Efficiency Vermont

Using Smart Devices to Achieve Intelligent Efficiency
February 6, 2013

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Efficiency Vermont

Learning Objectives

- Learn what new technologies are available to measure and manage energy performance in residential and commercial buildings.
- Learn how data from internet-connected devices can be used to identify and quantify efficiency opportunities.
- Lean about the services available from Efficiency Vermont to assist in selecting, purchasing, and analyzing data from internet-connected building monitoring and control devices.
- Learn about industry trends in building automation and data analytics.

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Next Generation Thermostats:

What we know, What we're learning, What's Next (and why it matters)

Nick Lange

Emerging Savings Opportunities

What's a next generation thermostat?

$

Expensive

- $200+ – (Recurring Service Fees?)

@

Internet Connection

- Remote Control – (Website, Phone, Service)
- Sophisticated controls – (automaticity, sensors, "smarts")

?

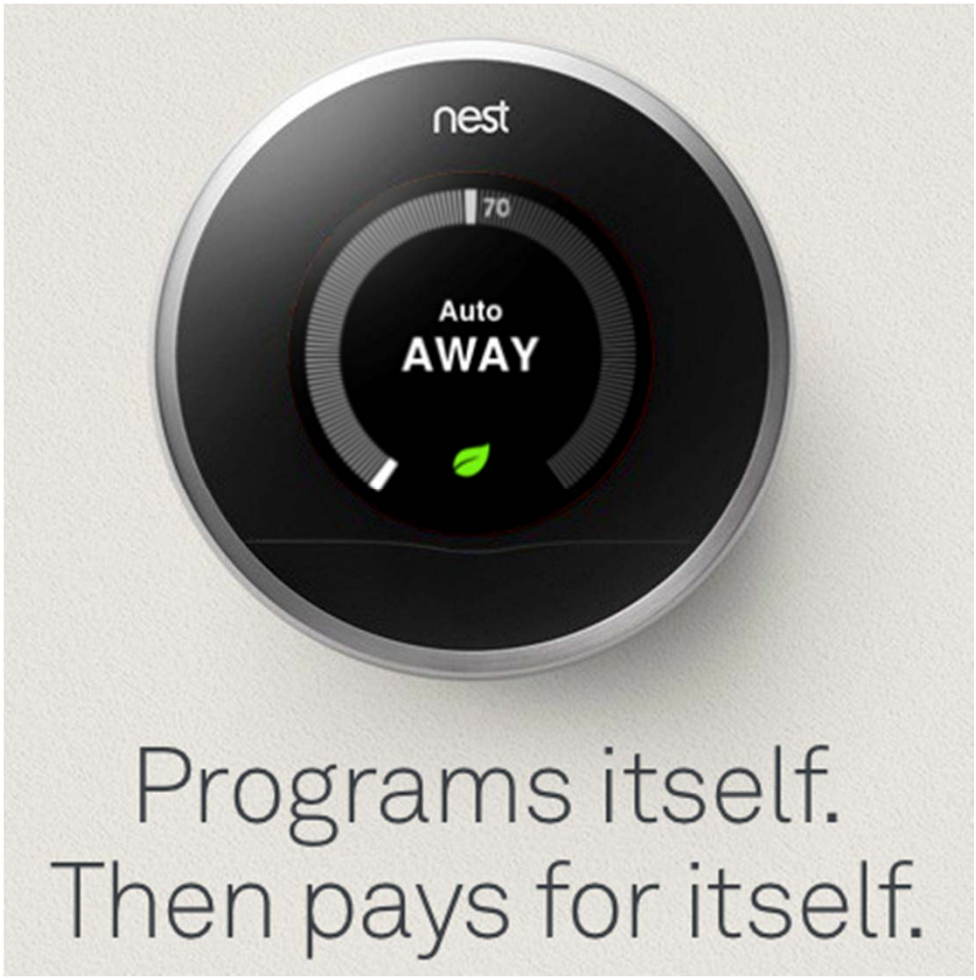
Savings Potential

- 5% to 25% Heating & Cooling – ($50 to $250+/yr)

Worth it?

nest $249

- Auto-Schedule!
  - 10-12% heating savings
  - 15% cooling savings
  - Average of $131-$145/yr
- Seasonal Savings™
  - *Even More Savings*



nest Google

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Worth it?

Lyric $279 $249

- Geofencing!
  - Phone GPS integration
- Fine Tune™
  & Smart Cues™
  - Avg $186/yr savings

Honeywell

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Worth it?

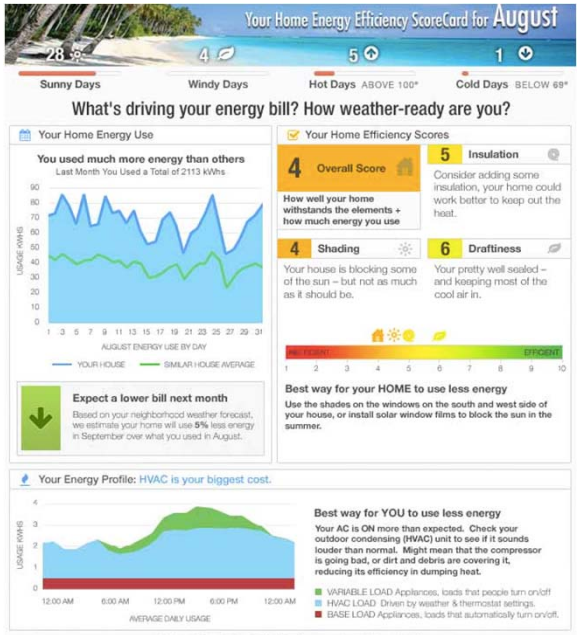
ecobee3 $249

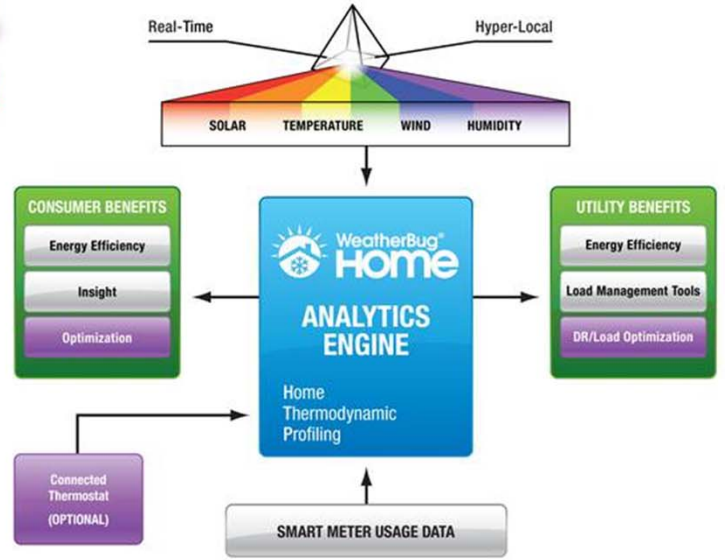
- Remote sensors
  - For homes with more than one room
- “Smart, really smart”
  - Average 23% savings!

ecobee

Worth it?

Wi-Fi only $100





3rd Party Services (Free*)

- Comverge
- Ecofactor (xfinity)
- Weatherbug
- Opower

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The big question:

Can a $250 product bring GEICO* results to 50% of Vermonter's home energy usage?

*save up to 15% or more?

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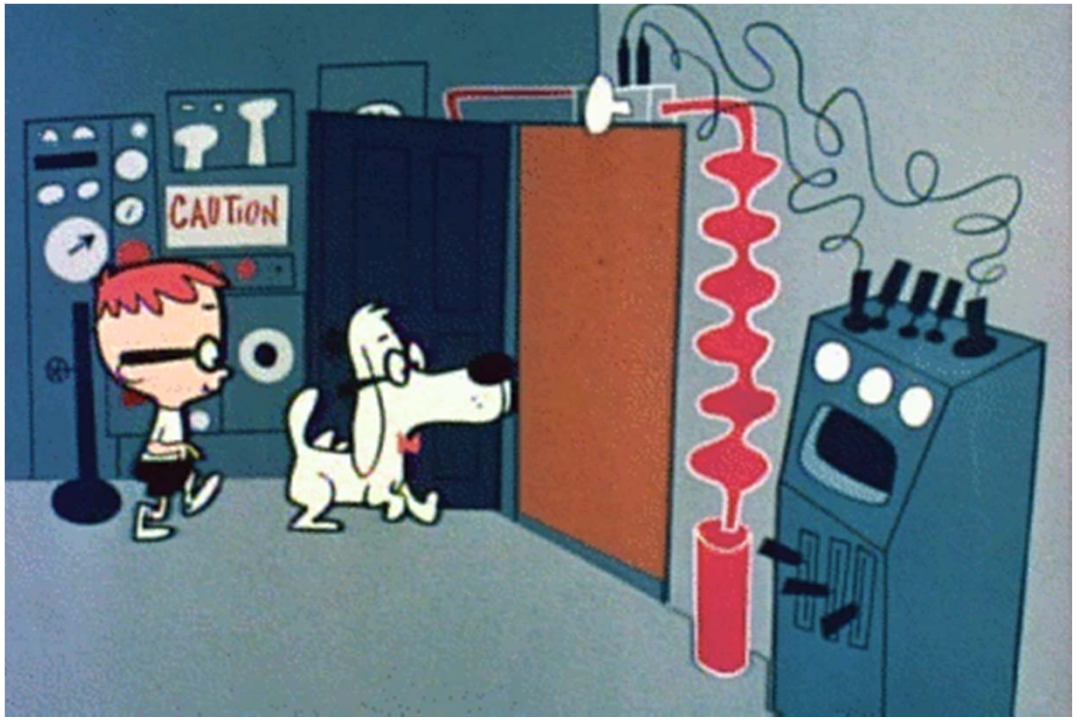
The easy answer:

It depends*

*on housing types and heating systems compatibility, sensor accuracy, heat load, multiple zones, measure life, baselines, ventilation & electrical & behavioral savings, data-driven diagnostics, add-on services, demand response, heat pump aux loads, and so many many many many more?

