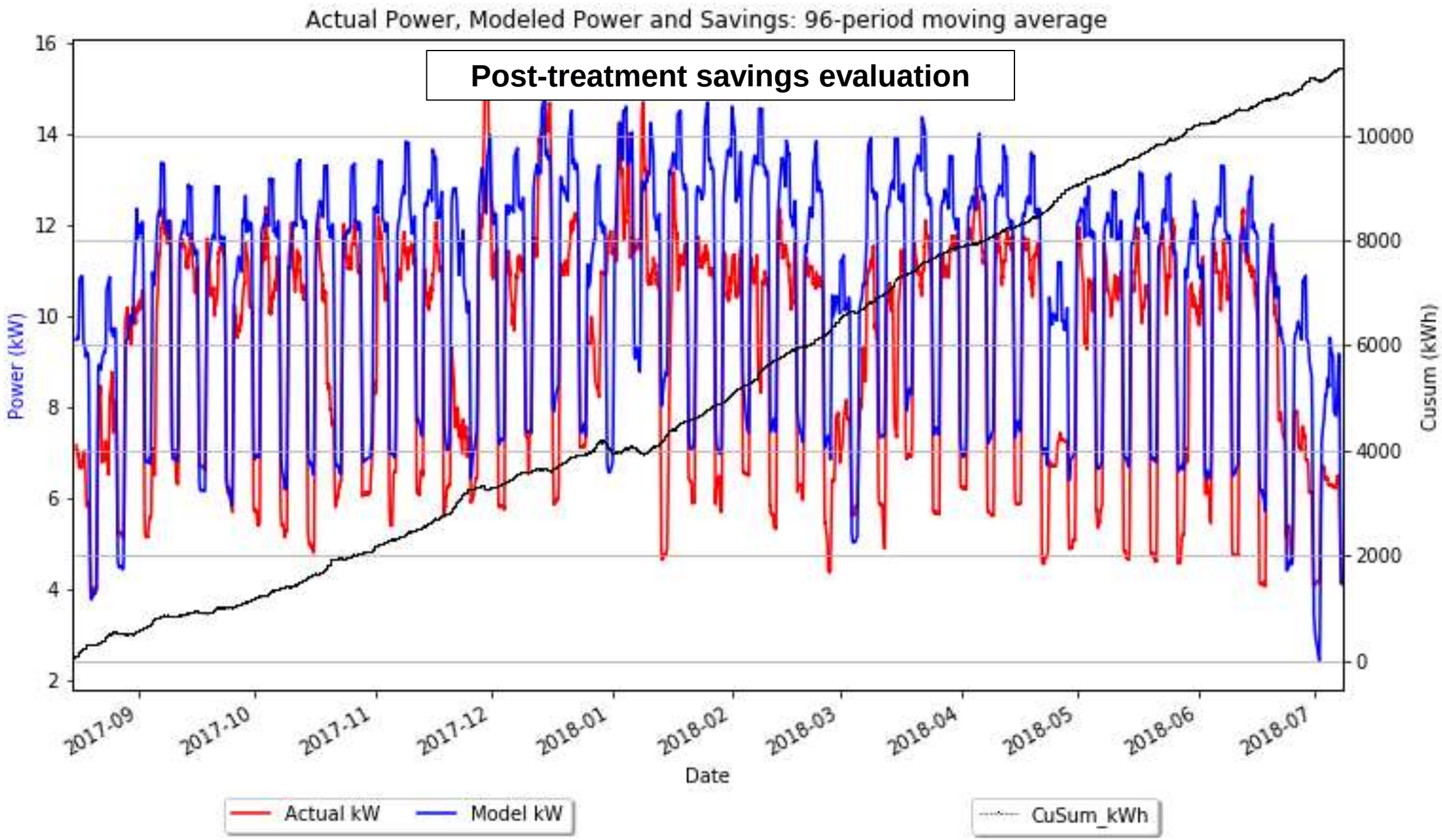
- Informs Pay for Performance (P4P) projects by eliminating surprises
- Provides an opportunity to address data challenges early

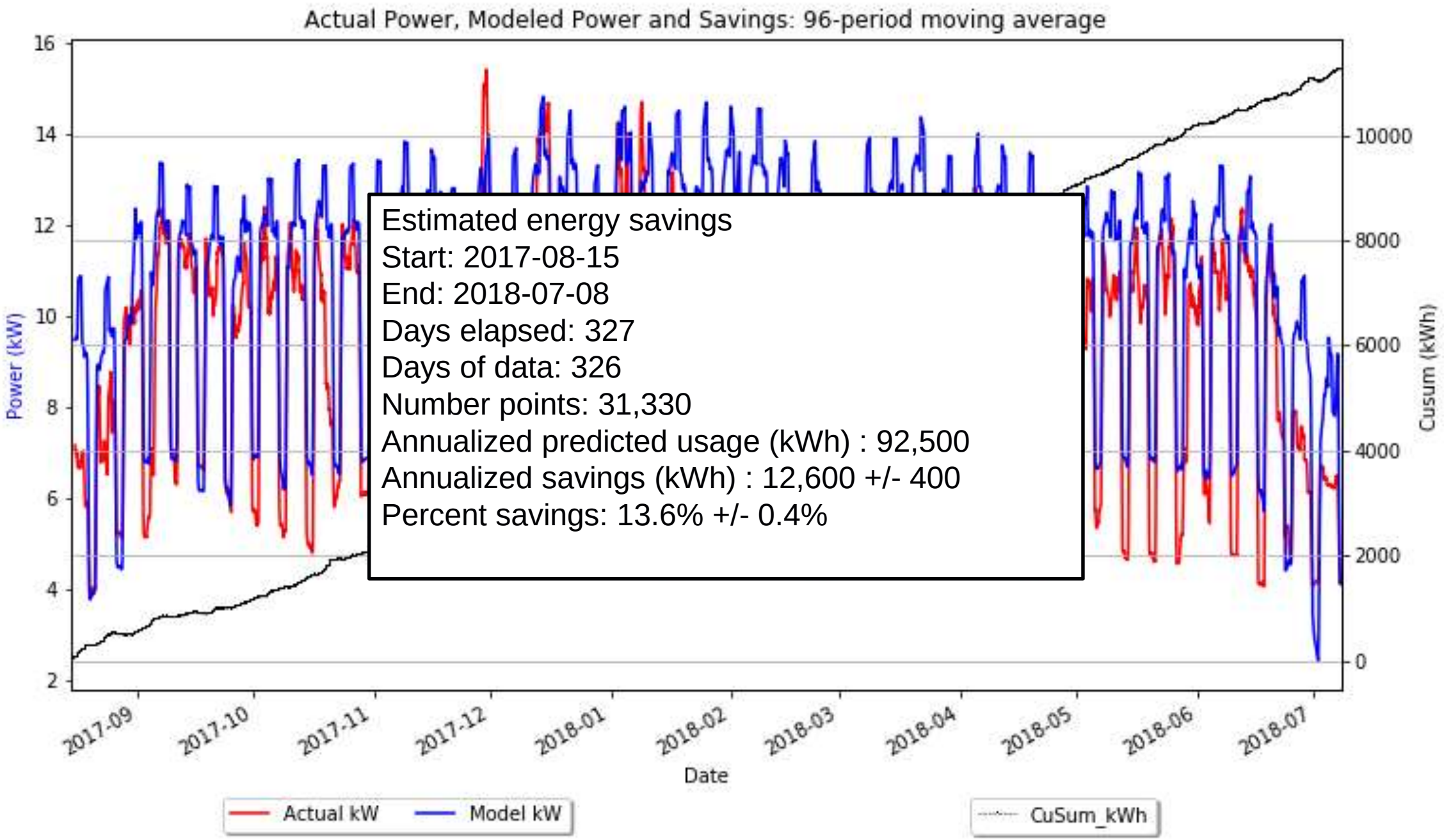
Streamlining the Process Saves Validation Costs

