



The Current Flavors of M&V

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ADVANCED M&V

MEASURE, UNDERSTAND, KNOW

NEEP M&V FORUM
October 3, 2017
Jeff Perkins

Reasons for Evolving M&V

1. More rapid data analysis
2. Improve programs during implementation cycles
3. Improve evaluations with little or no extra costs
4. Understand and manage demand curves
5. Evaluate GHG impacts of programs and measures
6. Efficiency as a grid resource

CHALLENGE

CHANGE

SHAKE UP

DISRUPT!

Integrated Resources

Can Energy Efficiency Compare with:

- Distributed Generation?
- Renewable Energy?
- T&D Upgrades?



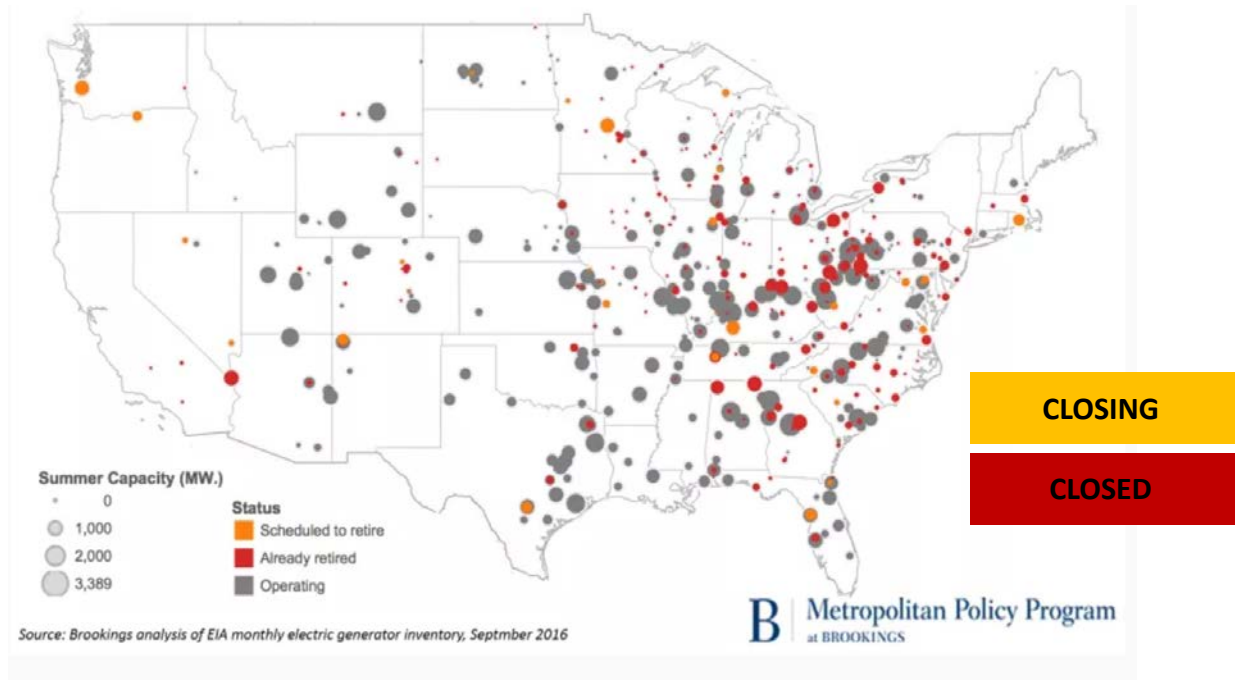
Traditionally, system planners have deeply discounted energy efficiency at the grid level.

Retiring Power Plants

A host of U.S. nuclear power plants closed or closing



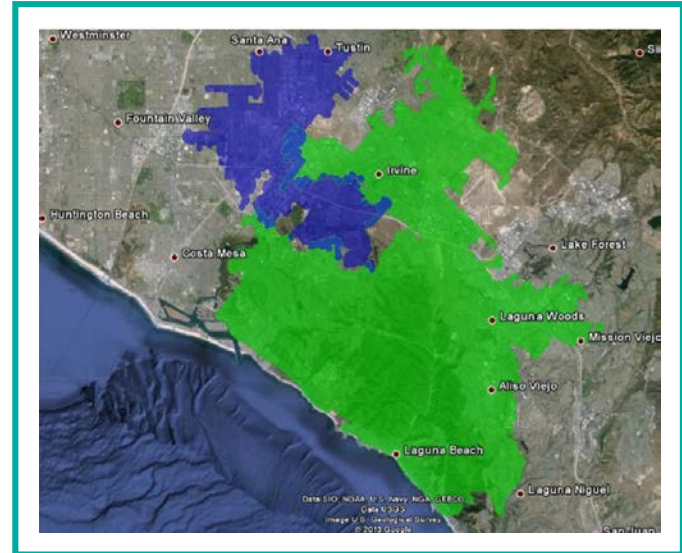
Even more coal plants offline



Dealing with SONGS Closure

2014 All Resources Procurement

- ❑ Implement portfolio solution to address local peak
- ❑ Demonstrate DSM can be used to meet capacity & reliability
- **125MW of Efficiency Projects**



Providers of efficiency solutions are required to meter the savings delivered.

Efficiency for Capacity Needs

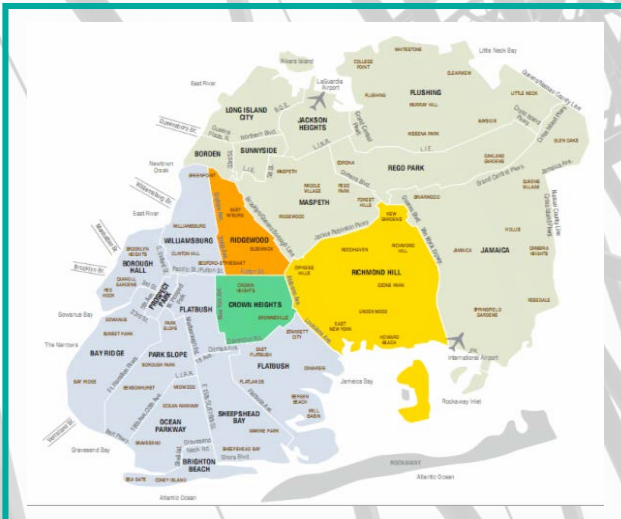
Demand Management Program (DMP)

Replacing Indian Point 2,000 MW

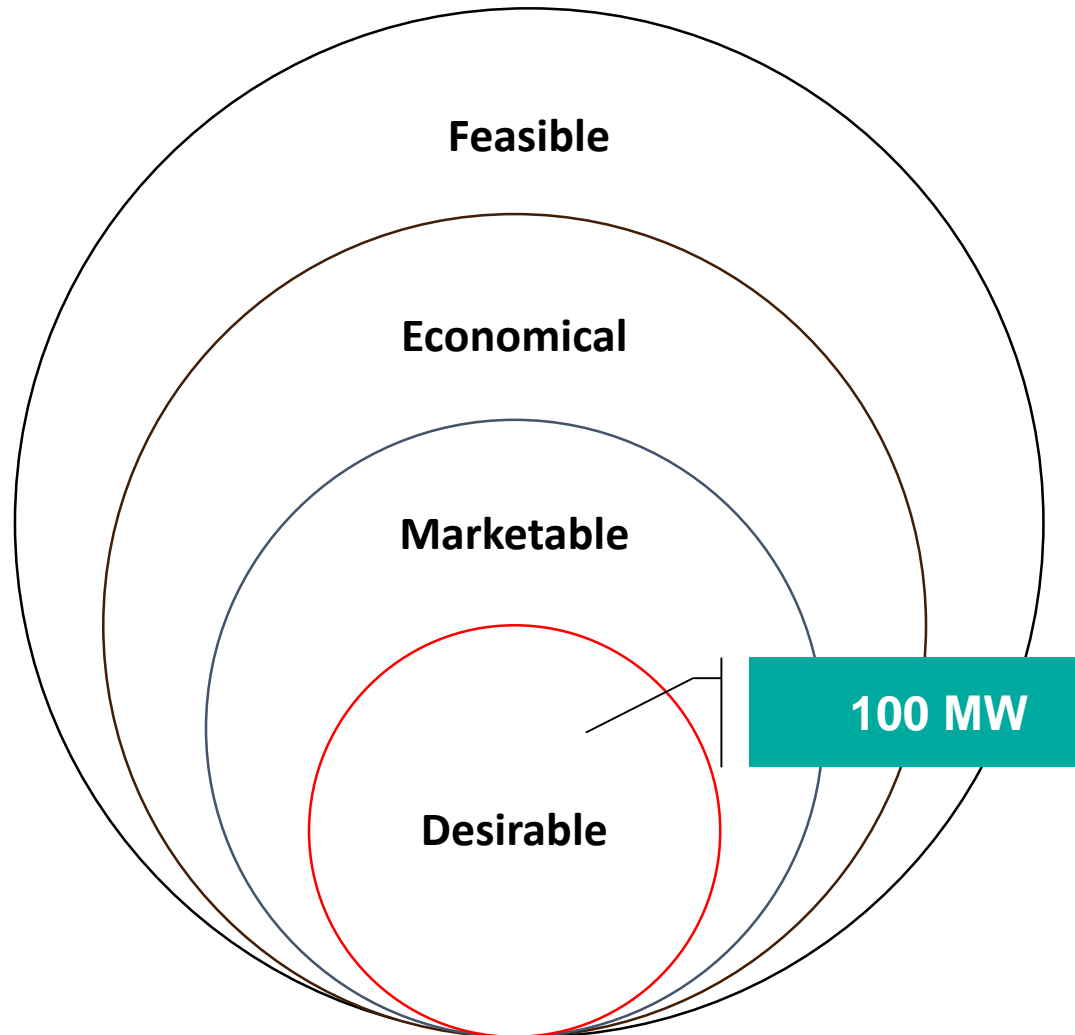
- 1,000 MW from Hydro-Quebec
- Renewables, CHP, other Generation
- Energy Efficiency
 - 100 MW of Efficiency Upgrades
 - Targeted 2-6 pm, Jun-Sep

Non-Wires T&D Solution: BQDM

- Install \$200 million customer side resources to defer building a \$1 billion substation



Most Desirable DSM






Increased Value of Efficiency

A premium paid for targeted efficiency when it can be measured and confirmed.

DEMAND MANAGEMENT PROGRAM

In addition to the current program offerings, increased incentive rates will be offered to eligible Con Edison electric customers for energy improvements that provide summer on-peak demand reduction.