A Brief History of Time Thermostat Savings

Mr. Peabody's Wayback Machine



The Rocky & Bullwinkle Show (1959-1964)

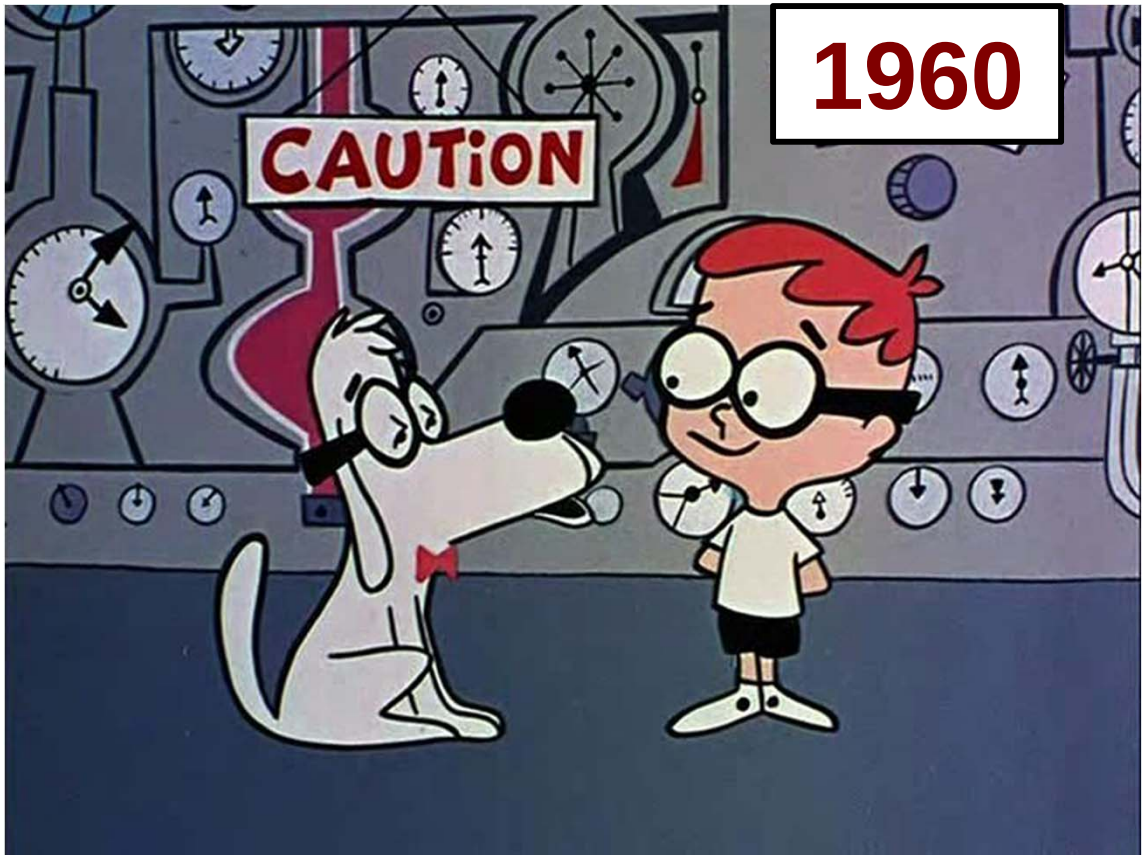
Two Questions:

#1: Why Review The History of Thermostats?

#2: Why Rocky & Bullwinkle?

A Brief History of Time Thermostat Savings

Mr. Peabody's Wayback Machine



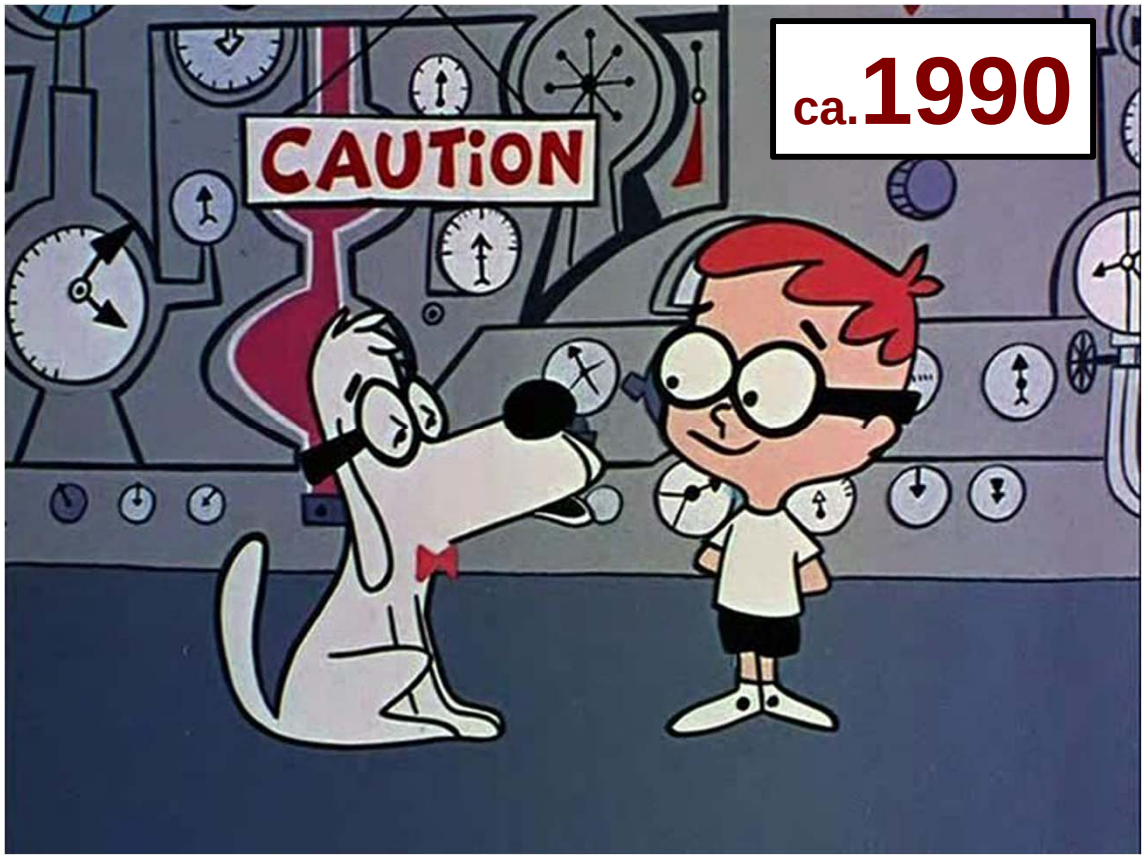
The Rocky & Bullwinkle Show (1959-1964)

Honeywell
"T87 Round"

- Semi-Automatic "wind-up" day/night setbacks

1960 – Present

A Brief History of Time Thermostat Savings



Digital Programmables!

1990 – Present

A Brief History of Time Thermostat Savings

Dudley Do-Right

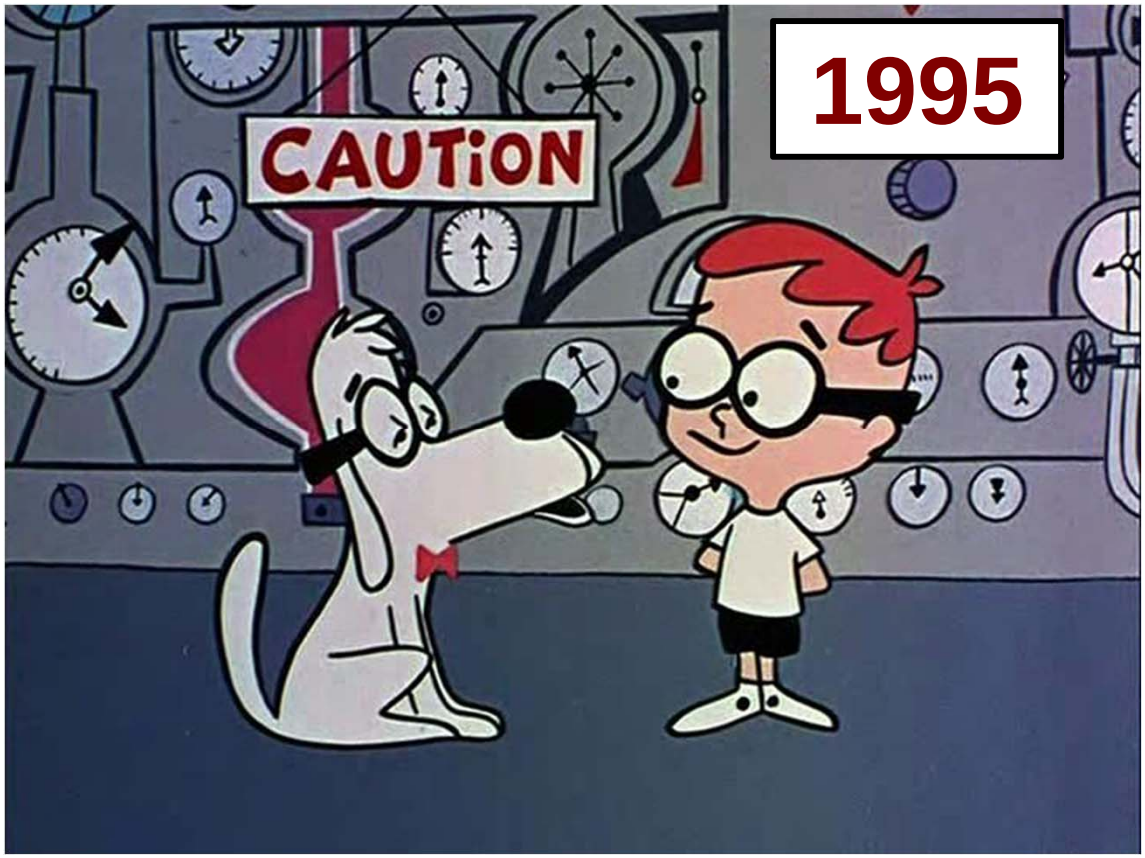
Programmable Thermostat Specifications

Table 1: Programmable Thermostat Setpoint Temperatures		
Setting	**Setpoint Temperature (Heat)**	**Setpoint Temperature (Cool)**
Wake	≤70°F	≥78°F
Day	setback at least 8°F	setup at least 7°F
Evening	≤70°F	≥78°F
Sleep	setback at least 8°F	setup at least 4°F