- Excel and Python-based solutions
  - No need to deploy submeters
  - No need to request building automation system data


Model development (baseline)
Actual and Modeled Power: 96-period moving average
Power (kW)
16
14
12
10
8
6
4
Actual kW
Model kW
2016-01
2016-02
2016-03
2016-04
2016-05
2016-06
2016-07
2016-08
2016-09
2016-10
2016-11
2016-12
Date


Actual and Modeled Power: 96-period moving average
Number points total: 35,024
Number points used: 35,021
Start: 2016-01-01
End: 2016-12-31
Days: 365
R-squared: 85.0%
CV-RMSE: 21.4%
Average power (kW): 10.2
Power (kW)
16
14
12
10
8
6
4
Actual kW
Model kW
2016-01
2016-02
2016-03
2016-04
2016-05
2016-06
2016-07
2016-08
2016-09
2016-10
2016-11
2016-12
Date


Actual Power, Modeled Power and Savings: 96-period moving average
Post-treatment savings evaluation
Power (kW)
Cusum (kWh)
Date
16
14
12
10
8
6
4
2
10000
8000
6000
4000
2000
0
2017-09
2017-10
2017-11
2017-12
2018-01
2018-02
2018-03
2018-04
2018-05
2018-06
2018-07
Actual kW
Model kW
CuSum_kWh


Actual Power, Modeled Power and Savings: 96-period moving average
Power (kW)
Cusum (kWh)
Date
Actual kW
Model kW
CuSum_kWh
Estimated energy savings
Start: 2017-08-15
End: 2018-07-08
Days elapsed: 327
Days of data: 326
Number points: 31,330
Annualized predicted usage (kWh) : 92,500
Annualized savings (kWh) : 12,600 +/- 400
Percent savings: 13.6% +/- 0.4%

Thank you

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November 7, 2018 | NEEP M&V 2.0 Workshop

Towards a 21st Century Efficiency Program Toolkit

Dan Fredman, PhD

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Agenda

- Context
- Our Story
- Lessons Learned
- Going Forward

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Context

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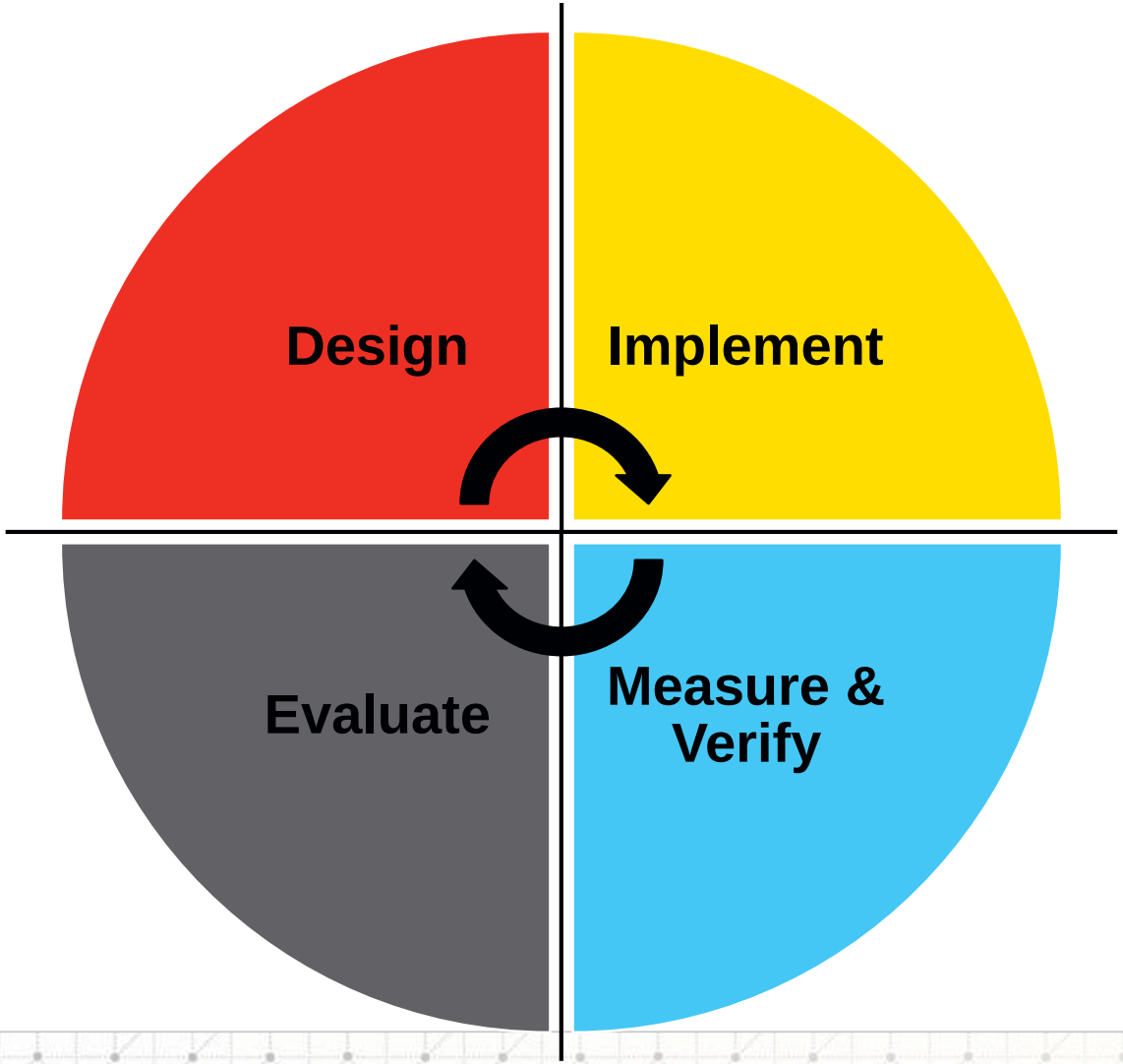
raconteur.net