Project Type	Before DMP		DMP Offer
Thermal Storage	\$600/kW		\$2,600/kW
Battery Storage	\$600/kW		\$2,100/kW
DR Enablement	\$200/kW		\$800/kW
Chiller/HVAC/BMS/Controls	\$0.16/kWh		\$0.16/kWh + \$1,250/kW
Lighting	\$0.16/kWh		\$0.16/kWh + \$800/kW

Targeted Efficiency

- ❑ Real-Time, Near-Time M&V
 - Efficiency hits target window
 - No room for error
- ❑ Specific knowledge needed
 - Which measures where
 - In which sectors
 - Which incentives to adjust
 - Measures to add/delete
 - How to target marketing

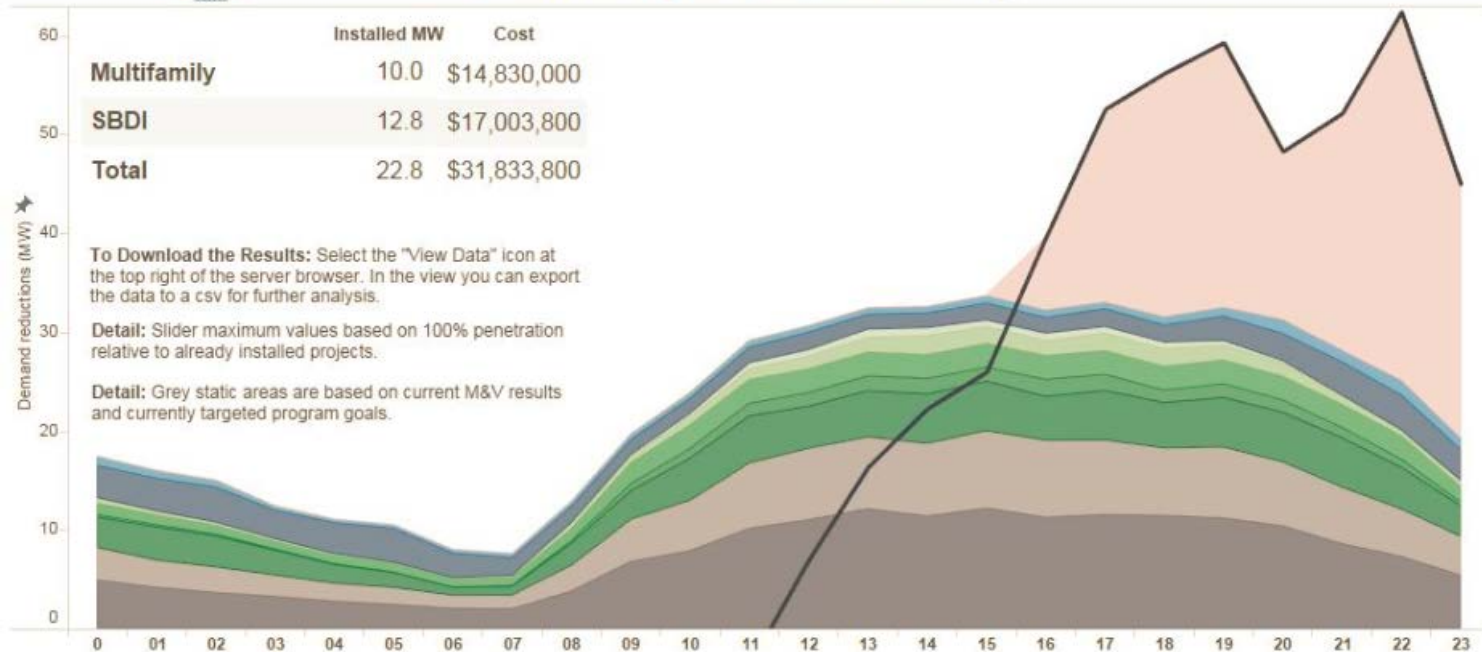
The Neighborhood Program



Most Desirable DSM



Planning & Forecasting



	Installed MW	Cost
Multifamily	10.0	\$14,830,000
SBDI	12.8	\$17,003,800
Total	22.8	\$31,833,800

To Download the Results: Select the "View Data" icon at the top right of the server browser. In the view you can export the data to a csv for further analysis.

Detail: Slider maximum values based on 100% penetration relative to already installed projects.

Detail: Grey static areas are based on current M&V results and currently targeted program goals.

SBDI Office Installed MW <input type="text" value="1.2"/> <input type="range"/>	SBDI Grocery Installed MW <input type="text" value="2.4"/> <input type="range"/>
SBDI Retail Installed MW <input type="text" value="1.8"/> <input type="range"/>	SBDI Industrial Installed MW <input type="text" value="2.4"/> <input type="range"/>
SBDI Other MW <input type="text" value="0"/> <input type="range"/>	SBDI Restaurant Installed MW <input type="text" value="5"/> <input type="range"/>
MFCFA Installed MW <input type="text" value="5"/> <input type="range"/>	MFIU Installed MW <input type="text" value="5"/> <input type="range"/>

	12	13	14	15	16	17	18	19	20	21	22	23
MW Needed	-23.7	-16.1	-10.3	-7.7	7.4	19.5	24.7	26.8	17.0	24.0	37.3	25.7
SBDI	10.0	10.9	11.7	11.2	10.8	11.5	10.7	10.8	10.2	9.3	8.0	5.7
MFCFA	1.8	1.5	1.5	1.7	1.6	1.8	1.7	2.5	2.7	3.4	3.5	3.1
MFIU	0.7	0.7	0.7	0.8	0.8	0.7	0.8	0.9	1.4	1.2	1.5	1.2
Achieved MW	12.4	13.1	13.9	13.7	13.2	13.9	13.2	14.1	14.4	13.9	13.0	9.9

- Remaining substation shortfall
- Other
- Installed & verified
- MFIU
- Grocery
- MFCFA
- Retail
- Office
- Restaurant
- Industrial
- Projected
- Demand reduction needed



The Evolving Grid...



Retiring Power Plants



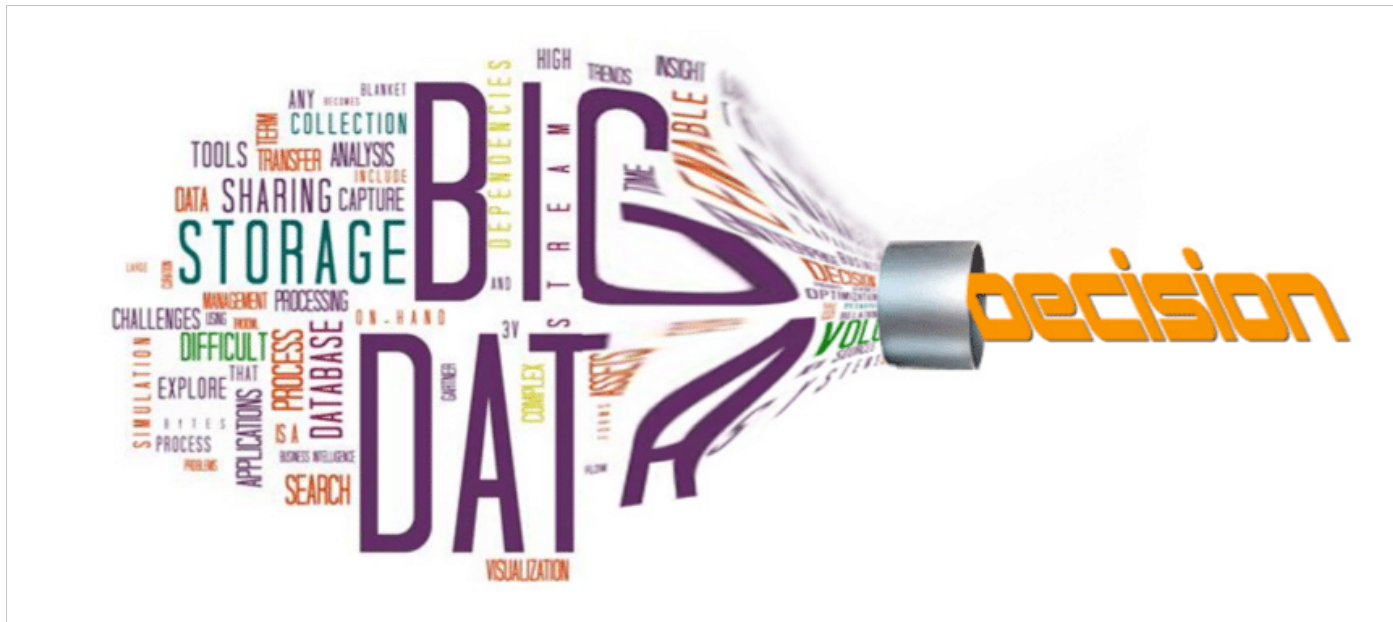
It's Really About Data



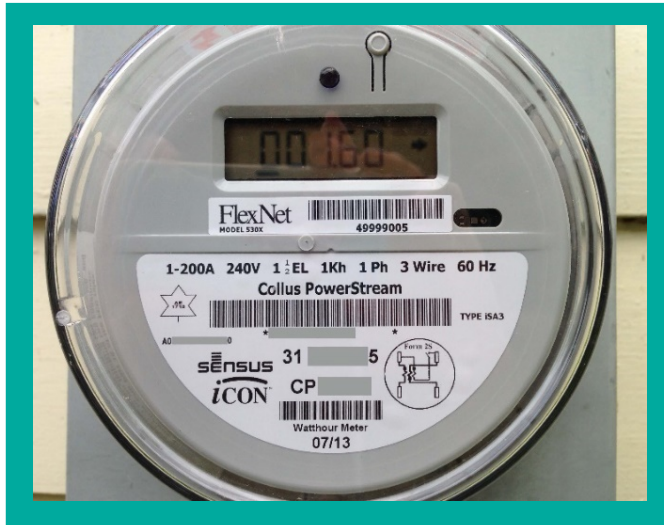
Defining Advanced M&V

Data Analytics

- Machine Learning & Artificial Intelligence
- People Learning & Real Intelligence
- Engineering & Statistical Analysis
- What is granular data?
- What is the value to the energy sector?
- The future of E and M and V?



Whole Building Data

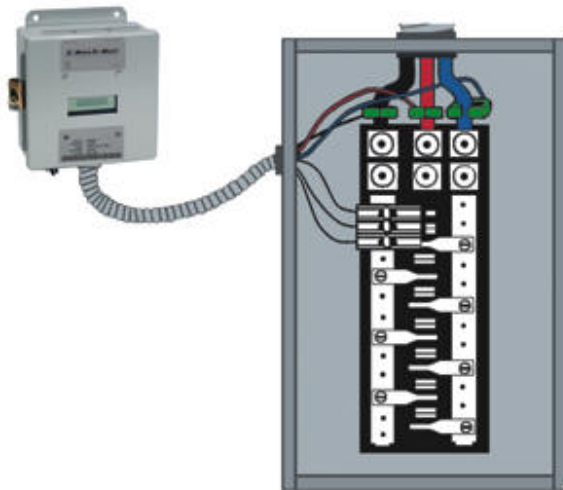
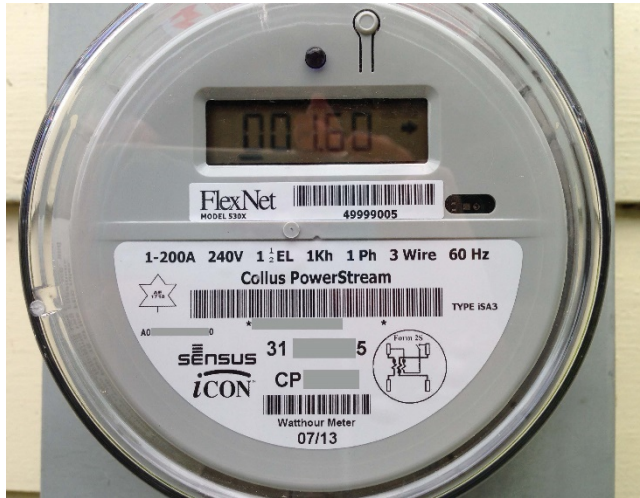


The Role of AMI Data?

- Scoping and snooping?
- Billing analysis?
- What sectors?
- Is it really “big” data?

What about even more granular data?