Table 2: Acceptable Setpoint Times and Temperature Settings			
Setting	**Time**	**Setpoint Temperature (Heat)**	**Setpoint Temperature (Cool)**
Wake	6 a.m.	70°F	78°F
Day	8 a.m.	62°F	85°F
Evening	6 p.m.	70°F	78°F
Sleep	10 p.m.	62°F	82°F

The Rocky & Bullwinkle Show (1959-1964)

A Brief History of Time Thermostat Savings



ENERGY STAR Programmables

- 10-30% Savings
- Default Program
- HOLD Button

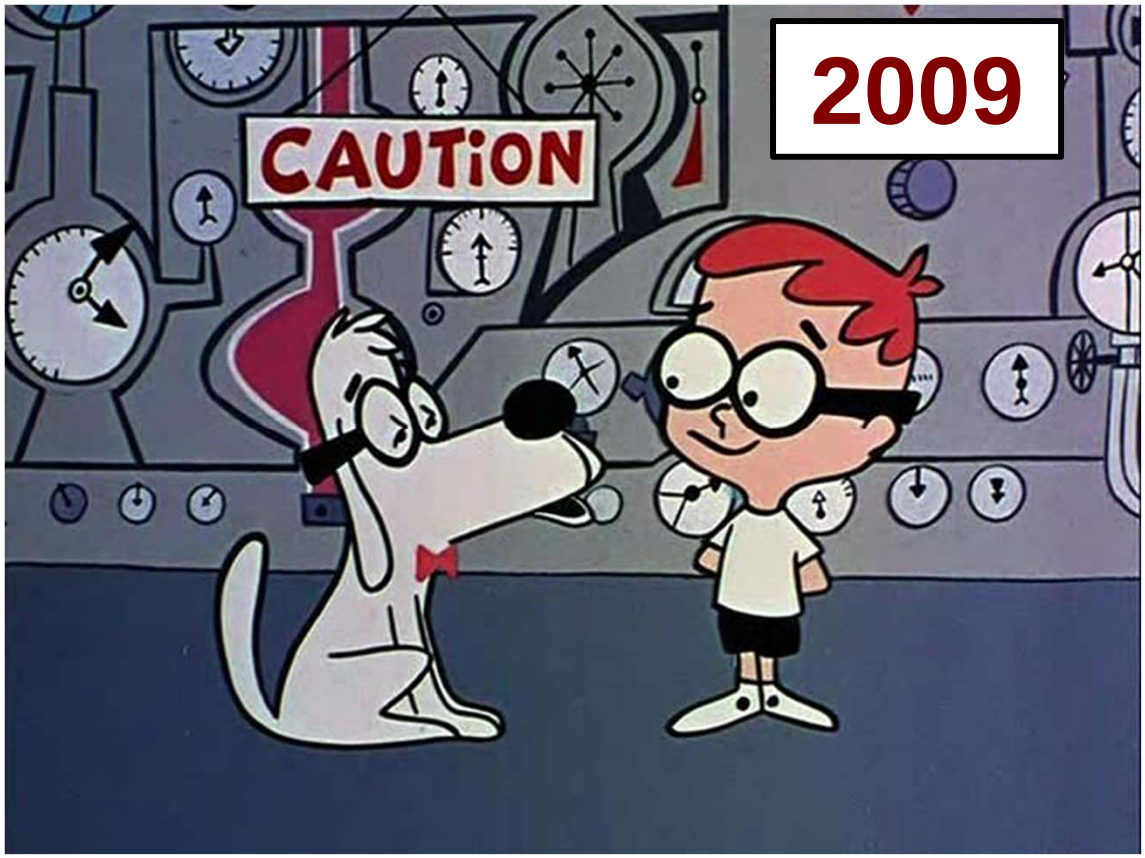
A Brief History of Time Thermostat Savings

Dudley Do-Right? Not so much…

Heating Savings: ~3% to 7%

Cooling Savings: -1% to 1%

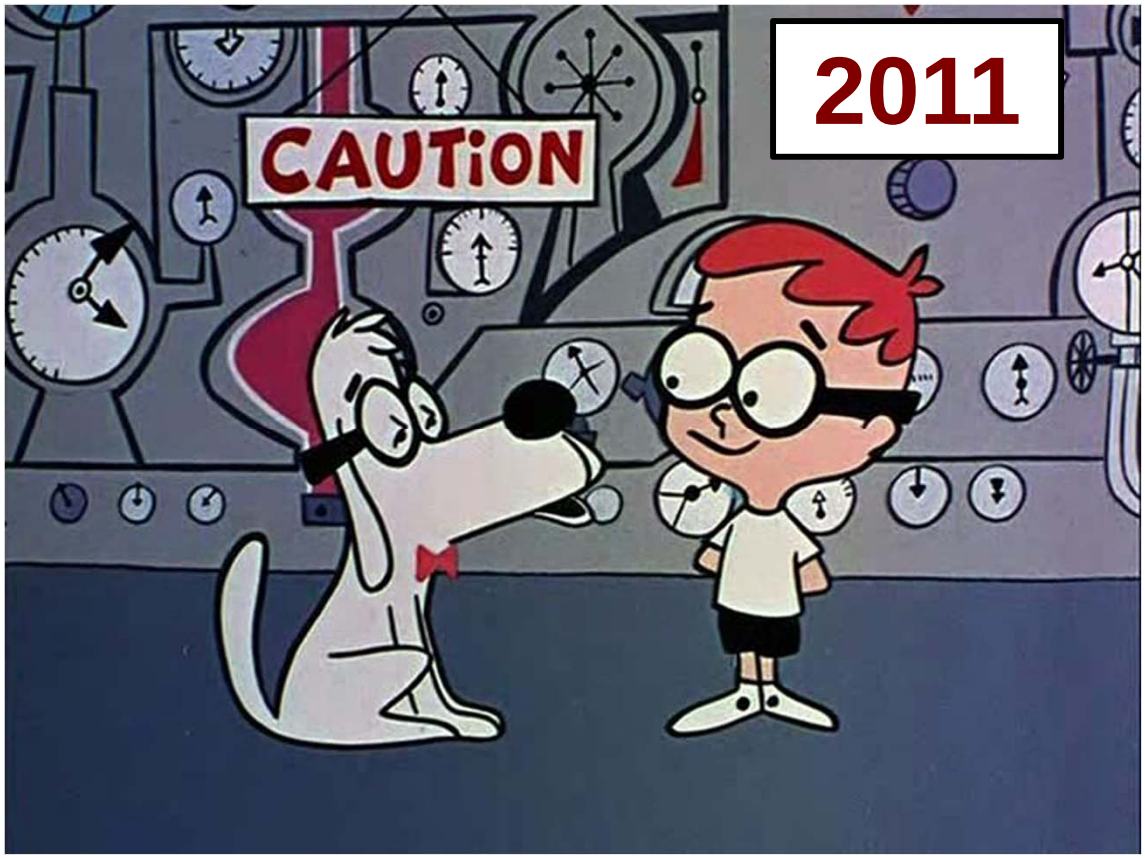
A Brief History of Time Thermostat Savings



Programmable
ENERGY STAR

1995 – 2009
Rest in Peace

A Brief History of Time Thermostat Savings

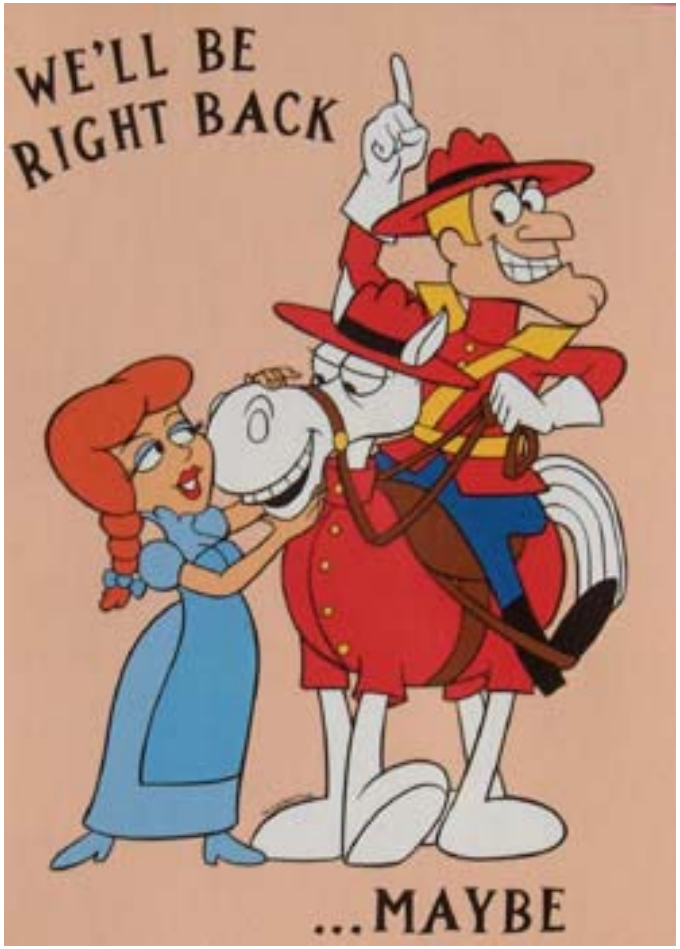


Nest

- The iPod of Tstats
- “Easy-to use”
- “Learning”
- “Attractive”