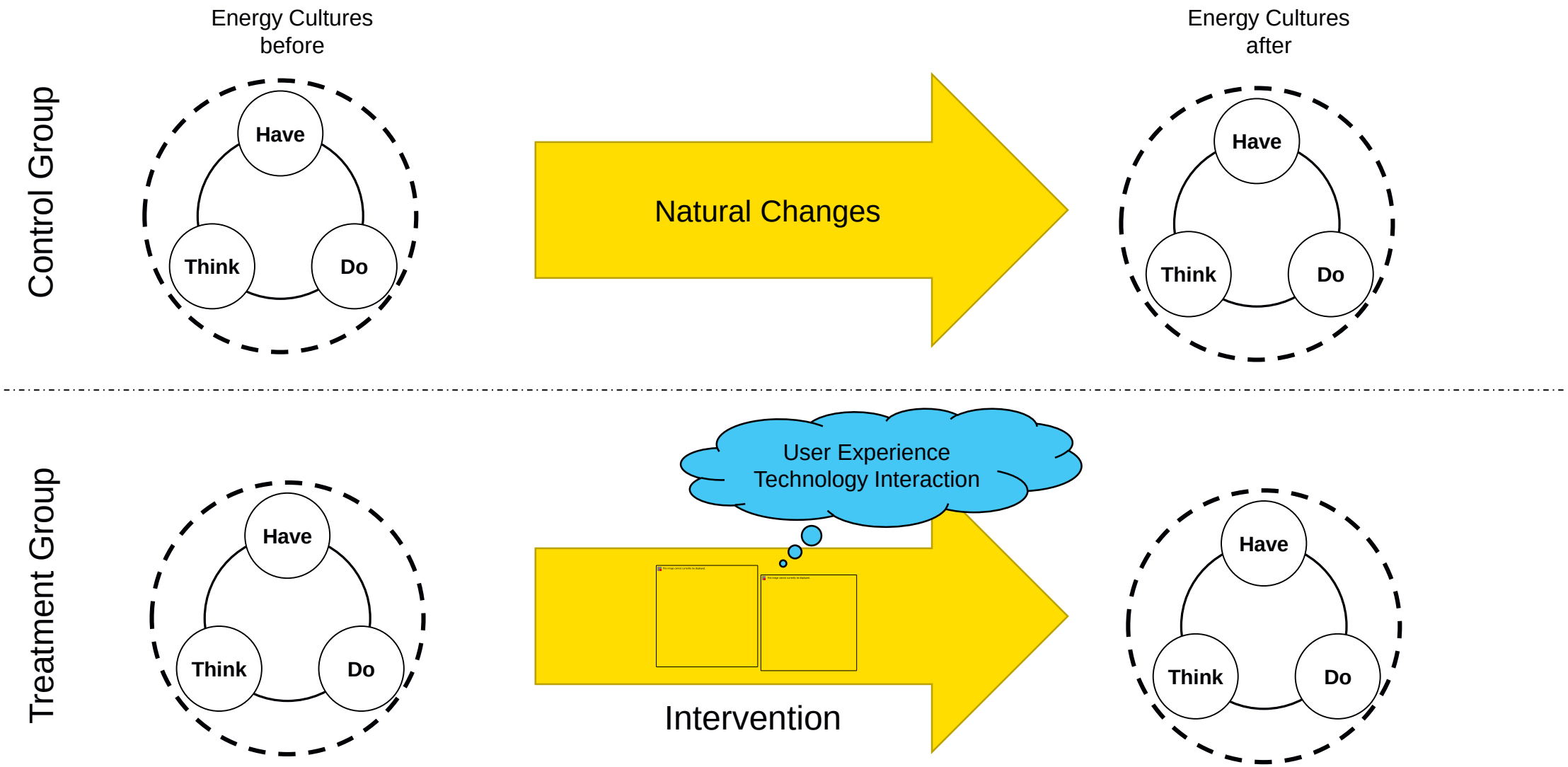
And yet …

… according to a recent (2017) survey by Gartner, Inc. of nearly 10,000 online respondents … during the second half of 2016 ... **only about 10% of households** currently have connected home solutions.

A Typical Program Lifecycle?



Measuring Changes in Energy Behavior



IEA-DSM Task 24 & Karlin et al. (2015)

Our story

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The Challenge (w/ remaining 2014-17 Behavior R&D funds)

Develop behavior programs that …

- Won't rely on HERs (neighbor comparisons)
- Will account for:
  - "Program uplift"
  - "Non-routine events"
  - 'Outlier' disruptors of consumption, e.g. Solar or HPWHs
- Maintain satisfactory customer experience
- Deliver savings via satisfactory M&V methods

source: intersector.com

Our approach: ARIES

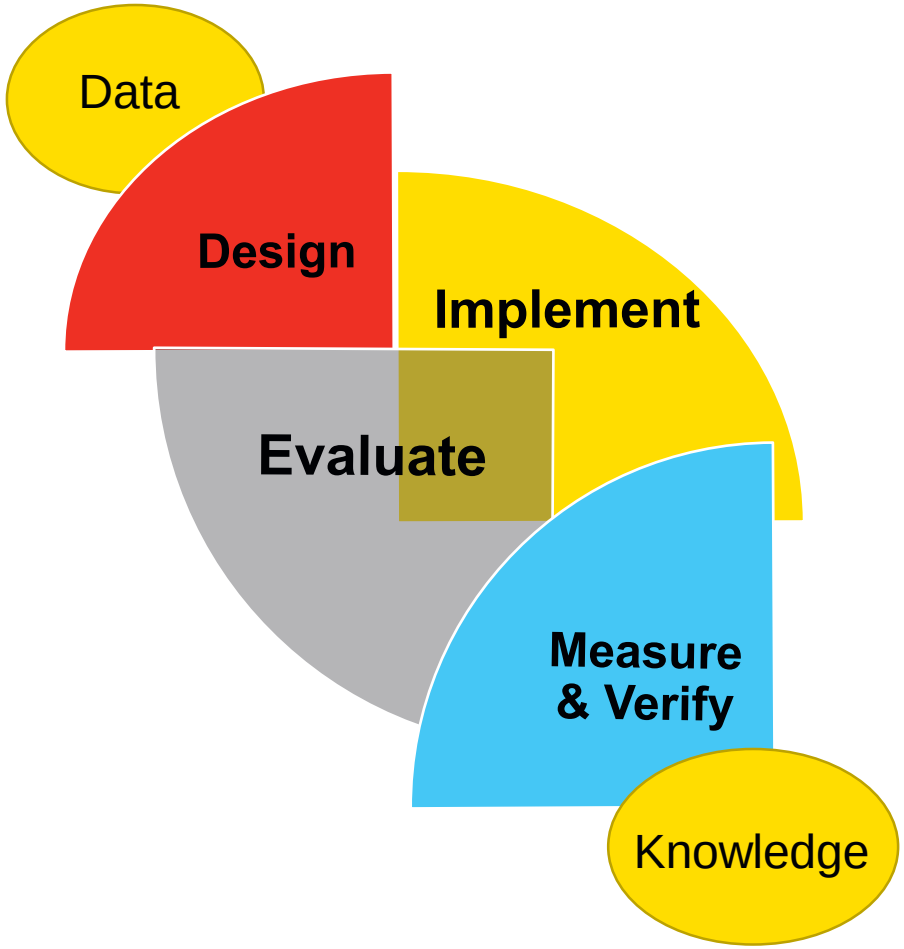
Advanced

Residential

Integrated

Energy

Study → Services



ARIES pilot overview

Driving Factors
1. Customer satisfaction
2. Rich data collection
3. Rapid deployment (free)
4. Maximize Effect
5. Maximize Measurability
6. Ongoing Assessment

Tools & Resources
Aligned Vendor/Partner
AMI Billing Data
Contractor Network
Survey & Data & Program Team

(Convenience Sample)