Sources of Data

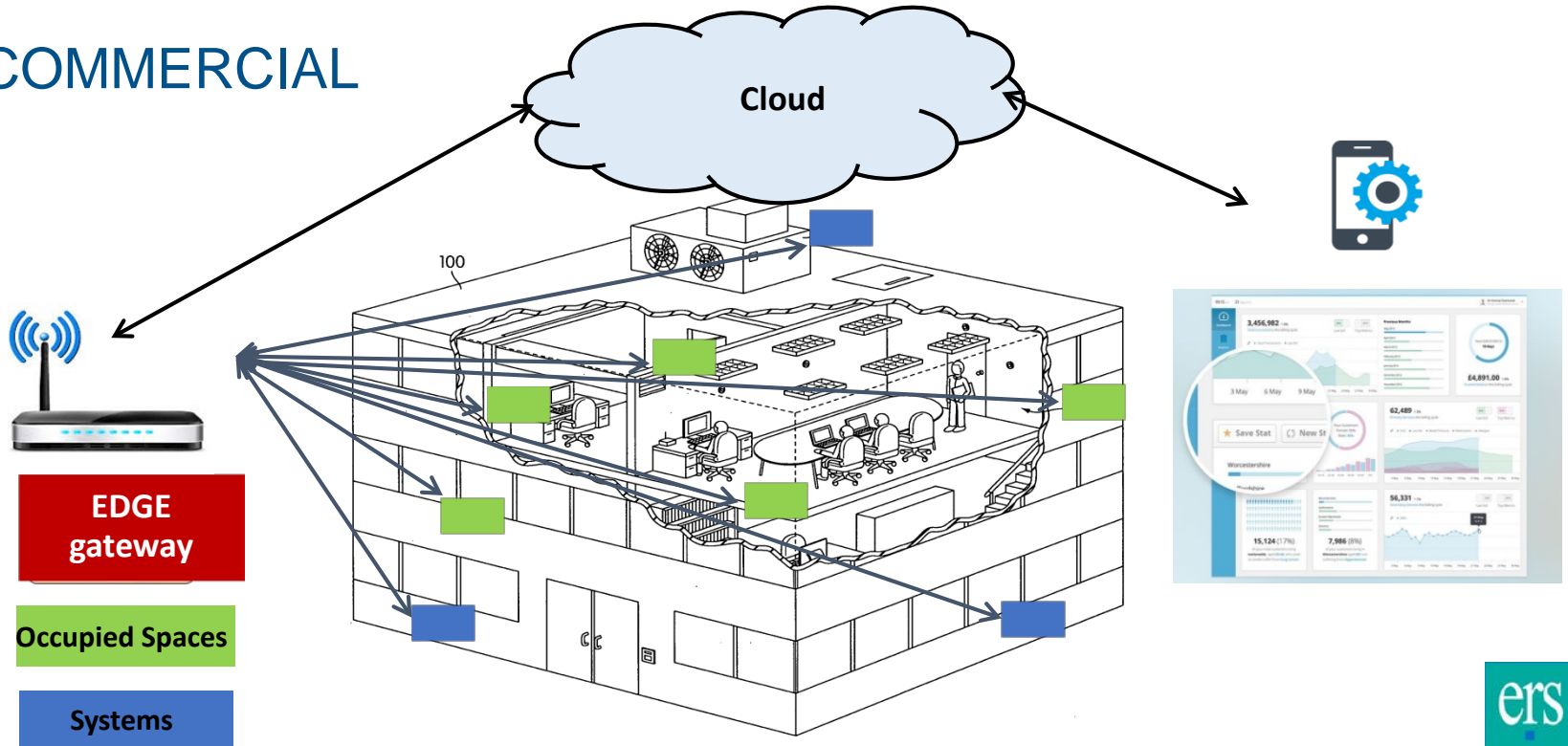


Real-Time, Near-Time, Full-Time

RESIDENTIAL

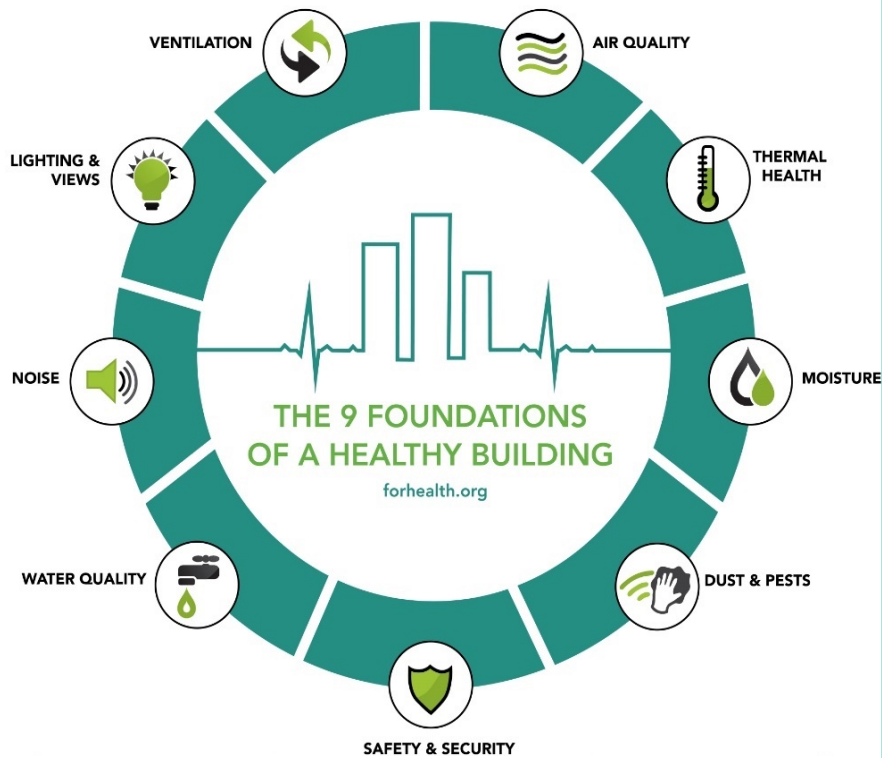


COMMERCIAL



NEBs: Building Health

Schools and learning outcomes...



SCHOOLS

+ FOR HEALTH

FOUNDATIONS FOR STUDENT SUCCESS

HOW SCHOOL BUILDINGS INFLUENCE
STUDENT HEALTH, THINKING AND PERFORMANCE



 **HARVARD**
T.H. CHAN

SCHOOL OF PUBLIC HEALTH
Center for Health and the
Global Environment

 **FOR HEALTH**
forhealth.org

ers

Who Owns Advanced M and V?

Possible Value Streams for M and V

PROGRAMS

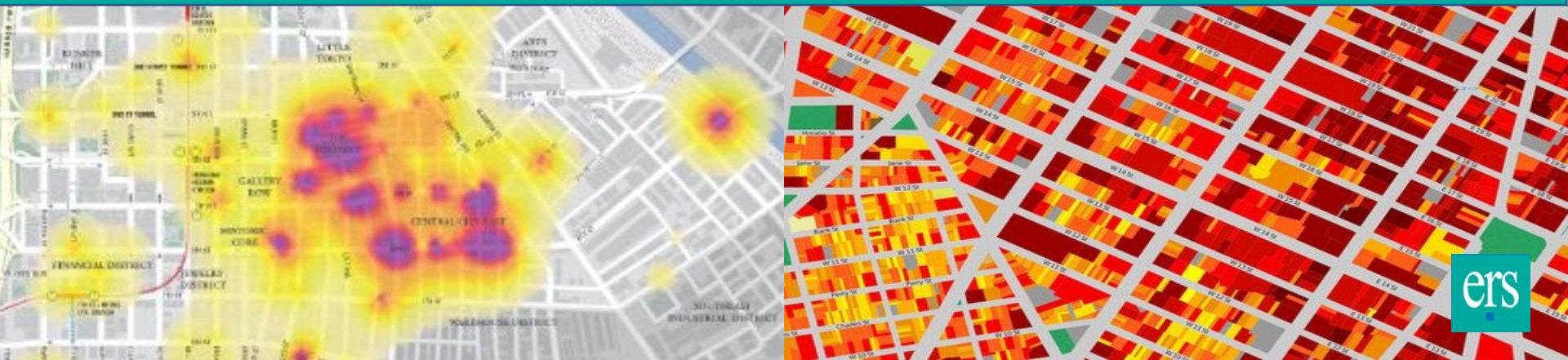
- Temporal and locational targeting and confirmation of CDM/DSM
- Evaluation of projects and programs

IMPLEMENTERS

- Contract performance monitoring
- Spot changes in use, impacts on usage, identify positive/negative shifts

OWNERS

- Better understanding of facility usage
- Building health
- Workplace analytics, productivity analysis



THANK YOU!



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Have you read Zondits today?





Advanced Evaluation and Measurement NEEP

Hartford, CT
10-3-2017



Non-regulated utilities

Pay-for-performance programs

“Fail Fast”



Trends

Valuation using actual costs,
not “regulatory” costs

Increasing visibility into the **data** business

Continuous iterative M&V + faster cycles



Capacity cost increase: the set up for a perfect storm

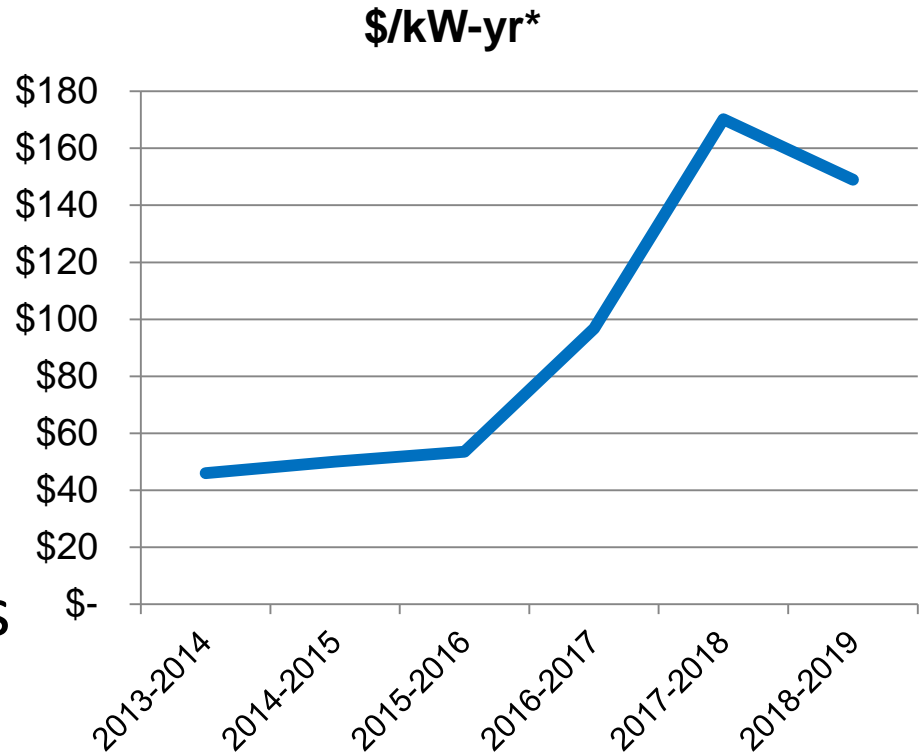
Boston area utilities

3x capacity cost increase

~40% increase in procurement costs

2% - Negative energy prices

Capacity > Energy



AMI meter analysis provides visibility into the business



“David was there all along, I just undressed the stone”