#1 Selling “Smart” Thermostat

A Brief History of Time Thermostat Savings



Currently "under" revision…

- Usability
- Demand Response-ability
- Auditability:

- **REAL WORLD DATA**
- **ANALYTICS**

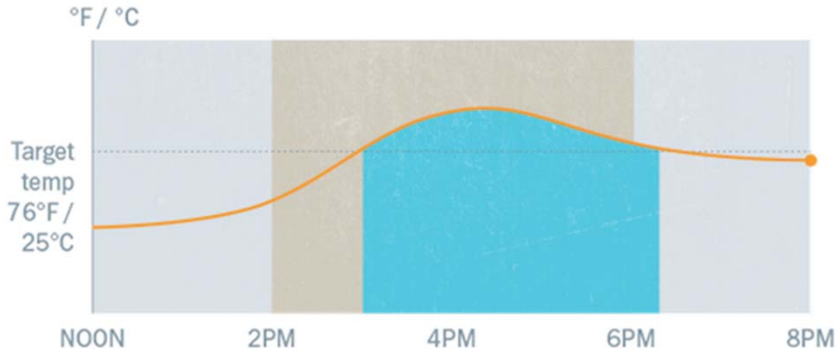
How Much Smarter?

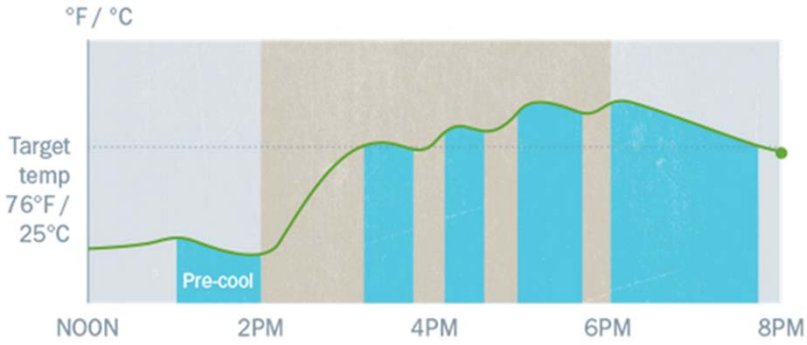
Less Heating or Cooling

- Optimize setpoints
  - Coarse Adjustments
  - Micro-Adjustments

Lower Costs

- Optimize Loads
  - Pre-cooling/heating
  - Staggered runtimes





Data Sources: People* Building* Weather* System*

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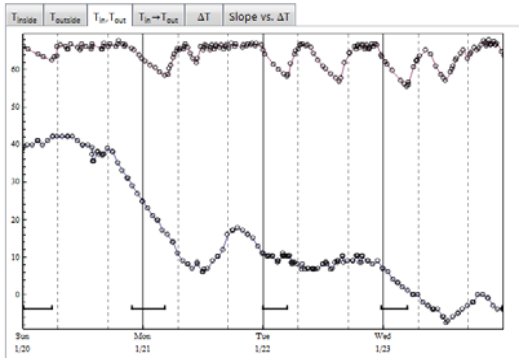
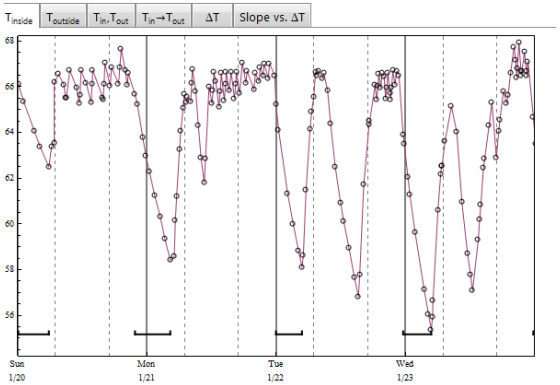
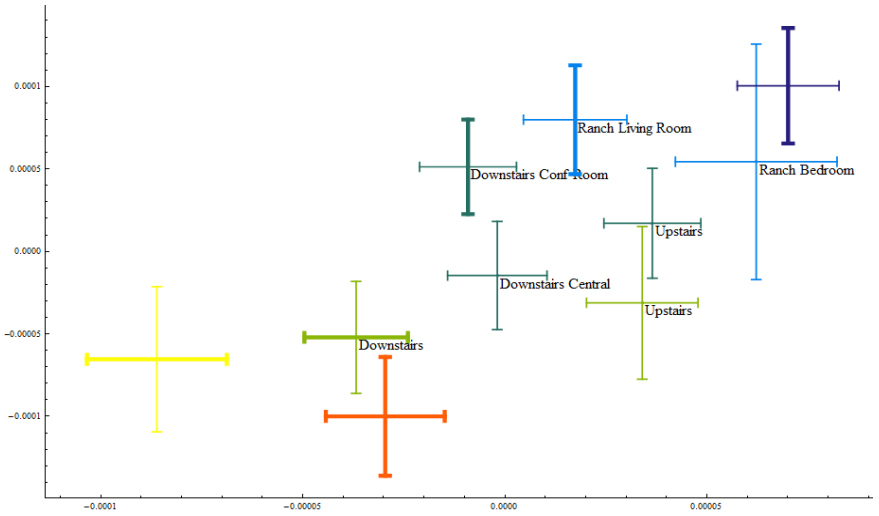
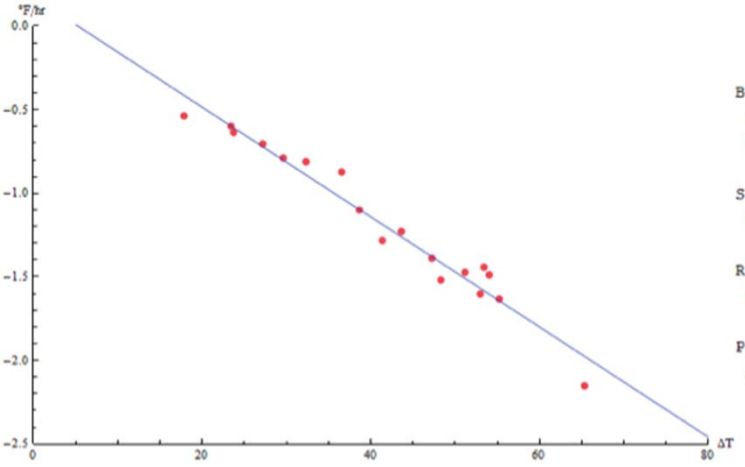
2012 R&D Study

Data → Indirect Savings potential









Best Fit: dT_{in}/dt =
-0.03291 hr^{-1} × ΔT +
0.1735 °F/hr

STDEV of Residuals:
0.0871999 °F/hr

R^2 (model variance / total
0.960033

Projected Balance Point:
ΔT = 5.27°F

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(2014) Thermostat Study Goals