Recruitment

Installation

E-mails & Surveys

Ongoing Analysis

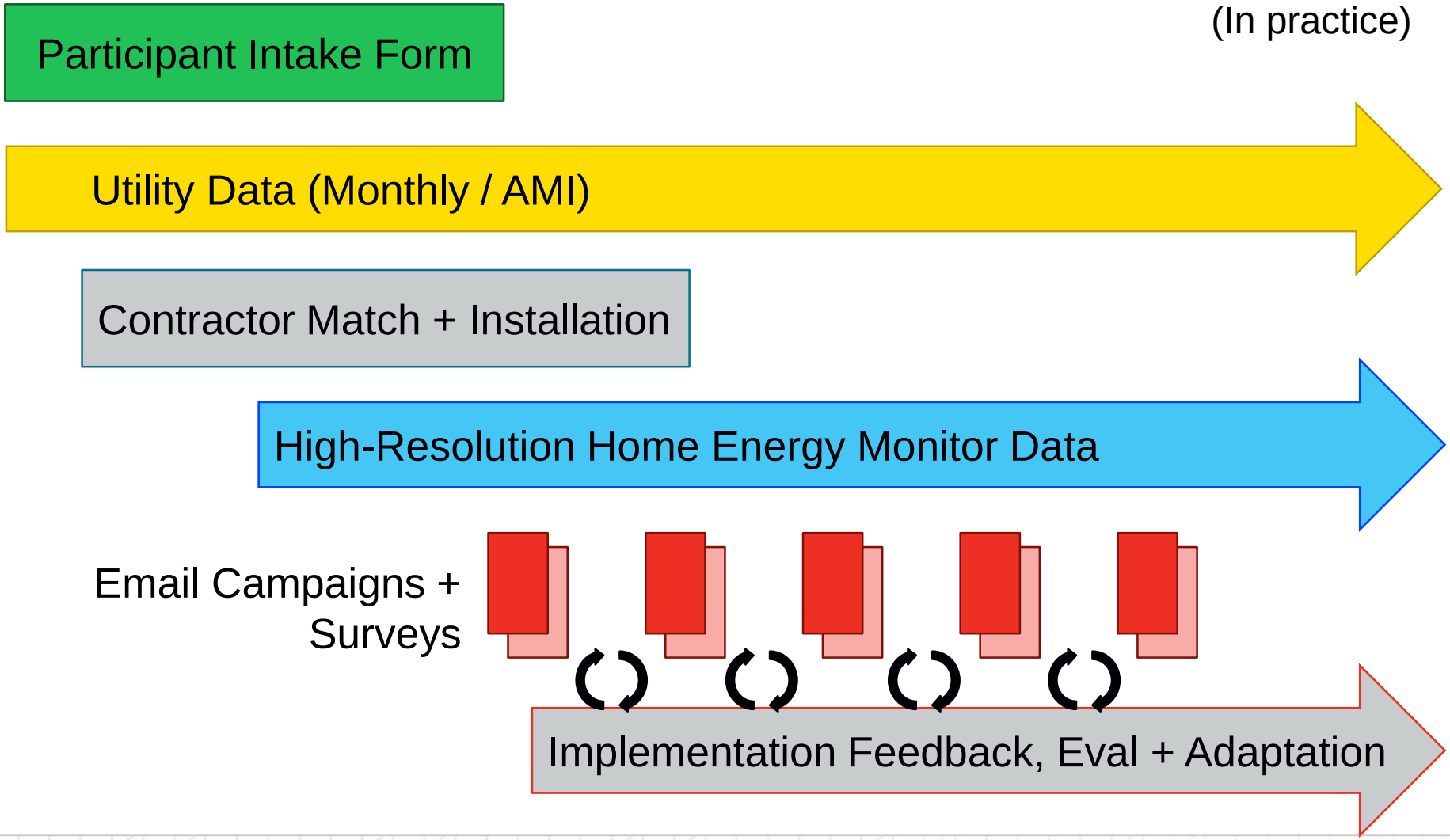
Savings Assessment

3 cohorts

N ~ 400

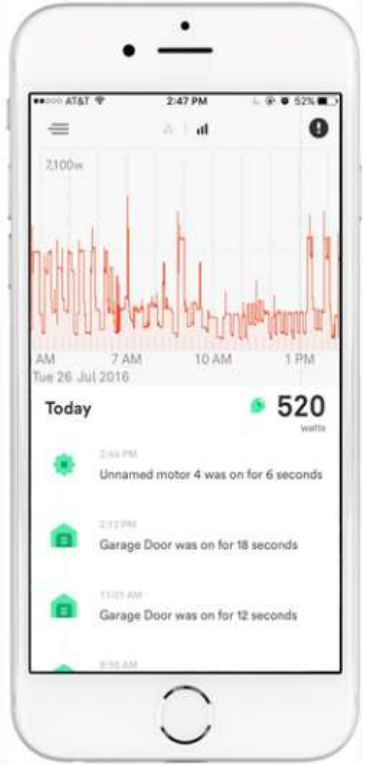
How it works

(In practice)



Finding a new way?

home screen



power meter

trends

Method: Off-the-shelf "virtual sub-metering" product

In-panel hardware + App + 'cloud'

Measure mains current and voltage

Very high frequency sensing (Mhz)

Pattern recognition, device detection

'Edge' Computing + Human-aided ML

Lessons Learned (so far)