-Michelangelo

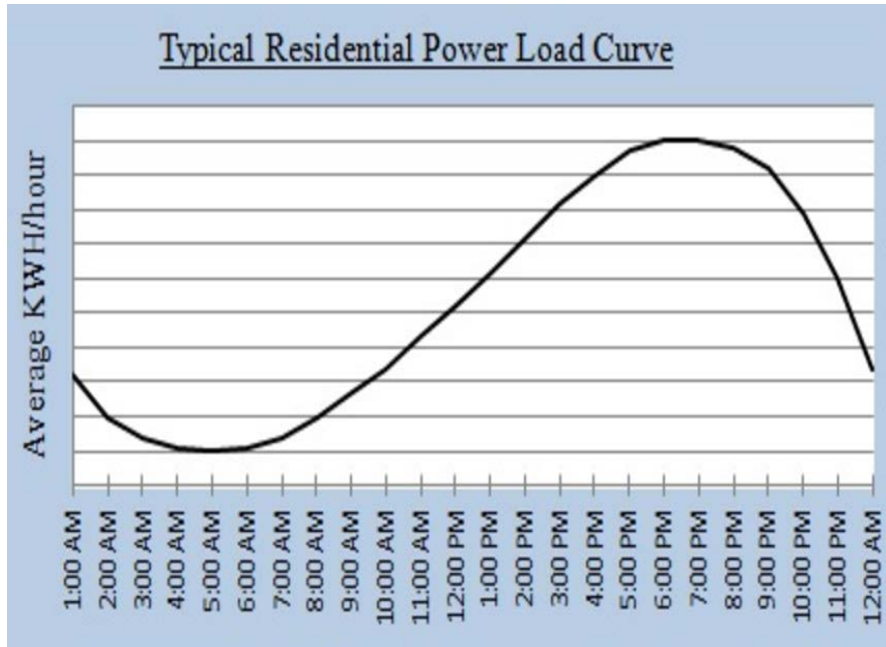
~~Reference load shapes~~

Individual customer level analysis

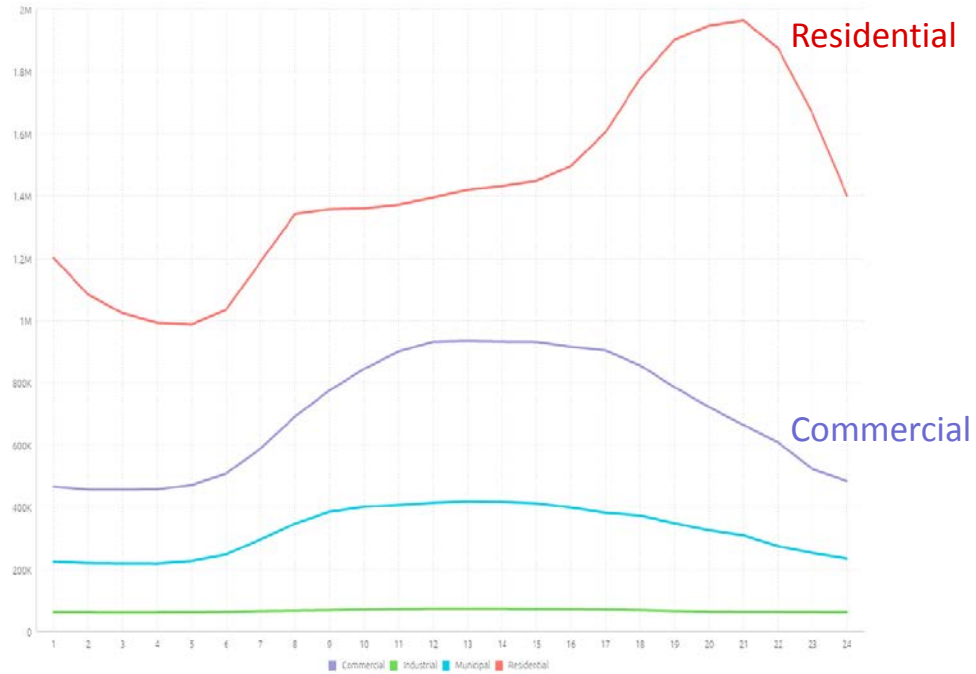


Modeled vs. actual load shapes by customer class

Reference load shape



vs. Actual peak day load shape



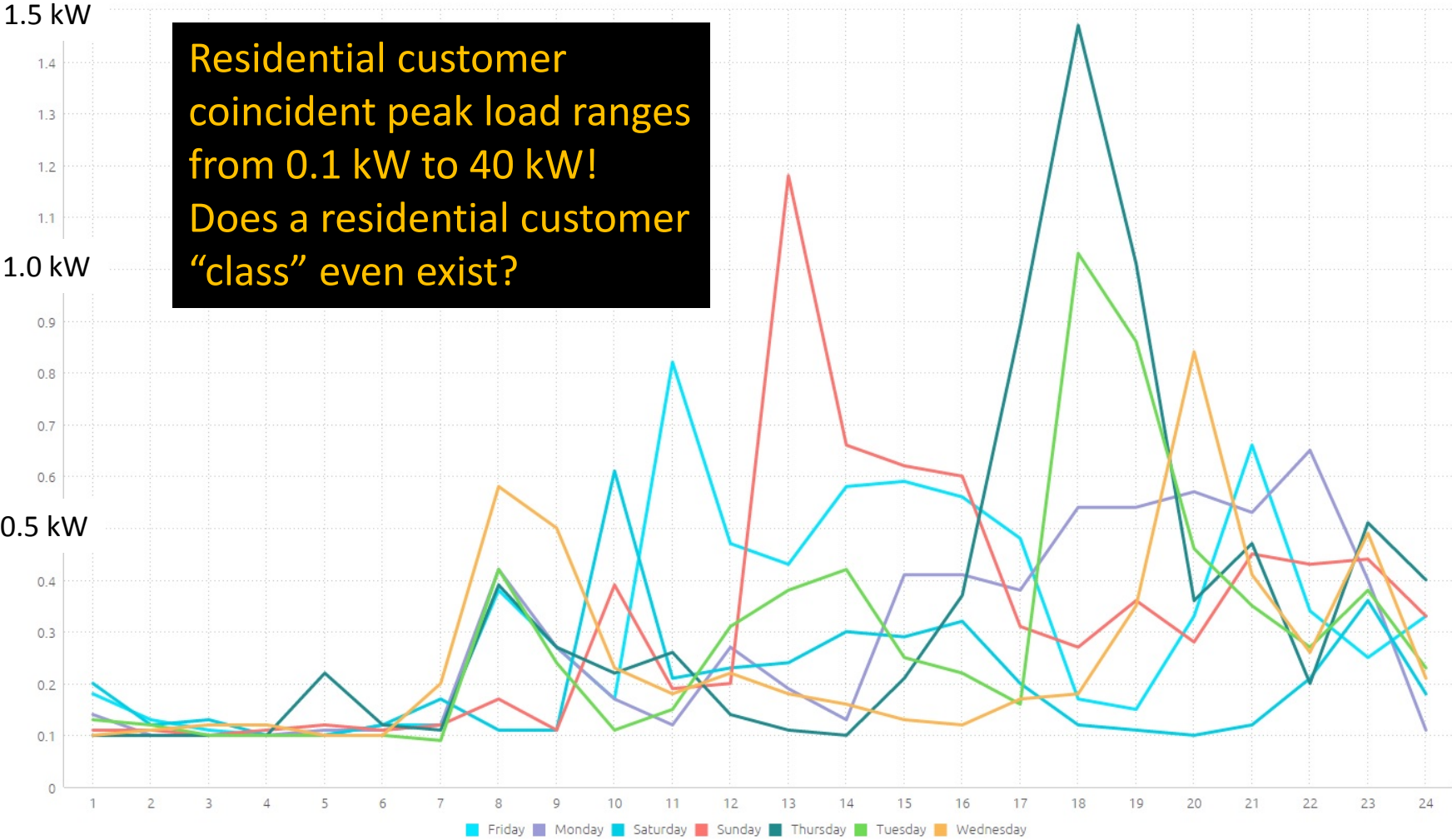
Significant implications for:

DSM valuation

Rate setting

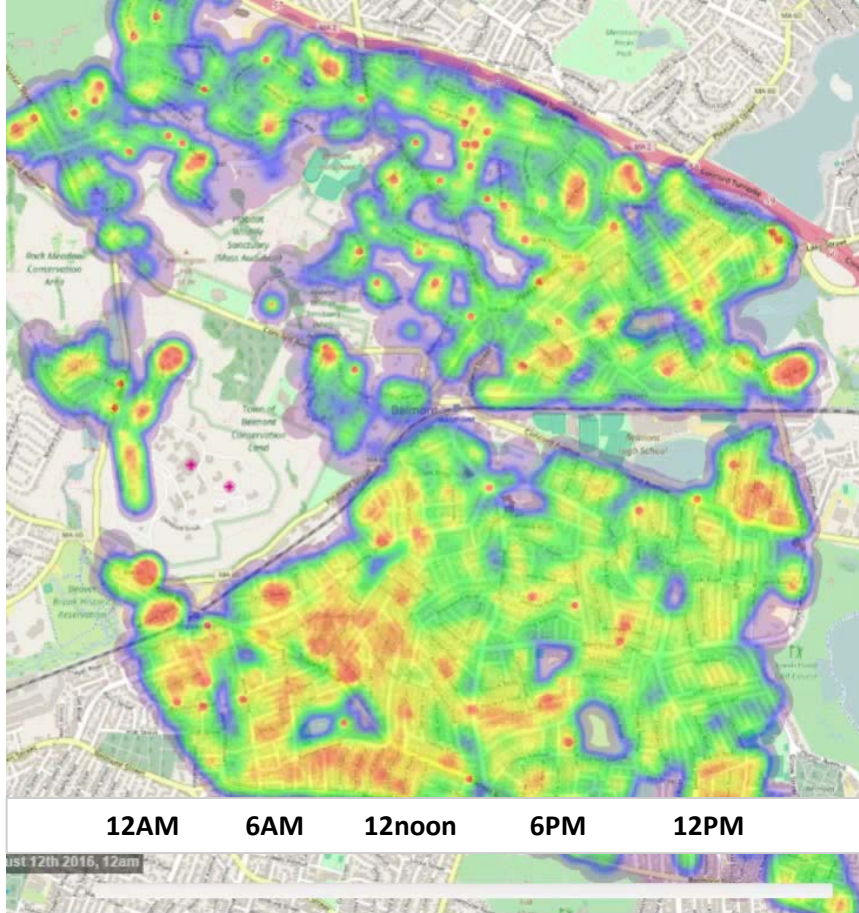
One customer, one week

Residential customer coincident peak load ranges from 0.1 kW to 40 kW!
Does a residential customer "class" even exist?

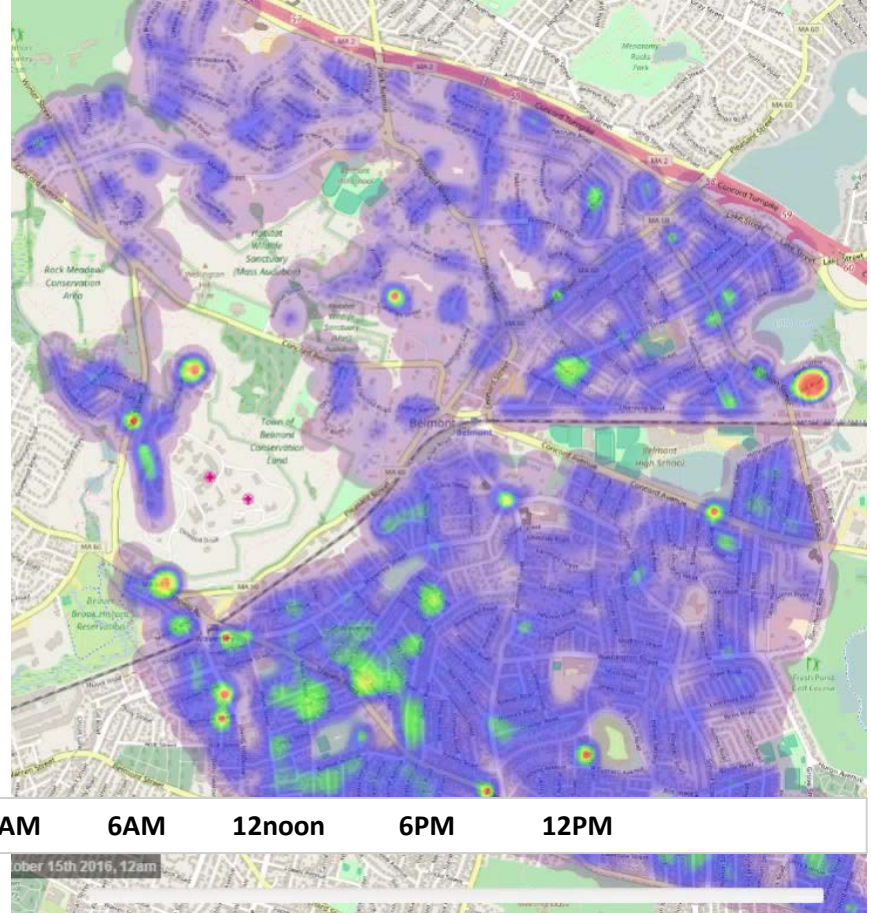


Shape shifting amoeba: residential peak load distribution

Summer peak



Fall Saturday



Animation from **Sagewell SageSightSM** AMI meter data analytics software

**Result:
EM&V will change**



THE NUMBERS GAME

CHRIS ANDERSON & DAVID SALLY

Continuous, iterative M&V

Principles:

Precision vs. accuracy

Look for obvious successes – do more

Look for obvious failures – stop

“Fail fast”

Continuous, iterative M&V

Case studies:

Weatherization

Heat pump impact measurement

Behavioral peak load reduction email program

Weatherization case study – peak reduction

Peak: 1.8 kW average summer coincident peak
0.1 kW peak reduction
5.6%



Weatherization peak reduction – Mass Save®

Reported reduction:


13,938 kW/ 20,745 participants = 0.67 kW

37% peak reduction from weatherization?