Build on R&D Success:
Thermostat-based performance metric proof-of-concept

Scale study:
Bring robust understanding to program benefits

Direct Savings

Characterization for Residential Market
Single and LI Multi-Family

Indirect Savings

Program Design
Analytics and Tools

Industry Impact

Promote Savings
Demonstrate & Coordinate

Primary Goal

Secondary Goals

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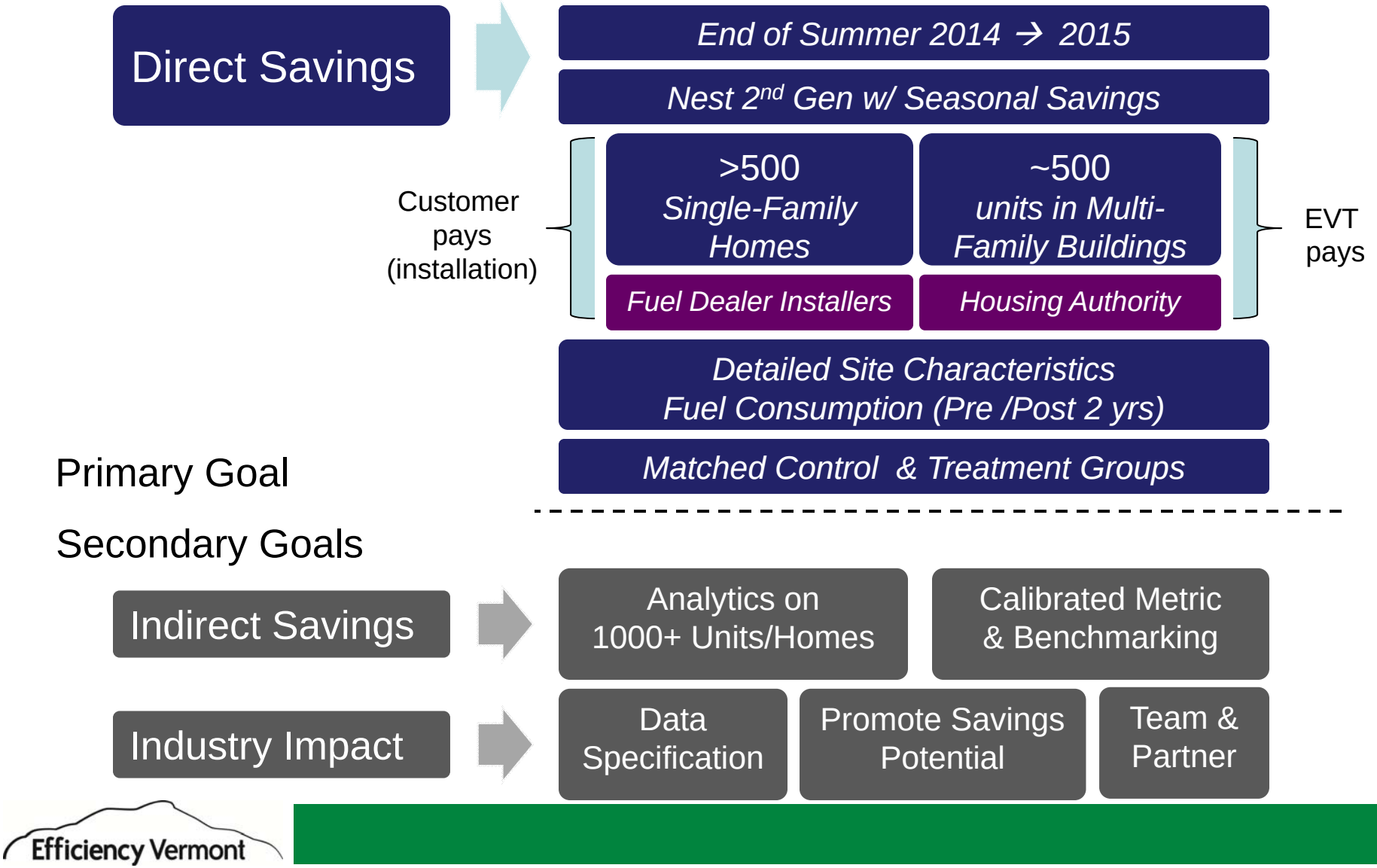
2014 Thermostat Study Design



Participant Screening & Recruitment

HOUSINGVERMONT Building possibilities.

bourne's energy Fueling the future 800-326-8763

ENERGY CO-OP OF VERMONT Your Local Energy Partner

Cota & Cota

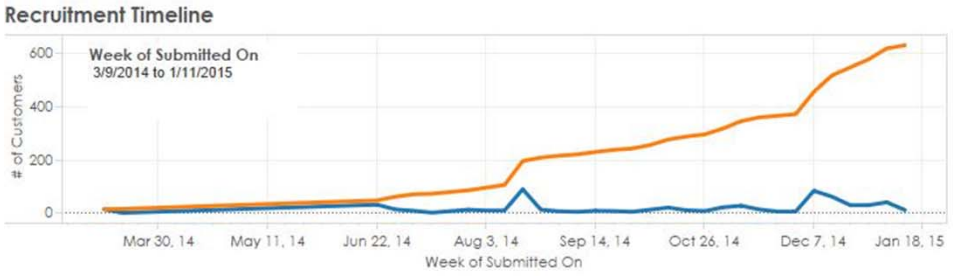
Vermont Gas

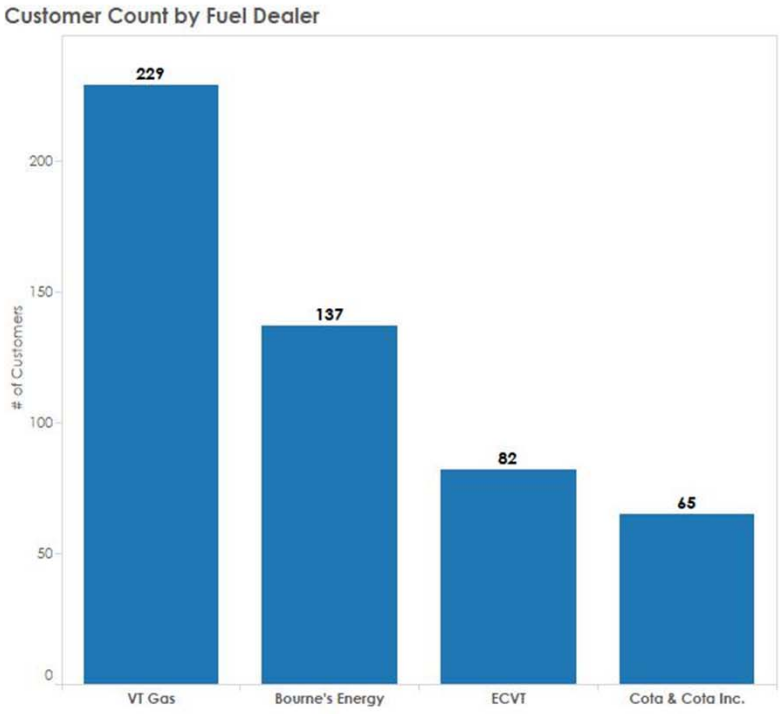
- Housing Vermont:
  - Property Managers across the state

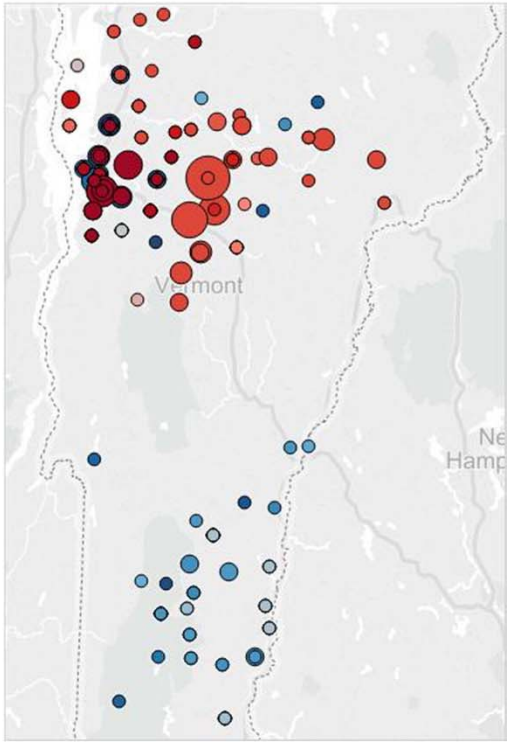
- Fuel Dealer Partners:
  - Bourne's Energy
  - Cota & Cota Inc.
  - Energy Coop of Vermont
  - Vermont Gas Systems

Study Dashboard (small data)

- Recruitment
  - Marketing/ Outreach
  - Geo-Location
  - Installing Partner







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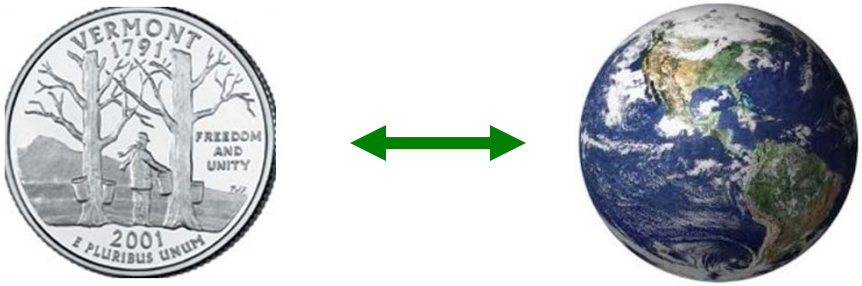
Who Cares?

Ratepayers & “Customers”