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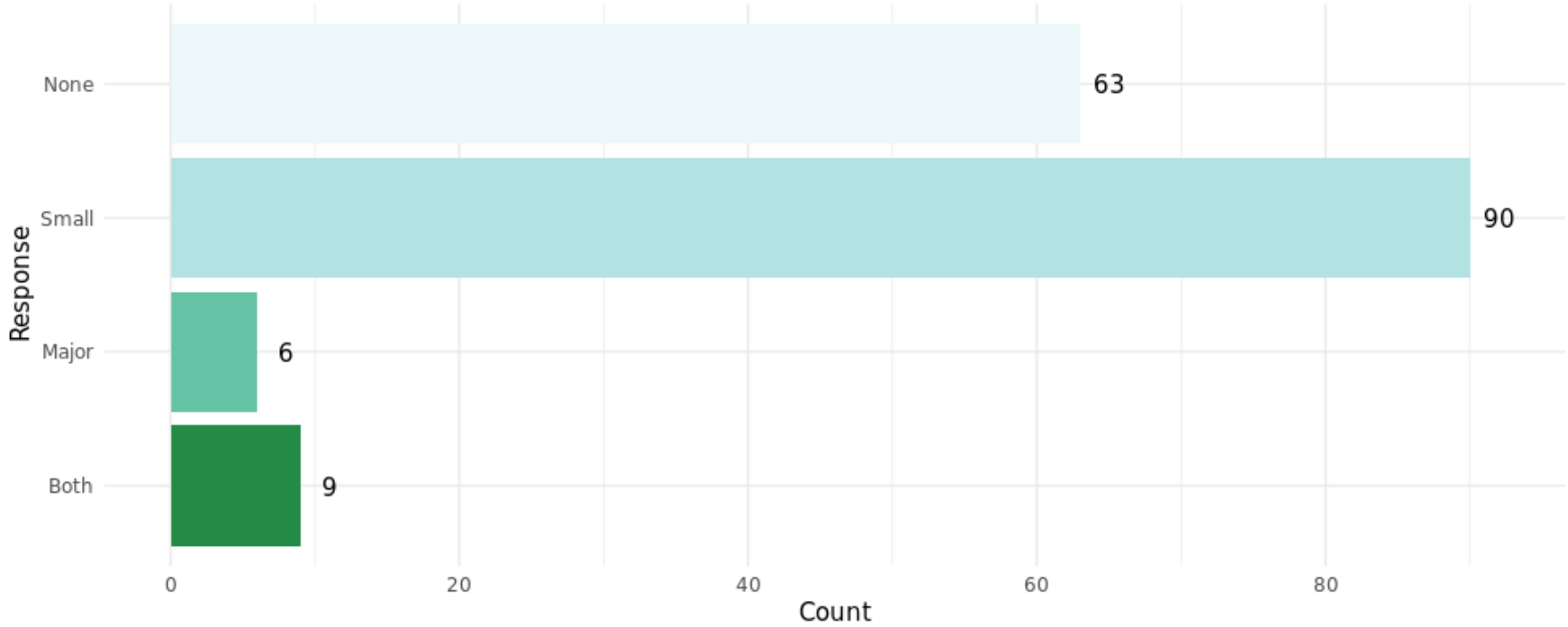
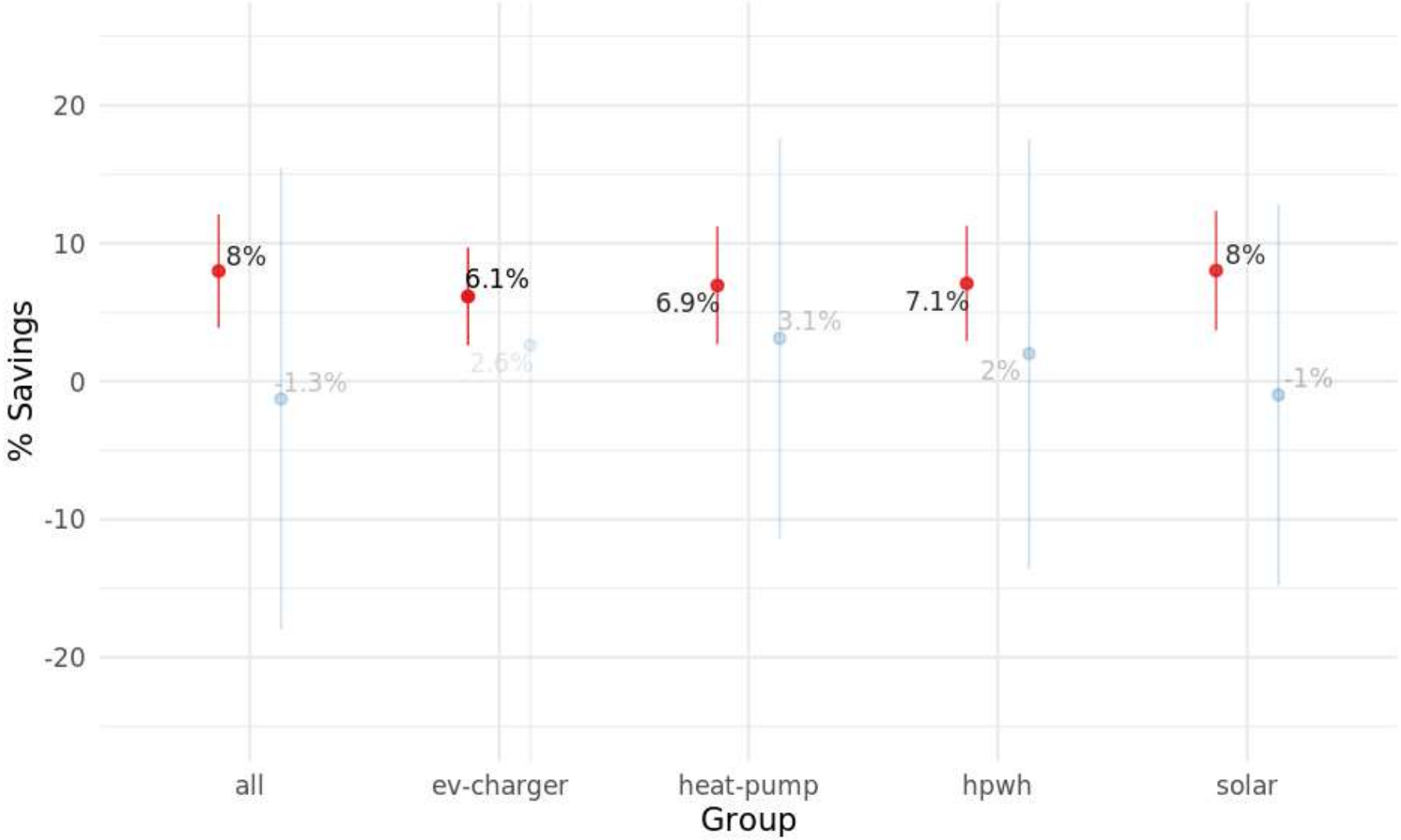
Energy-saving changes at home since monitor installation



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

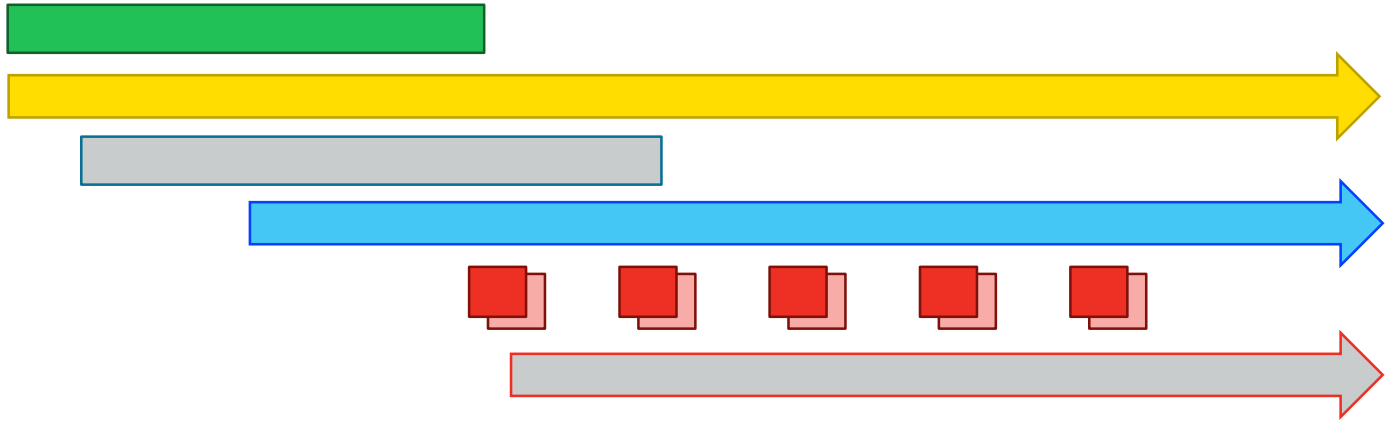
VERY Early Savings Estimates?