Precise but not accurate?
Will “deemed savings”
approach survive?

Q2 2017 Electric & Gas Summary Report

*Prior to 2016, benefits were only reported in Q2 and Q4. Benefits in the other quarters are shown as zero.

As of Q2 2017	Participants 	Total Expenditures	Annual MWh Savings	Lifetime MWh Savings	Summer Capacity (kW)
<input checked="" type="checkbox"/> Residential	3,593,671	\$ 270,393,187	584,086	4,475,067	79,313
<input checked="" type="checkbox"/> Residential Whole House	1,139,855	\$ 162,093,278	232,877	1,157,469	37,935
Residential New Construction	5,134	\$ 7,059,826	7,184	109,228	3,066
Residential Multi-Family Retrofit	19,417	\$ 18,031,125	9,310	91,805	833
Residential Home Energy Services - Measures	20,745	\$ 111,740,730	87,548	826,601	13,938

Source: Masssavedata.com

Heat pump peak impact

0.5-1 kW peak reduction over old equipment

Equivalent to high efficiency central AC

If you just look at AC impacts... no advantage

But...



Heat pump impact – beneficial electrification

2,000-6,000 kWh of “beneficial electrification”

Significant carbon reduction

\$300 to \$1,000 of additional contribution margin

Verdict: continue

Note: ductless systems vs. ducted systems outcomes

Change focus to favor ducted over ductless?

Decoupling still a good idea? Recouple?

Case study: emails & “fail fast”

2015, “great success” – 10-15% peak reduction

2016, 5-day heat wave – 2-3% reduction, fatigue

Daily evaluation of success

2016, at 3 other utilities: 5-10% increase!

Total failure; end program, celebrate, move on



The catch

1  = 100,000 data points/yr

5 million meters & 5 yrs = 2.5 Trillion

~~Traditional databases~~

New EM&V software firms will emerge

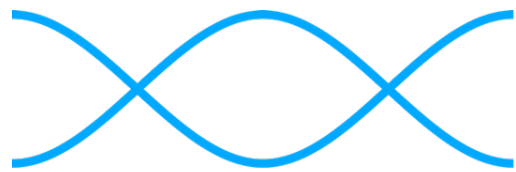
Analysis and analysts will evolve



WHISKERLABS

Jaden Crawford
October 3, 2017

Company Overview



WHISKERLABS

- Sensor & software services platform company delivering total home intelligence
- Expertise in big data processing, thermodynamic modeling & consumer engagement
- HQ in Oakland, CA w/ lab in Germantown, MD - privately held, backed by top VCs



Savings

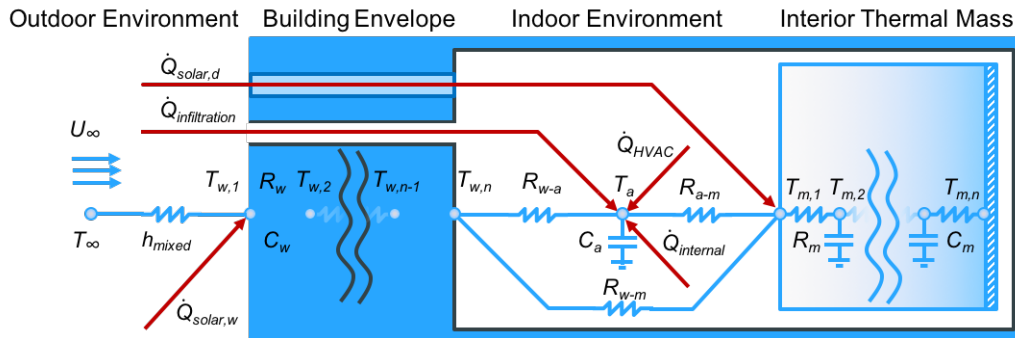
Engagement

Peace of Mind



Thermodynamic Modeling

Our Thermostat Grey Box Model:



- Correlate indoor to outdoor conditions
- Unique for every house
- Uses minimal customer data
- Developed in collaboration with University of Maryland



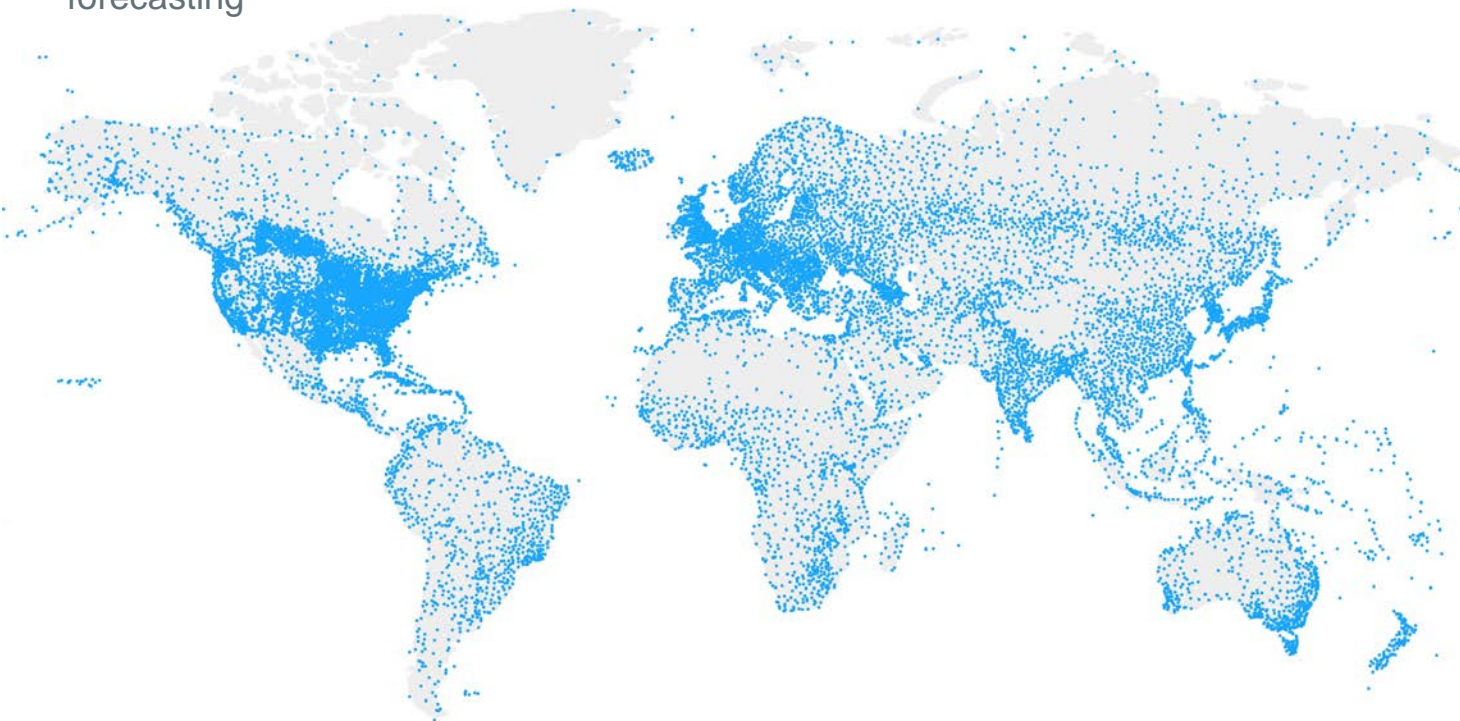
3x more energy efficiency p/t-stat

15% more DR capacity per home

Connected Savings Intelligence DRMS

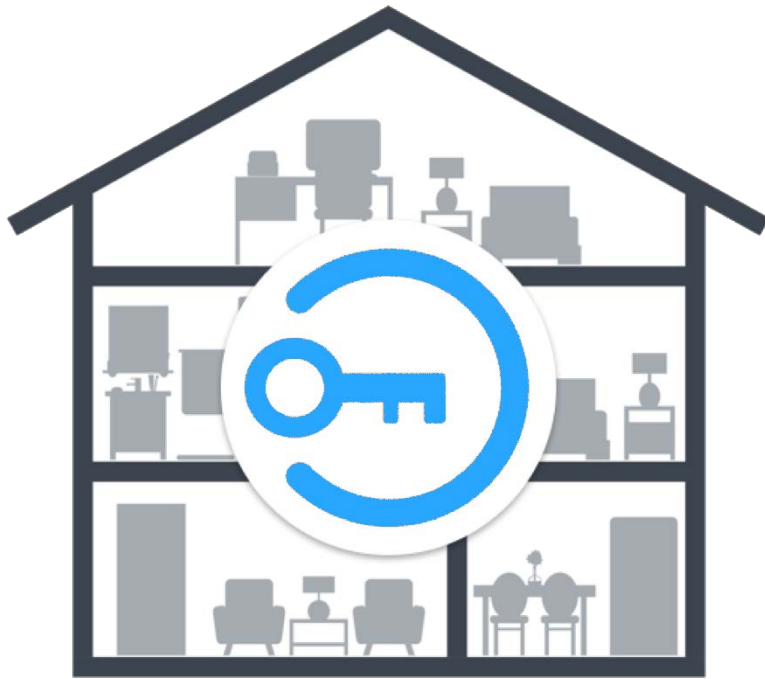
Granular Weather Data

Hyperlocal, real-time weather data for energy efficiency modeling & load forecasting