Industry Partners

EFFICIENCY EXCELLENCE NETWORK
Efficiency Vermont

ENERGY STAR

U.S. DEPARTMENT OF ENERGY

AHRI

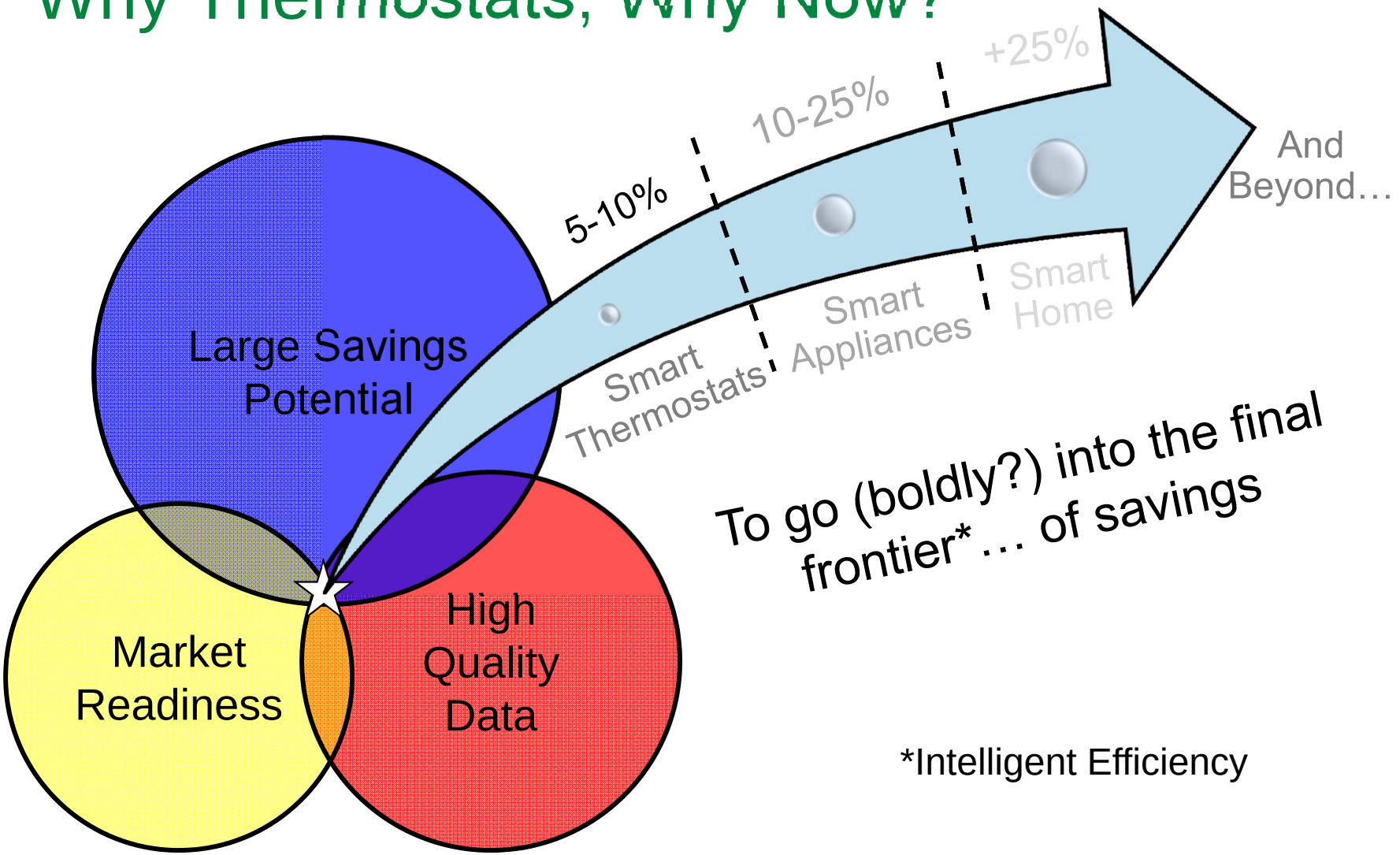
CEE

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Market Actors Supply Chain *

*800lb Gorilla… May wag the dog

Why Thermostats, Why Now?



To go (boldly?) into the final frontier* … of savings

*Intelligent Efficiency

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A glimpse of what's to come…

"**And Nest Thermostats get better over time.** Thanks to automatic software updates, the Nest Thermostat you buy actually gets better at saving energy the longer you own it.

Over the past three years, we've updated the thermostat more than 30 times, and added new features to help people save even more."

10x

per year

because data

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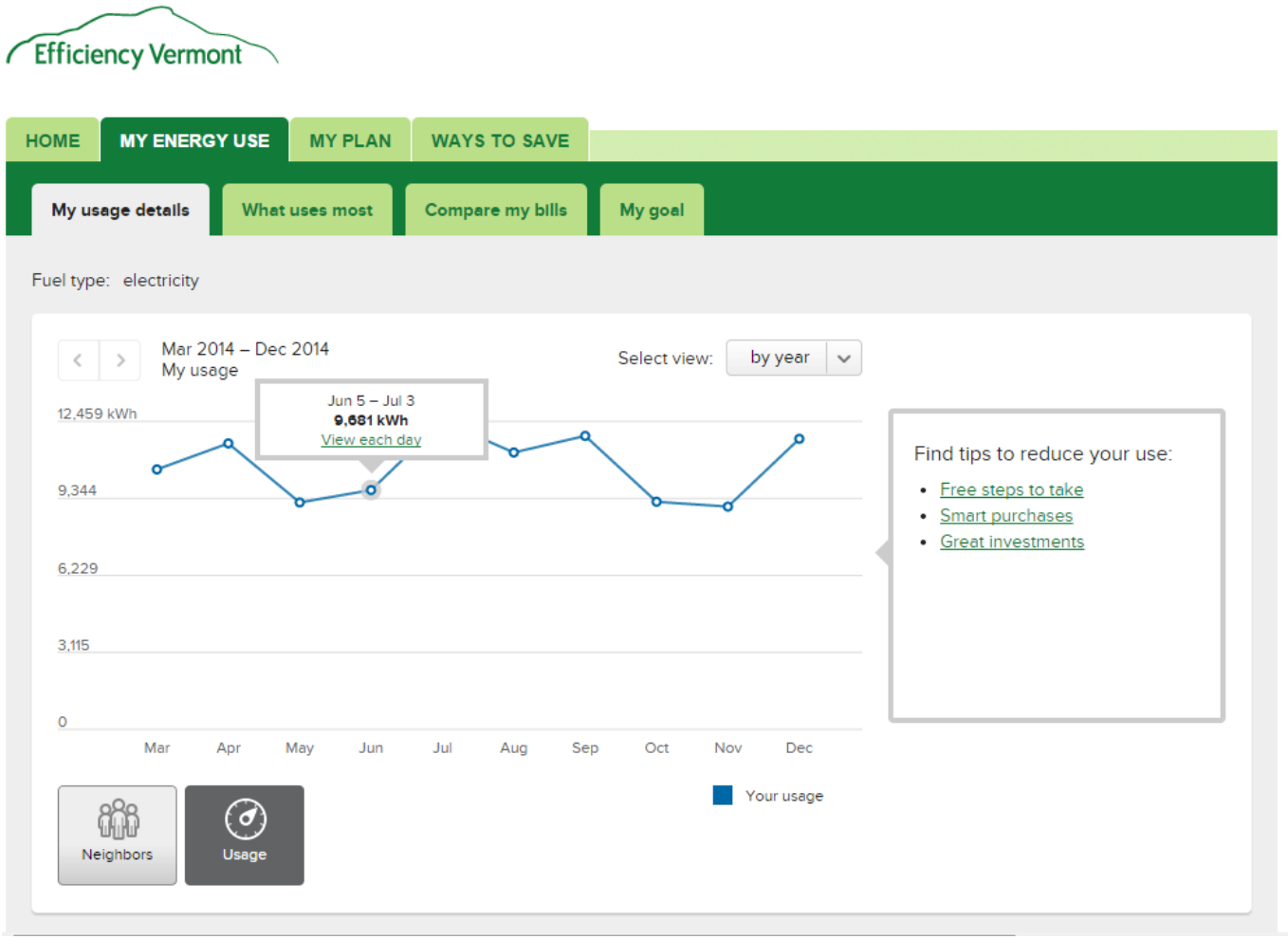
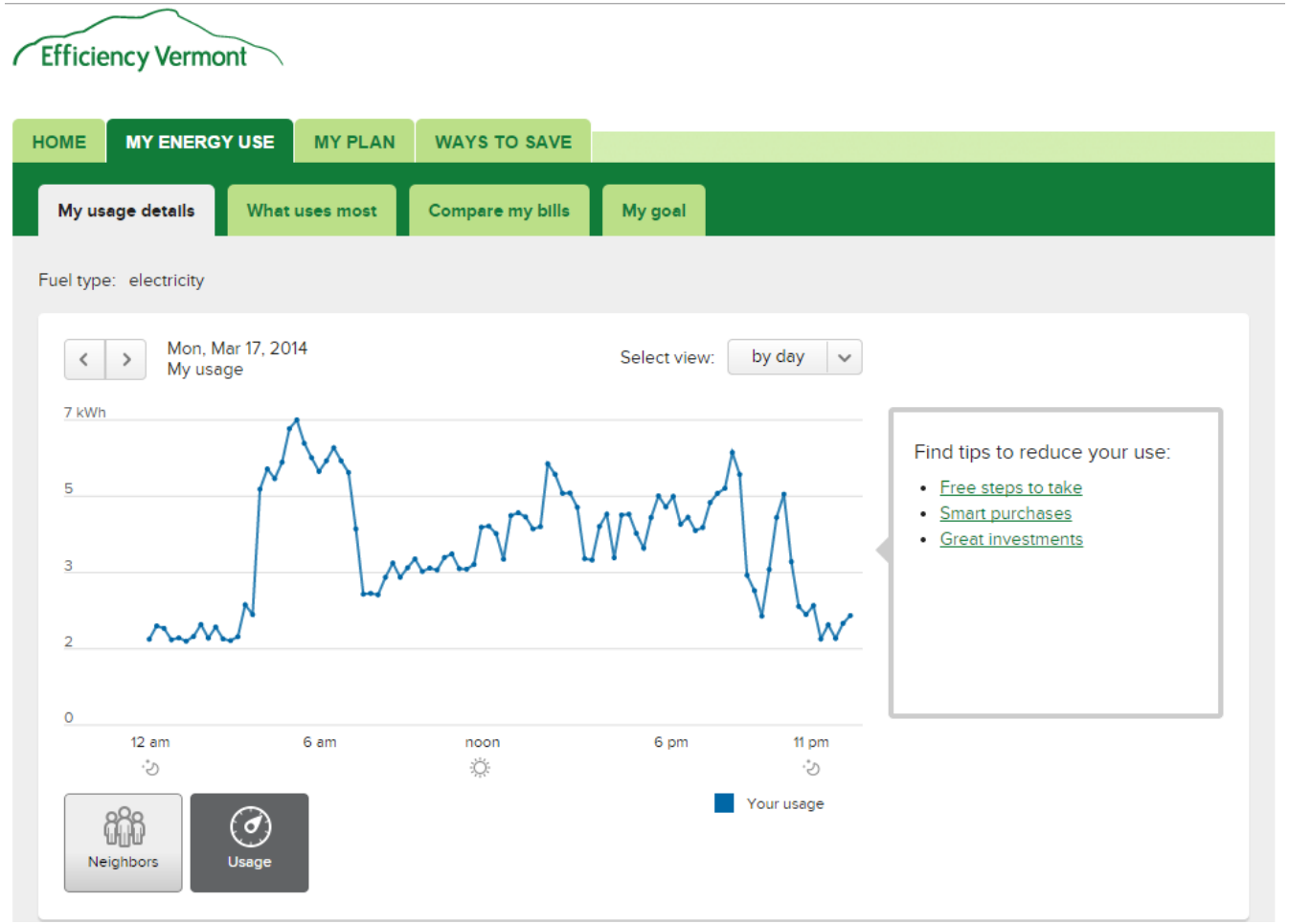
Finding the Information Hiding In Your Data