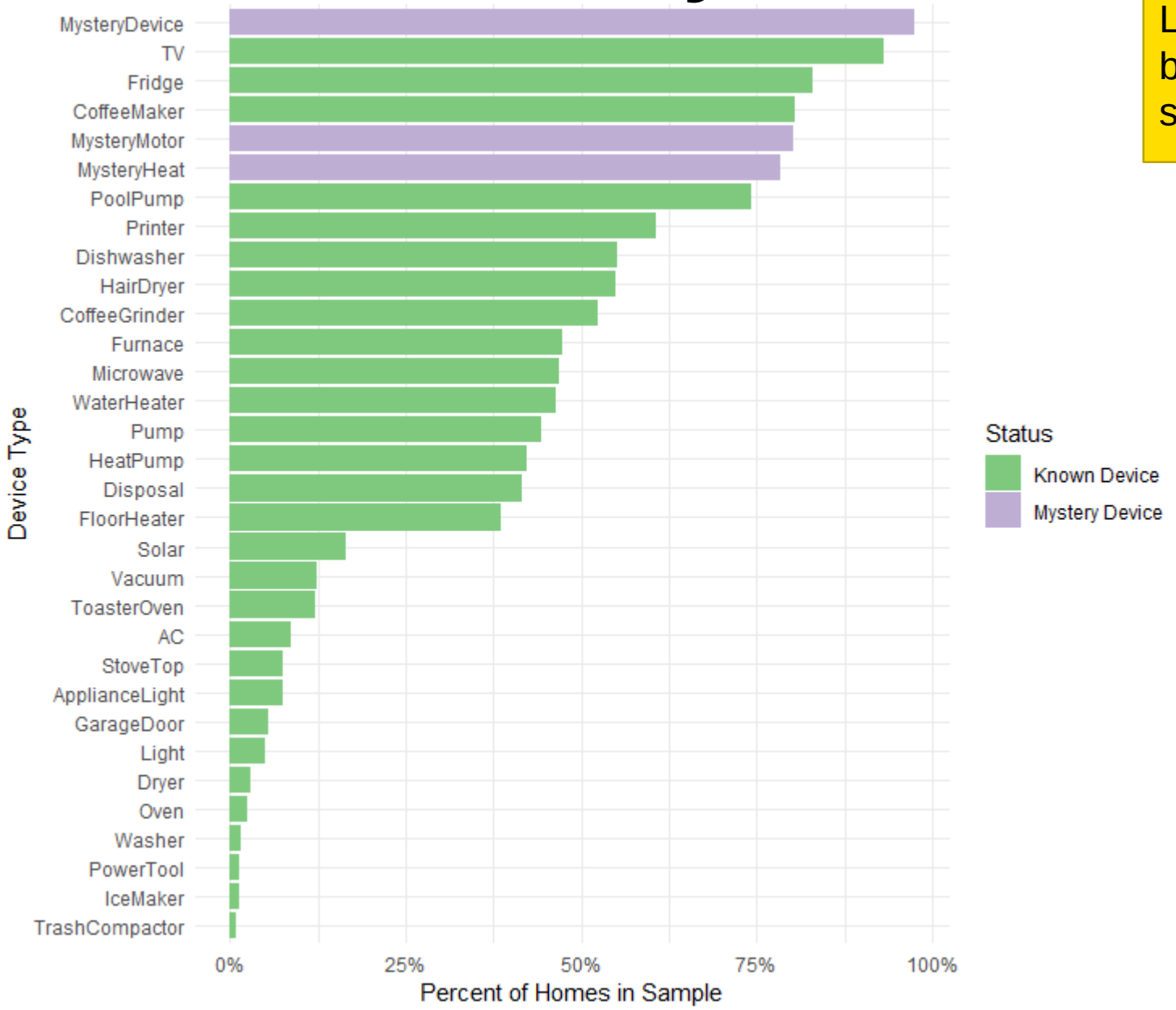
- “M&V 2.0”
- Segmenting on ‘anomalies’ revealing
- Passes “is something here” pilot test

Learning in context

- Different service areas: Different priorities
  - Peak-related demand response
  - Concerns about DER expansion
  - Technology reliability & non-AMI solutions
- Same pattern, different data streams:

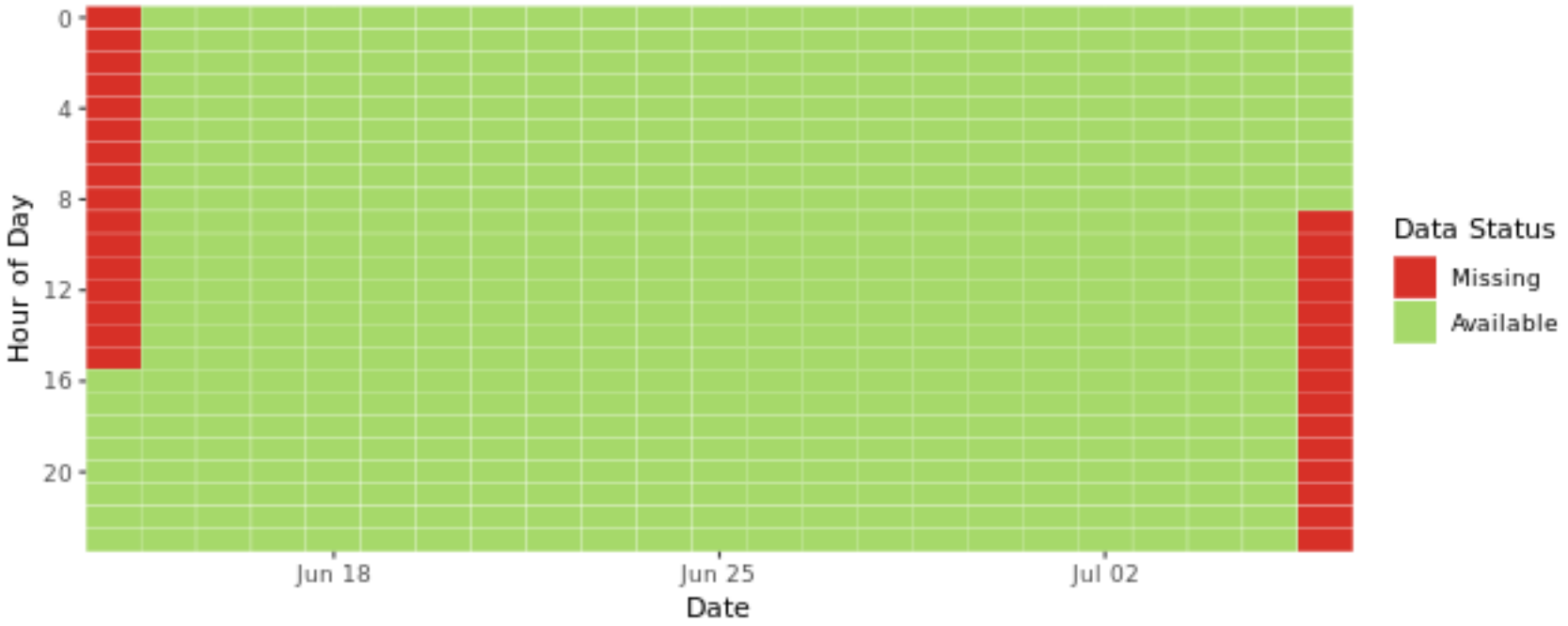


Device Diversity

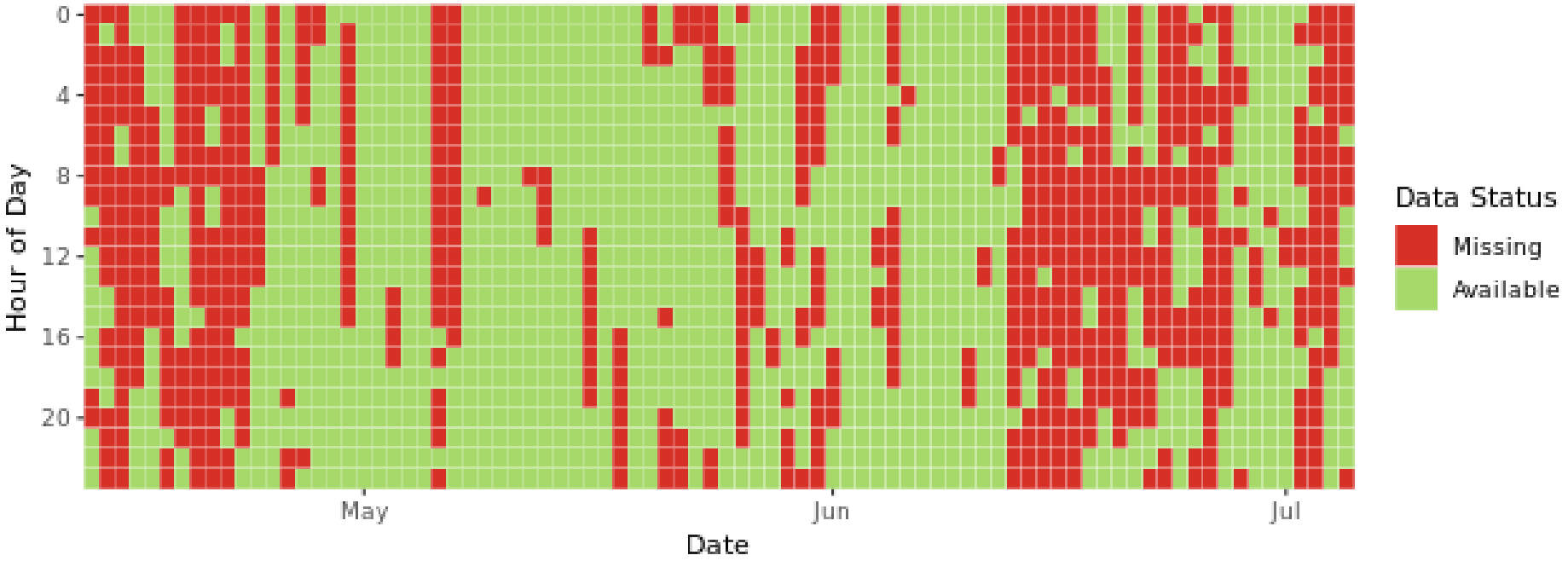


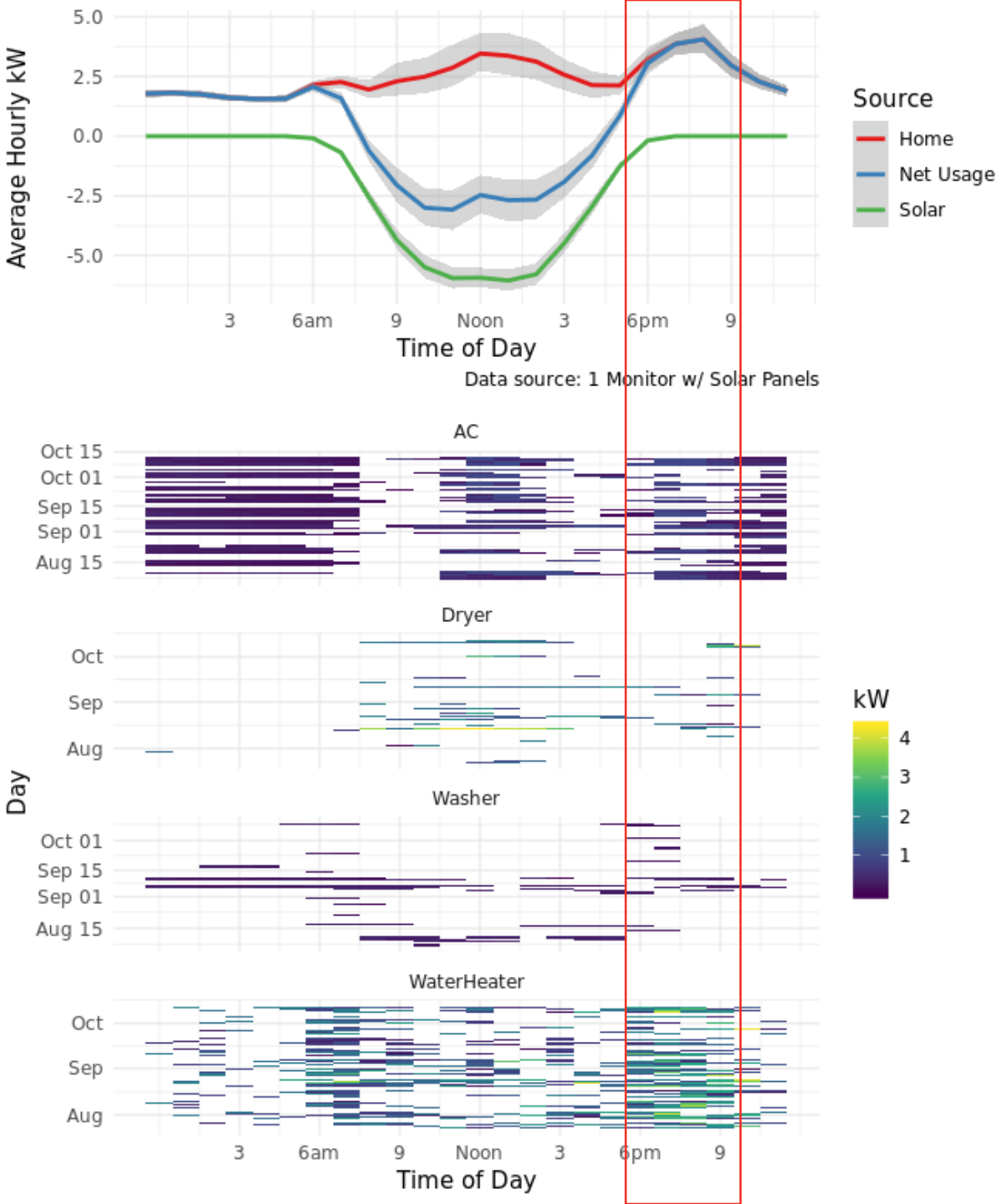
Example only. Labels have been randomly shifted!

Monitor Uptime



Monitor Uptime





Grid Impacts?

- Demand response
- Rate guidance
- Pay-for-performance
- Custom messaging
- Anomalous loads

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Going Forward

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Some (New?) Obstacles

- Data source diversity (+ management)
- Complex programs + time spent recreating:
  - Program designs
  - Implementation approach
  - Analyses and Evaluation
- Interpretation of data feeds
  - Accuracy + Validation
- Fast turnaround time required

If you learn something today:

1. Changing EE needs + new technologies require
   new ways to create and ID savings
2. Implementers need new tools to get this done → there's something here (and needs more work)
3. Innovative programs need a coordinated, open science initiative
   → You should contribute!

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Thank you!

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Regulatory Perspective EM&V 2.0

November 7, 2018
Burlington, VT

EM&V 1.0

- EM&V 1.0 +
  - Well defined best practices and methodologies
  - High levels of confidence in its results
  - Deemed Savings
  - Accepted and understood by Regulators
- EM&V 1.0 –
  - Time-consuming
  - Expensive
  - Additional equipment required
  - Potentially disruptive to the participant
  - Not particularly responsive to program needs

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EM&V 2.0

- More accurate deemed savings values
- Lower cost of EM&V
- Real-time energy performance of new equipment
- Ability to evaluate measures and programs within a shorter time period
- More uniform methods of determining energy savings in certain areas
- Help to understand measure persistence.

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But….