of your energy
use is driven
by the
weather

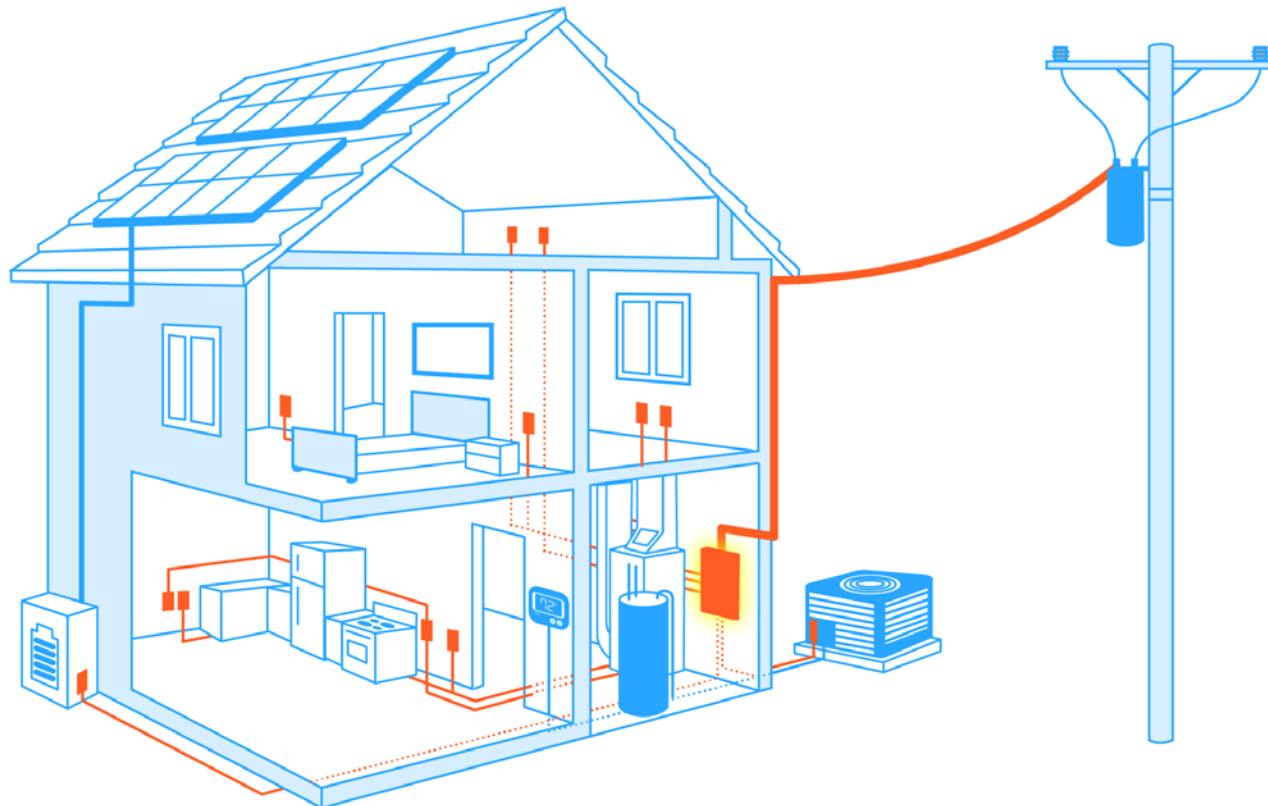
Today's Home is Not Really Connected



<1%

of all devices
connected

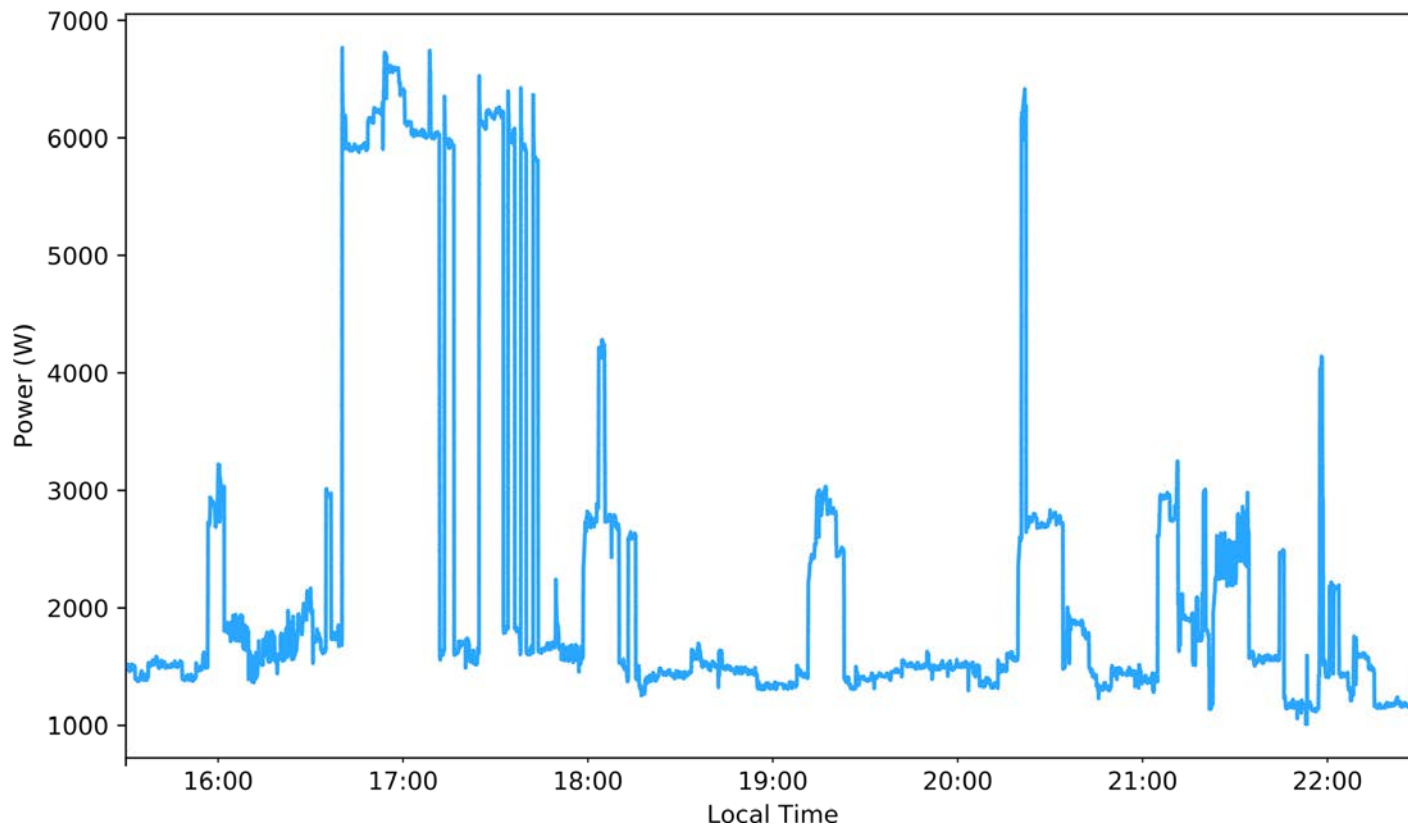
Or Is It?



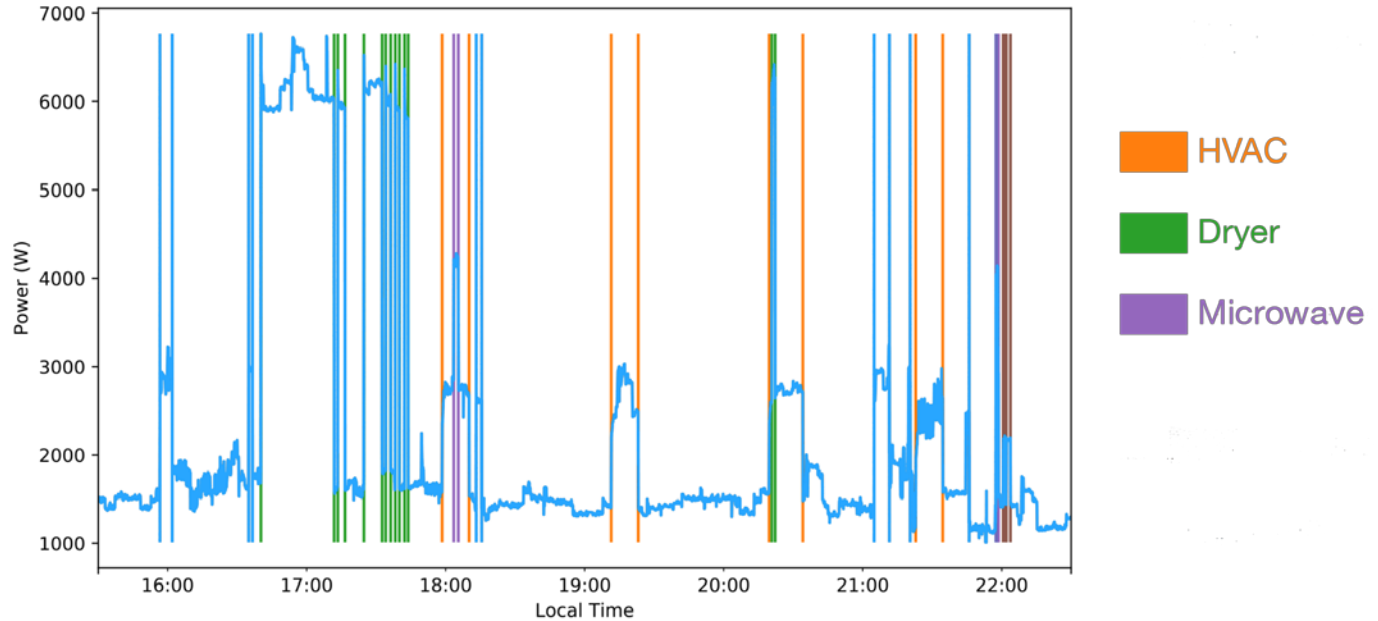
Whisker Labs Energy Sensor



Typical Energy Data



Our View of Energy Data

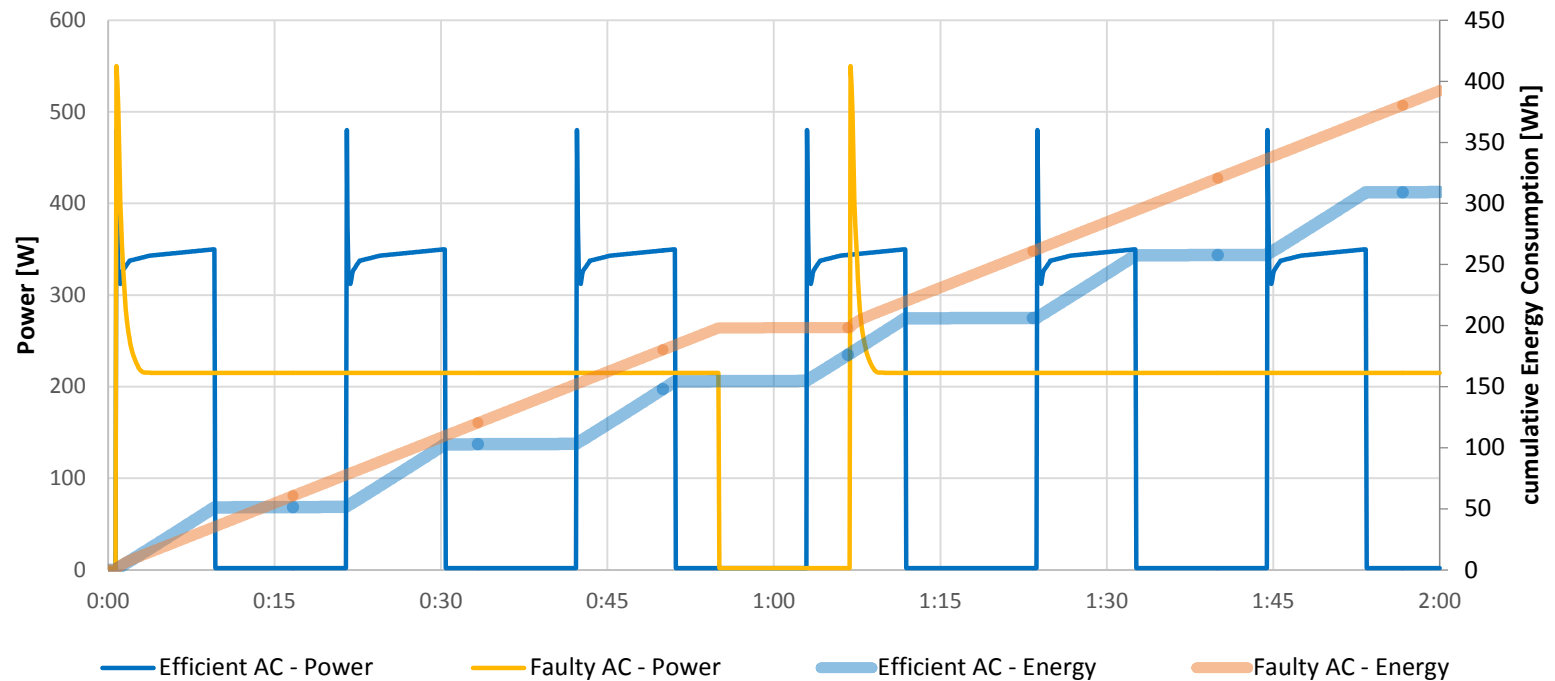


Large Device Runtime
by Circuit:

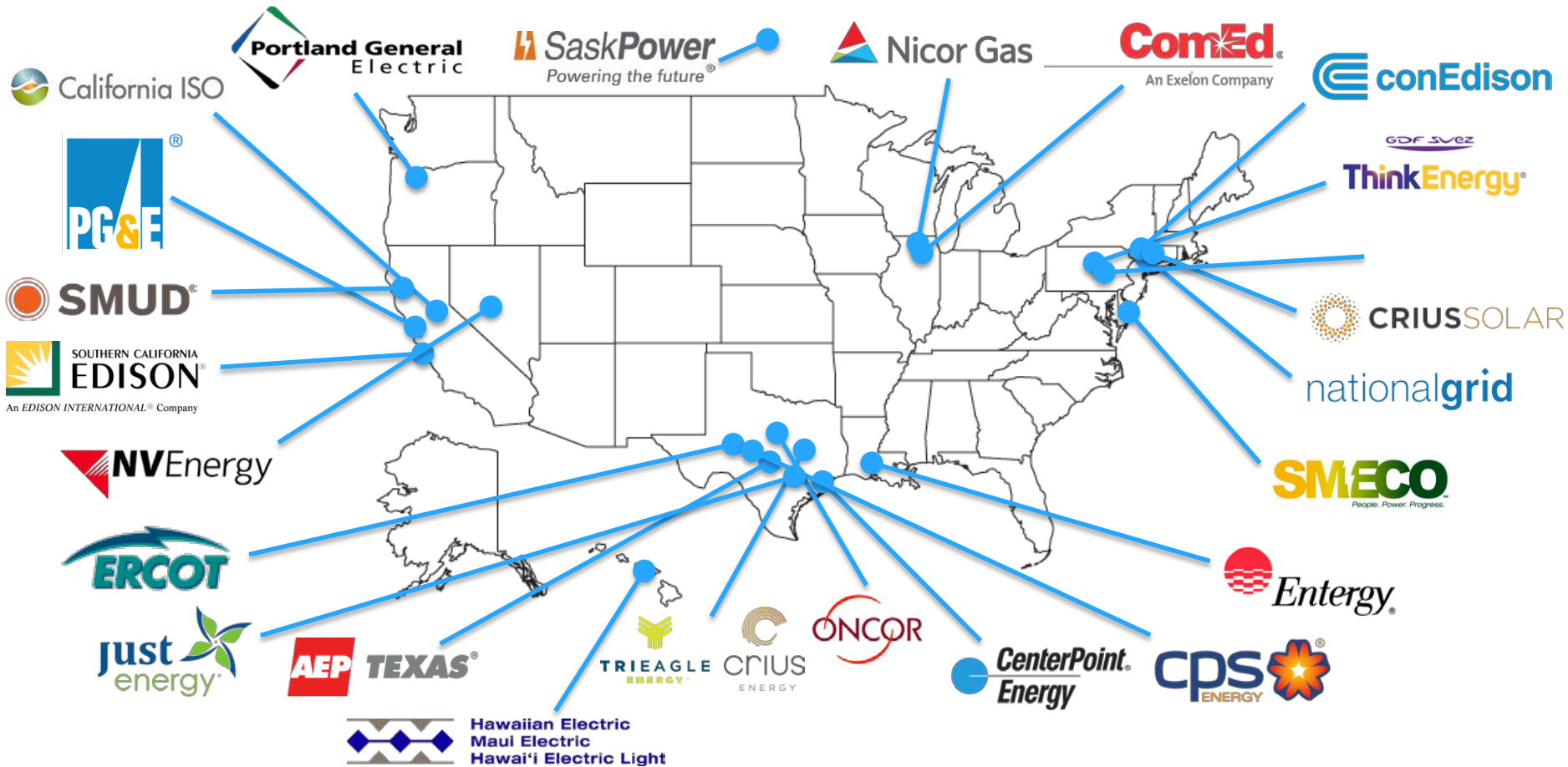


Detecting Efficient vs. Faulty Window AC

Inefficient Systems Produce Less Cooling & Use More Energy



Connected Savings Programs & Pilots



Connected Savings Programs & Pilots

- Residential DR as a reliability product
- Residential DR, HVAC optimization, and behavioral EE for peak load reduction
- Whole home energy monitoring & HVAC fault detection
- Risk mitigation and short-term supply/demand optimization for residential electricity retailers
- Persistent virtual energy auditing & optimized measure implementation*

EM&V is Critical to Everything We Do

But No Single EM&V Approach Works for Everything We Do

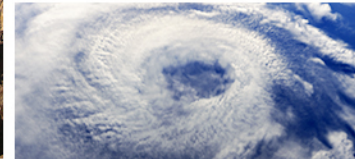
- Our customers have differing objectives & preferences
- Rules, data sources and data access differ by program type, by jurisdiction and by customer
- Programs are designed to do different things and can't always be measured the same way
 - Mile markers vs. micrometers vs. measuring cups
- Program budgets are always tight
 - There may not be sufficient program-level benefit to warrant the cost of collecting, storing, analyzing, and protecting large amounts of customer data



WHISKERLABS

The logo for CADMUS, featuring the word "CADMUS" in white, uppercase, sans-serif font centered within a solid blue rectangular background.

CADMUS

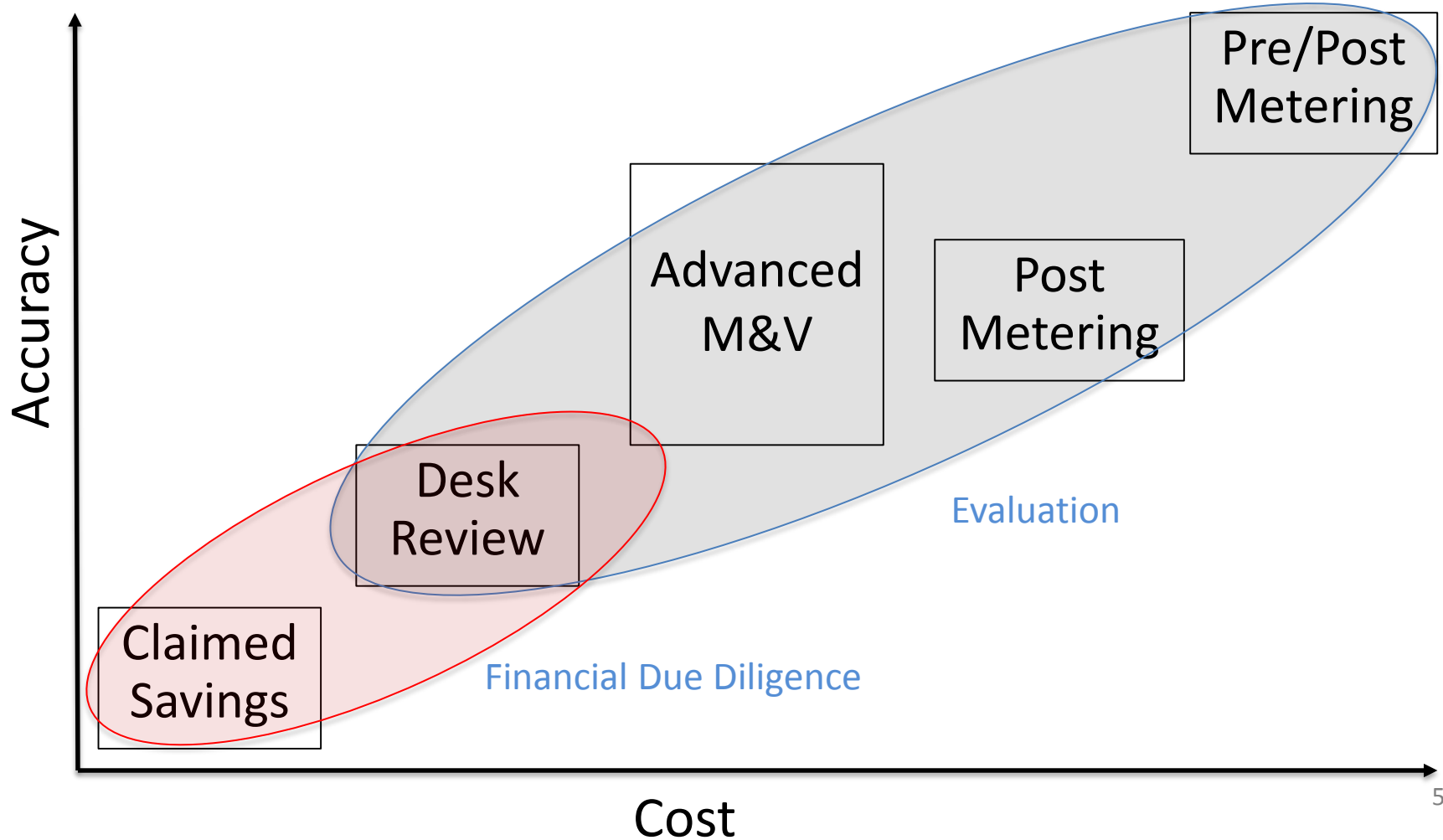
A large yellow arrow pointing to the right, with a white outline, positioned to the left of the main title.