Ethan Goldman
Efficiency Vermont

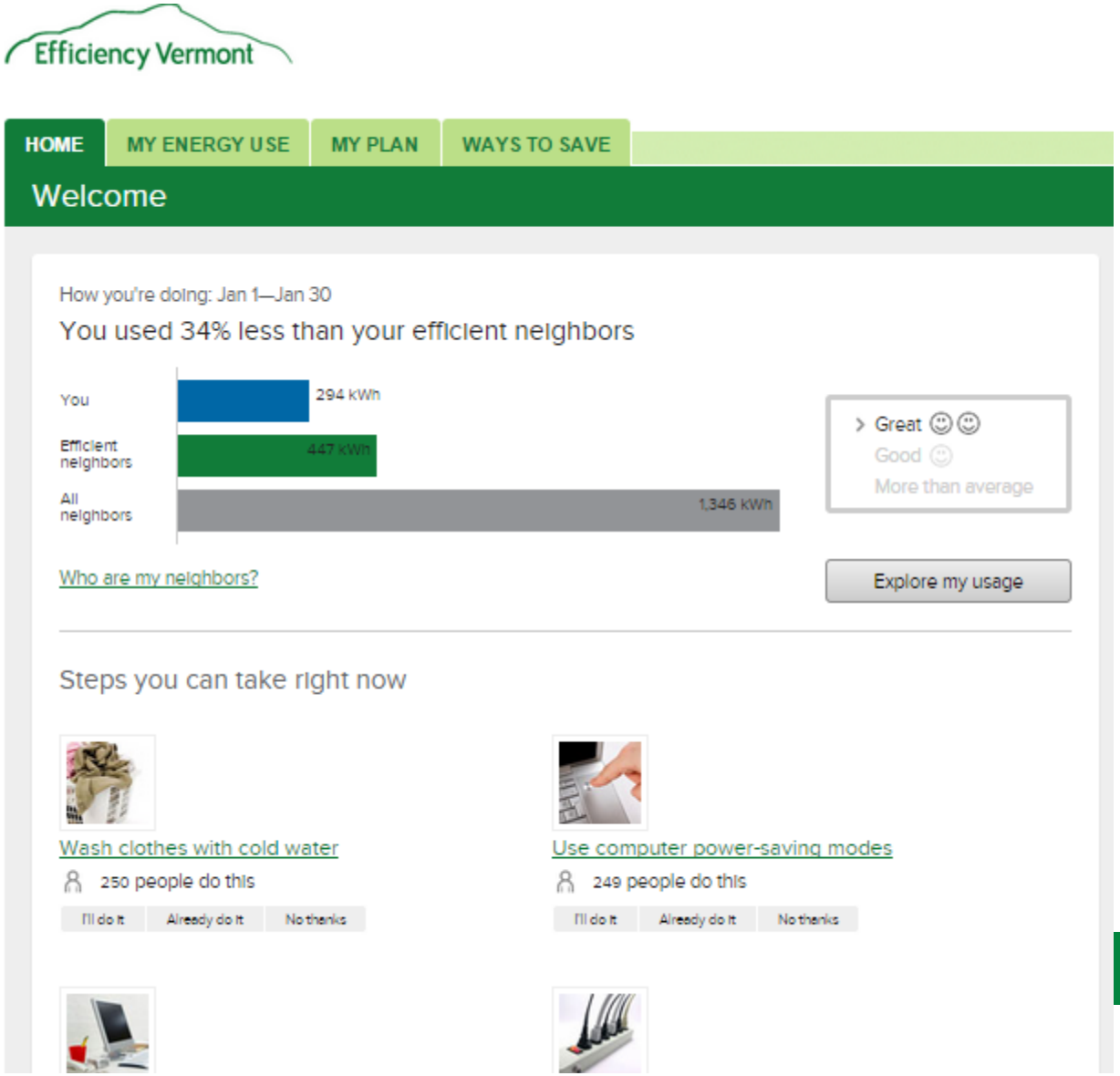
Once, there was darkness



Then, came data



And it is (pretty) good



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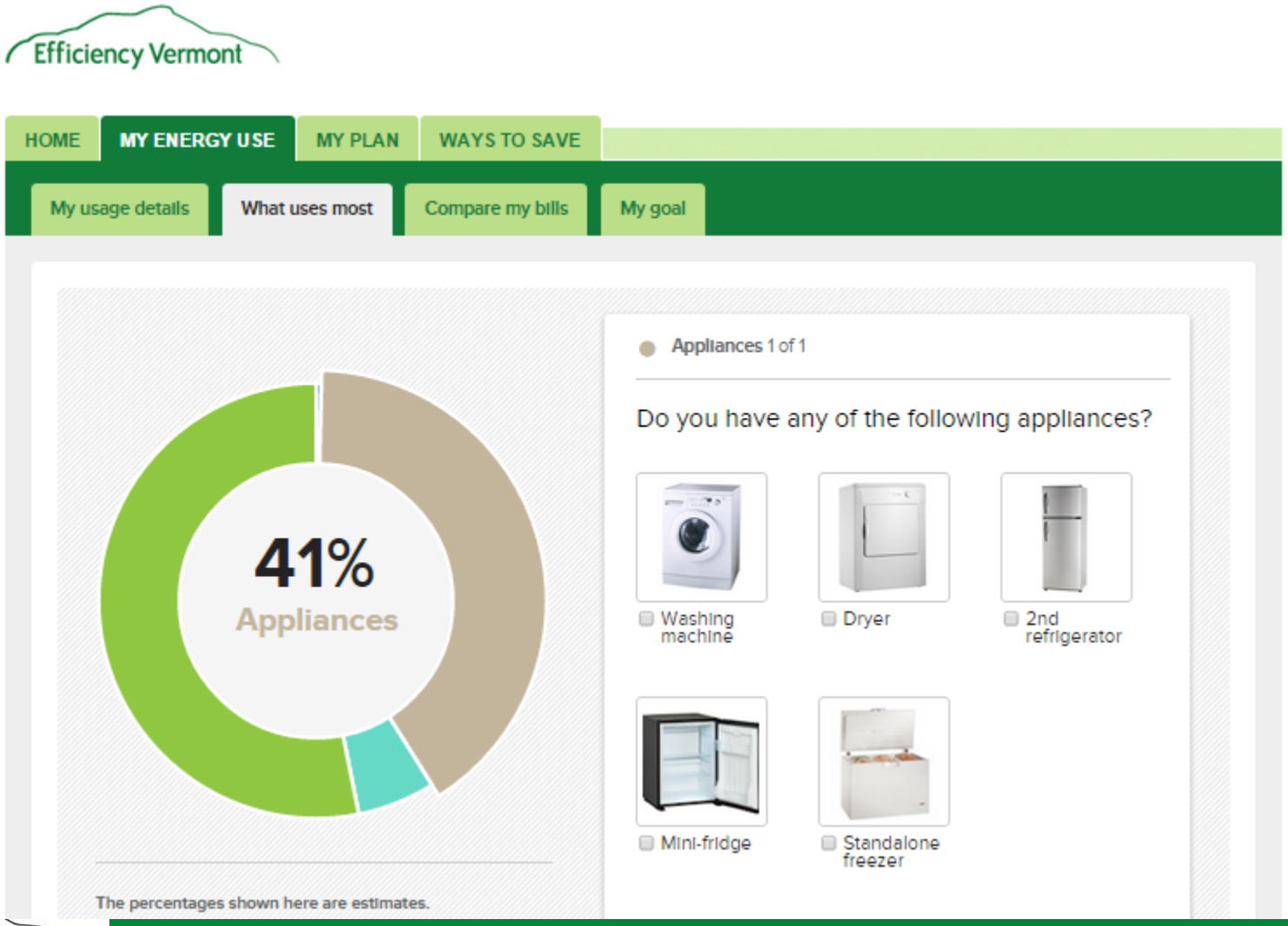
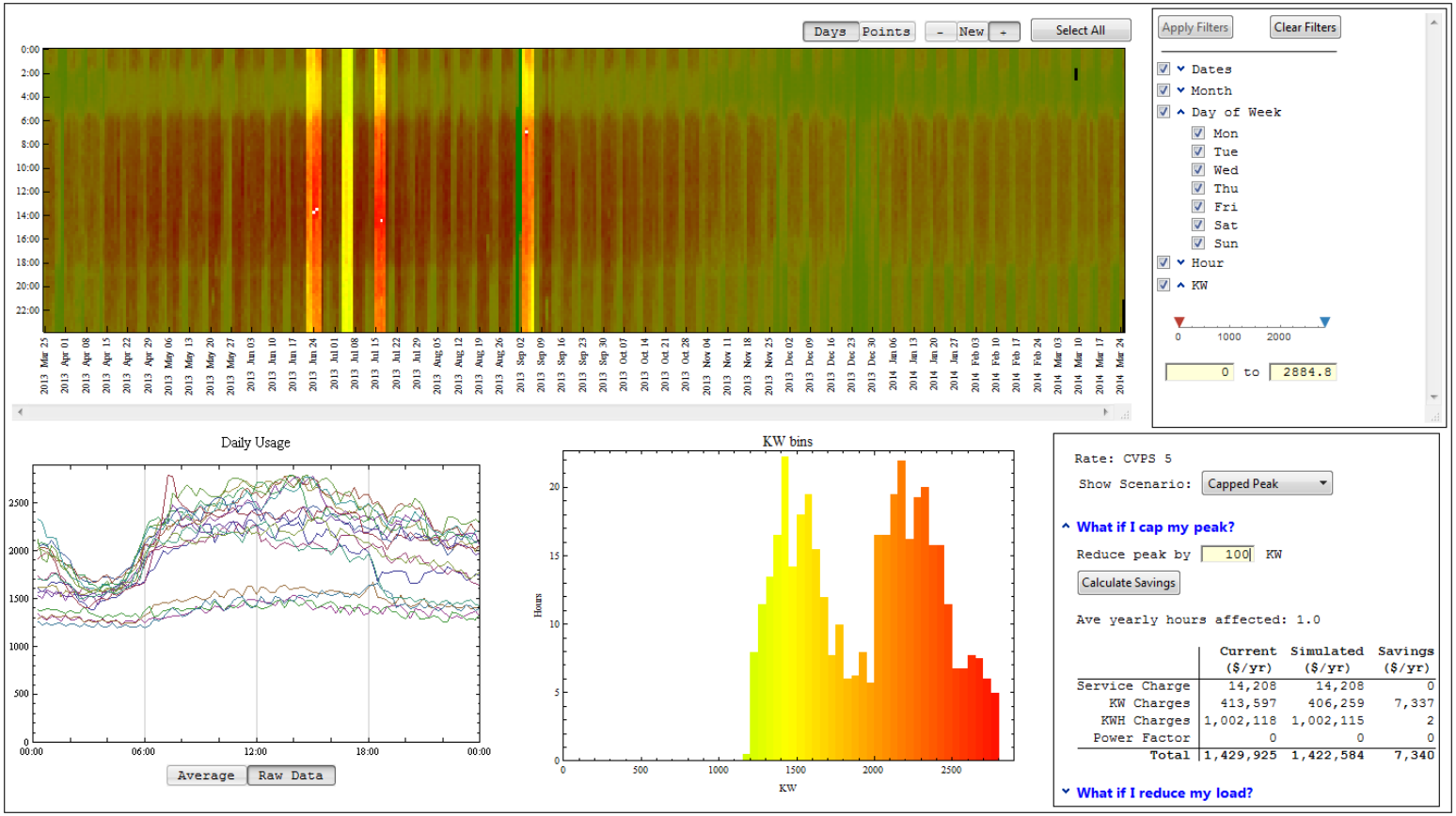
Bring your own data