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Data Sources

- Large-scale Data Analysis
- Interval Meter Data
- Nonintrusive Load Monitoring
- Embedded Sensors in Equipment

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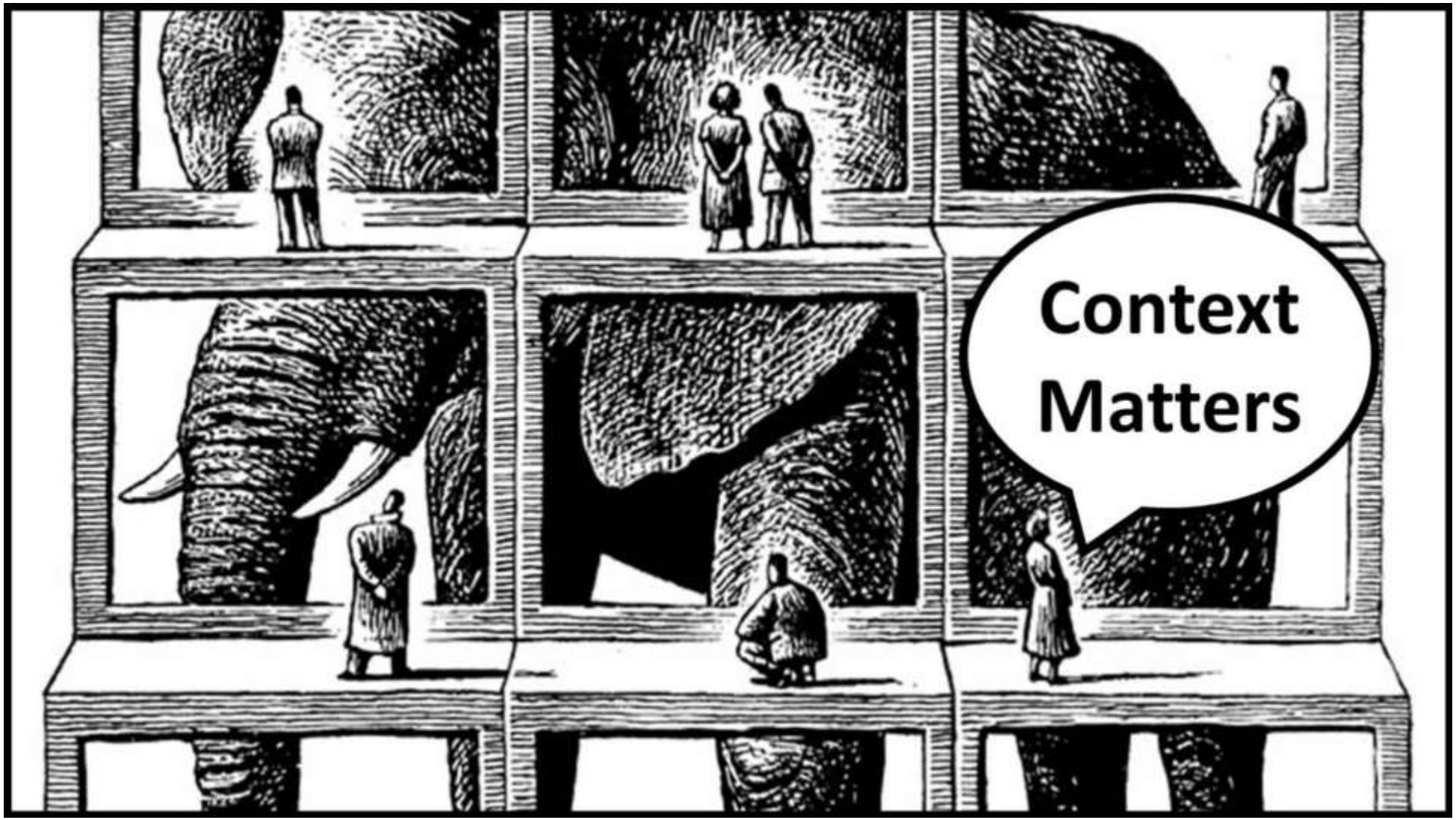

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What the Regulator Needs

- Education on what EM&V 2.0 is and how it works.
- Best practice guidelines for these tools
- Empirical evidence that results from EM&V 2.0 are statistically similar to those from EM&V 1.0

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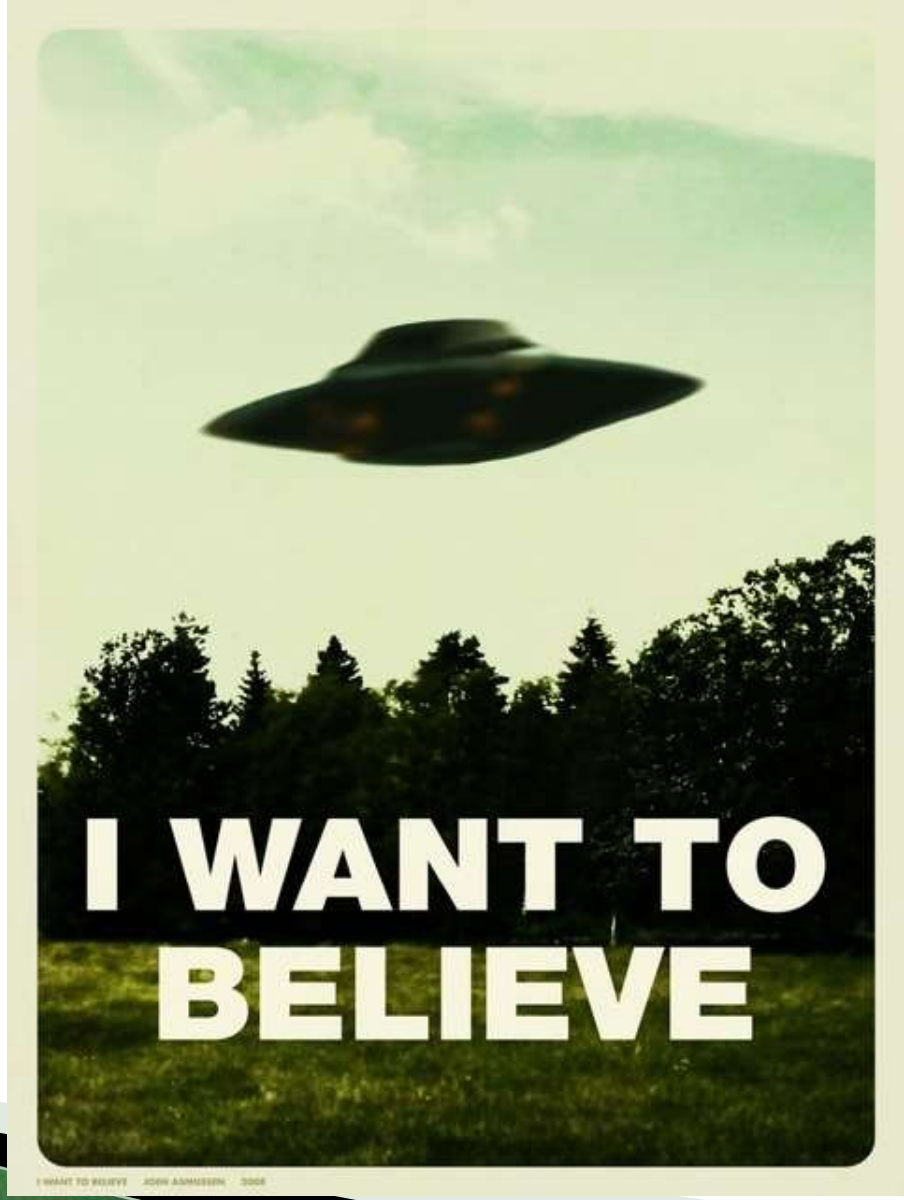
Convince Me



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QUESTIONS AND DISCUSSIONS