Advanced M&V

*NEEP 2017 EM&V Regional Fall Meeting
Hartford, CT
October 3, 2017*



Trade-offs in M&V





Claimed Savings

- Project Summary
 - Custom lighting project
 - Replaced metal halides with LEDs, added staged dimming
 - Assumed 7,200 lighting hours of use (HOU)
- Energy Savings
 - Annual savings of ~266,000 kWh



Desk Review

- Personnel Interview
 - Confirmed installation of proposed measures
 - Adjusted HOU from 7,200 to 6,935
- Energy Savings
 - Annual savings of ~255,000 kWh

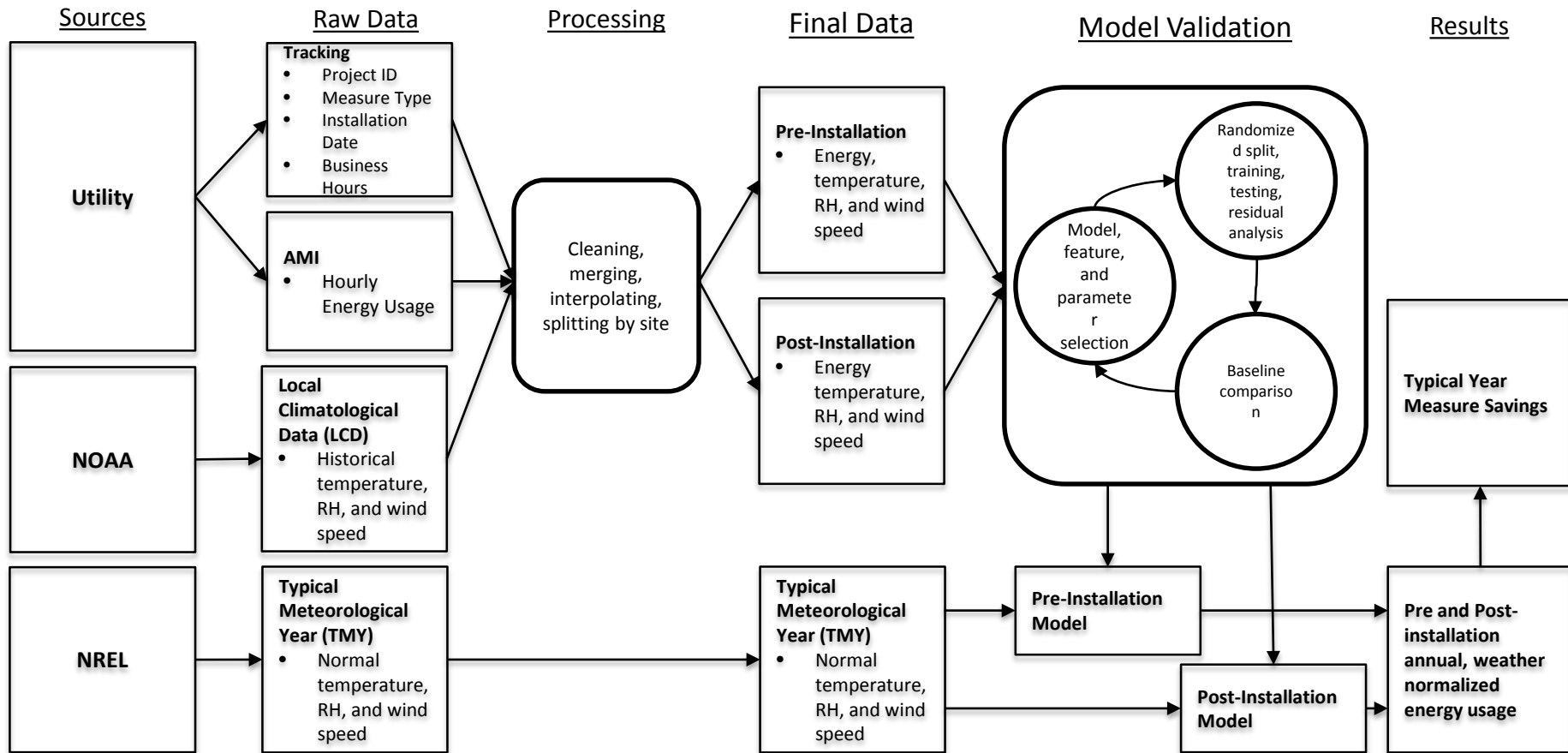


Advanced M&V

- Modeling Approach
 - Split AMI data into pre and post-installation periods
 - Merge with data from additional sources (weather, occupancy, schedules, etc.)
 - Fit separate models to pre and post dataset
 - Apply models to typical year conditions
 - Take difference in response

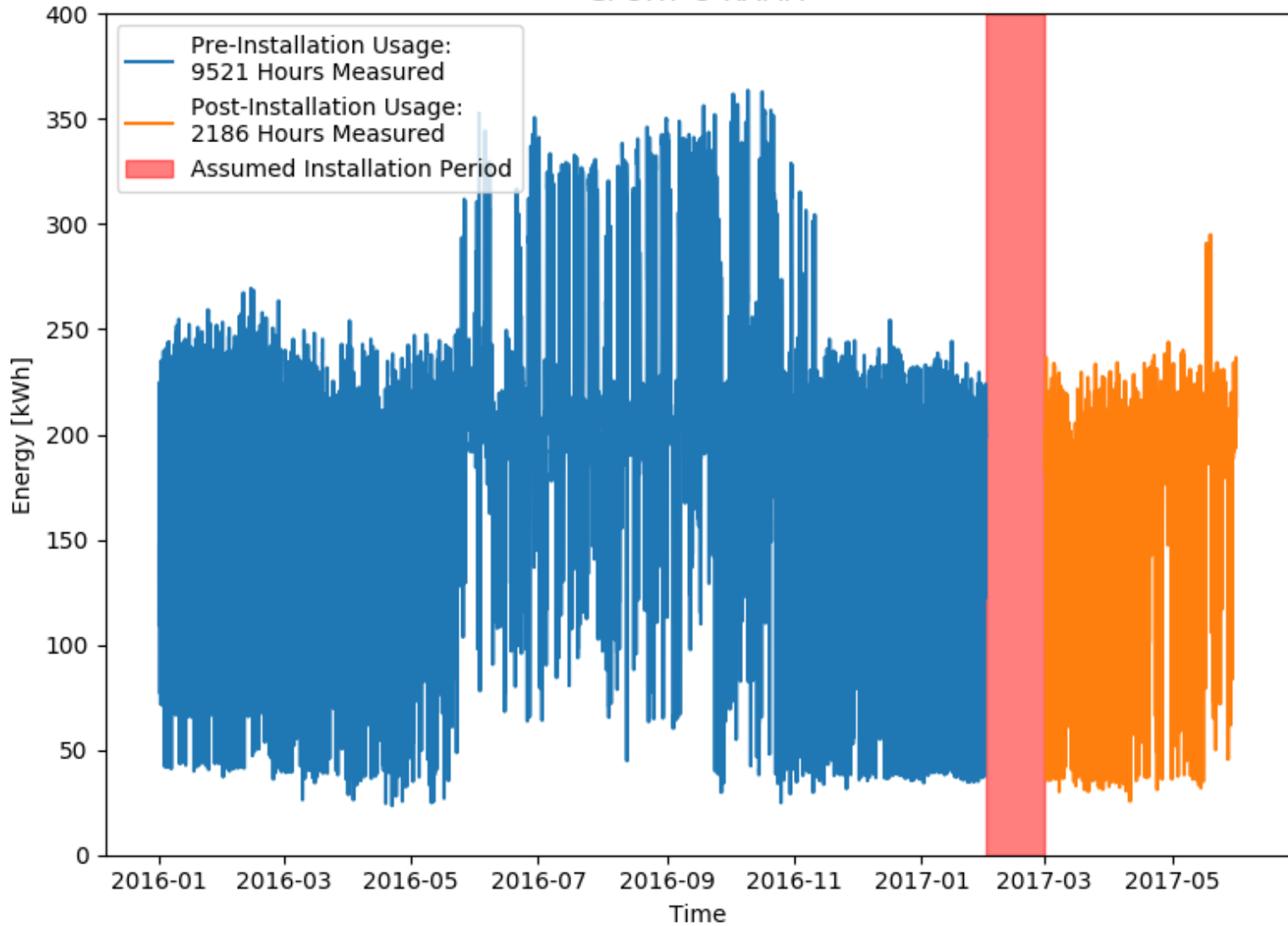


Process



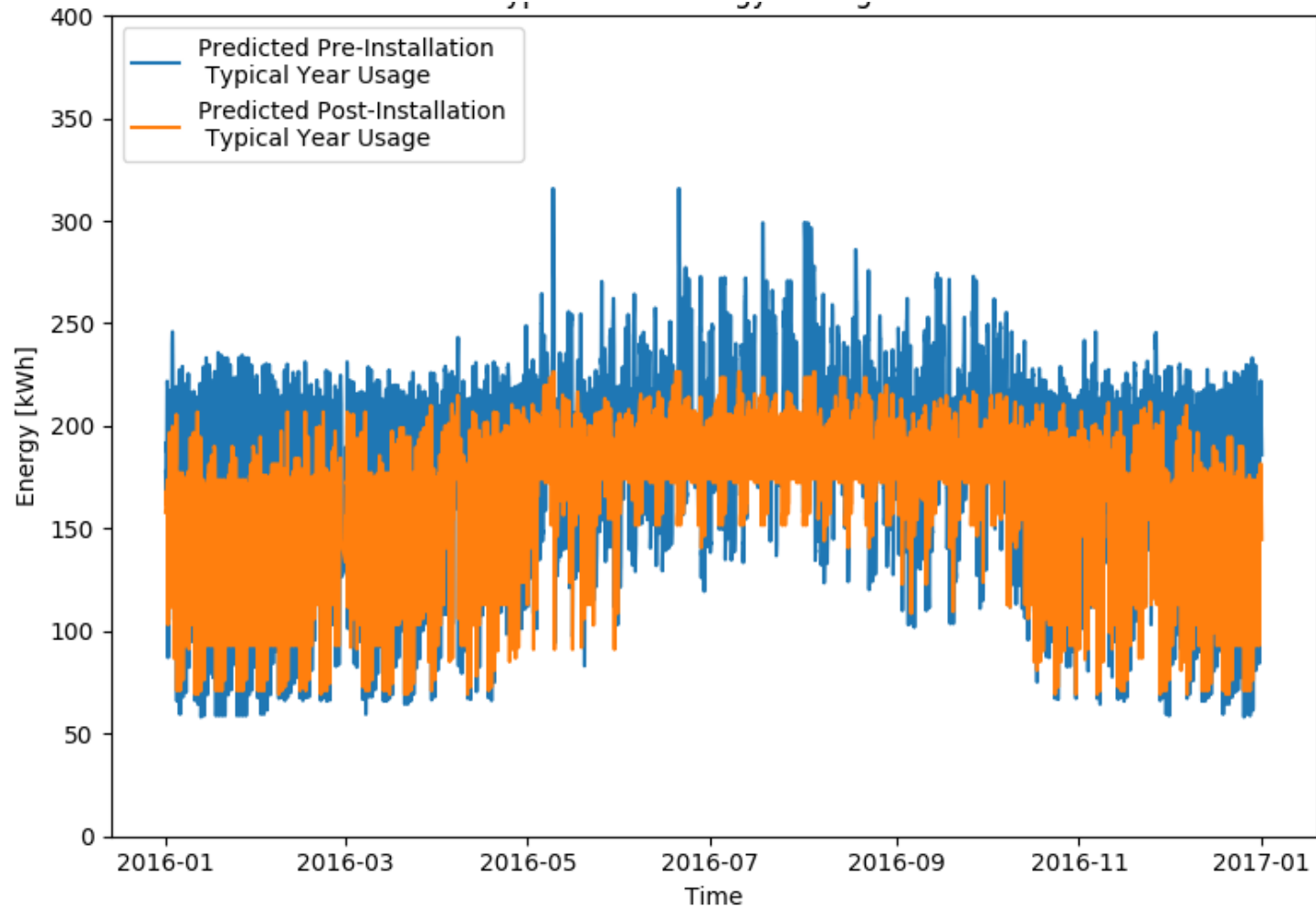


Advanced M&V





Advanced M&V



– Annual savings of ~186,000 kWh



Post Metering

- Metering
 - Summer only (August, early September)
 - May skew low
- Energy Savings
 - Annual savings ~173,000 kWh



Results

Method	kWh Savings	Realization %	Notes
Claimed Savings	266,000	NA	7,200 hour claimed operation
Desk Review	255,000	96%	Hours reduction
Post Metering	173,000	65%	May be skewing low for summer
Advanced M&V	186,000	70%	108% of metered

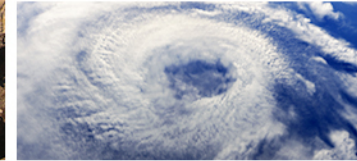


Closing Thoughts

- Use of AMI (advanced analytics) versus traditional approaches is not a binary choice
- Traditional M&V varies from not so accurate to very accurate (and expensive)
- Some other businesses have lower or different M&V requirements
- Even 1-hour AMI data can give great results for simple C&I projects

The logo for Cadmus, featuring the word "CADMUS" in white, uppercase, sans-serif font on a solid blue rectangular background.

CADMUS

A large yellow arrow pointing to the right, with a white outline, positioned to the left of the text.

Dave Korn

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