VIPER Tool (AMI data)



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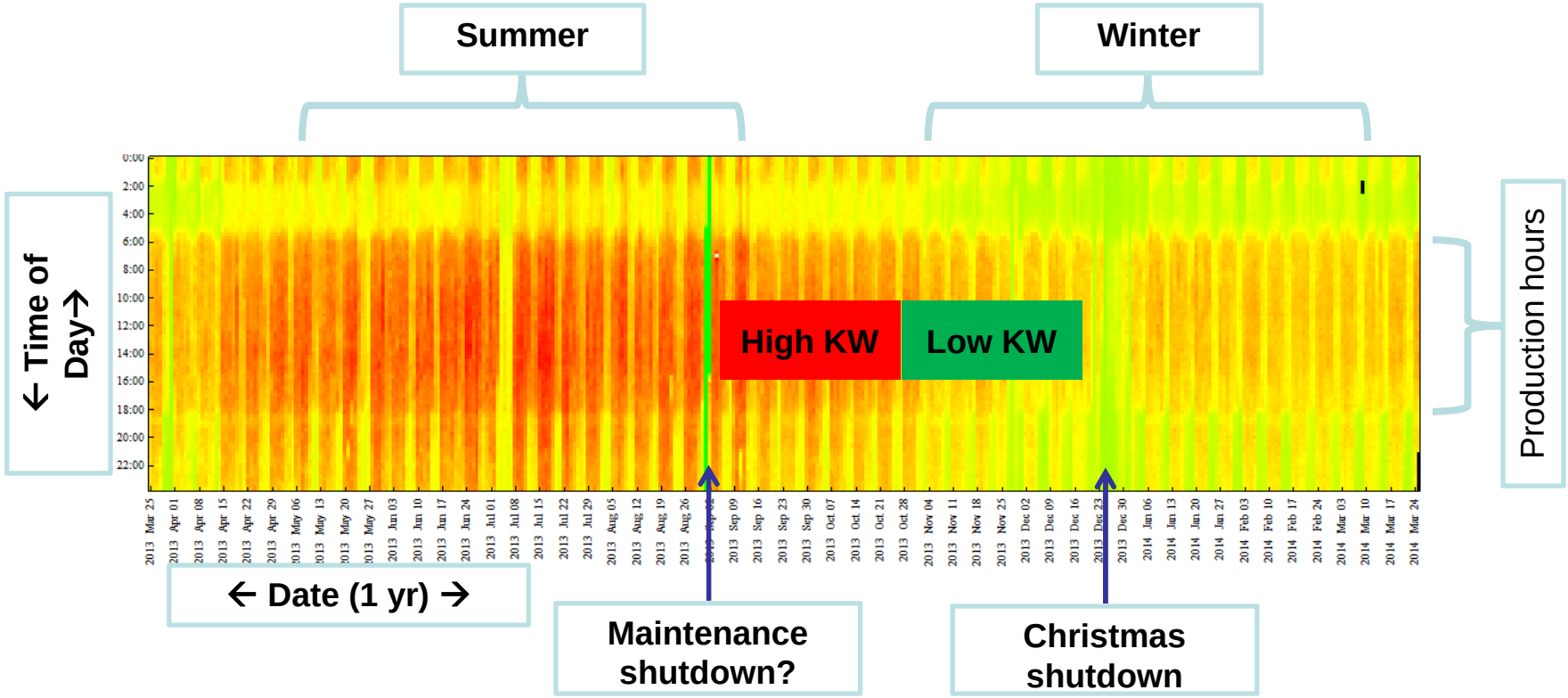
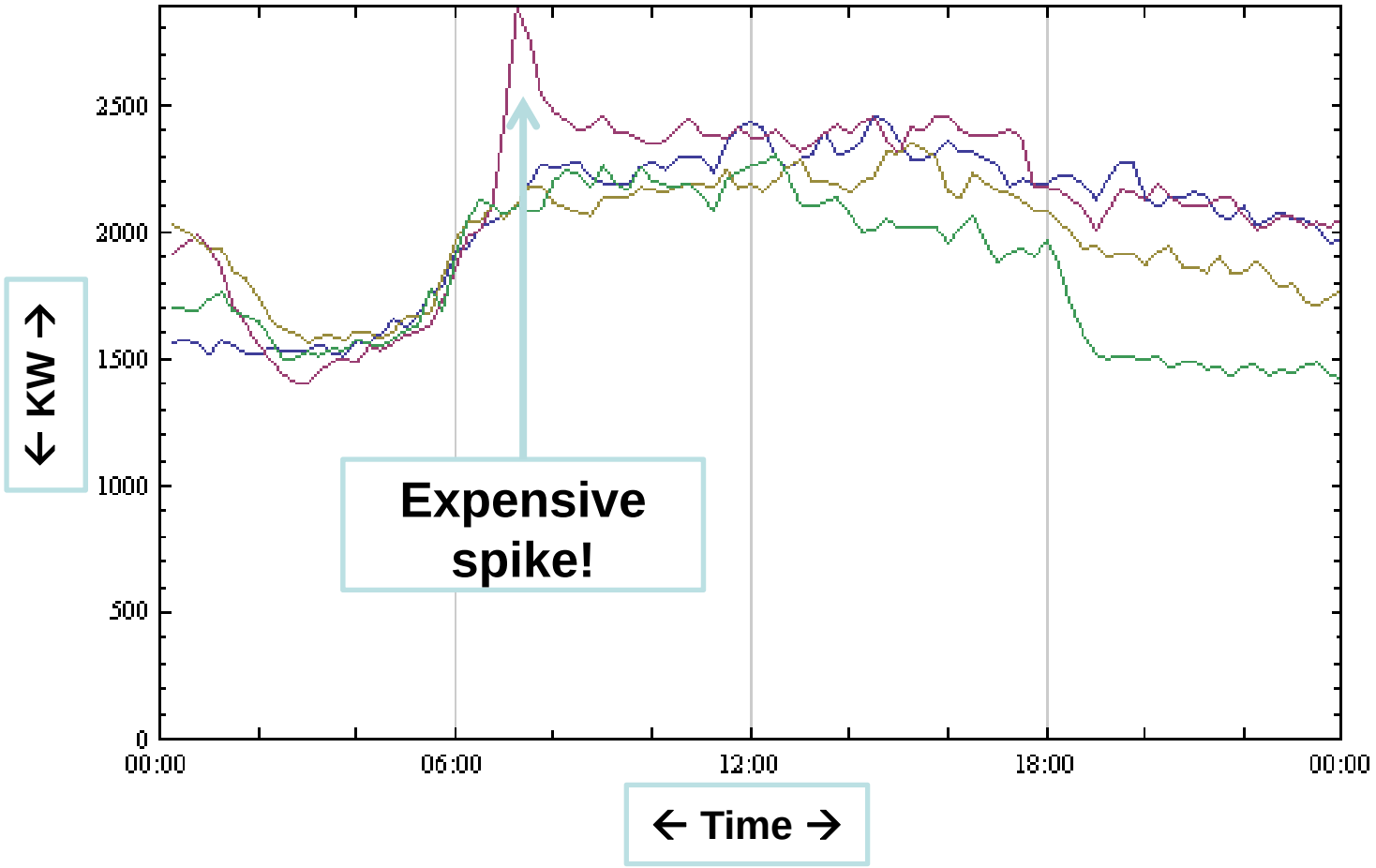
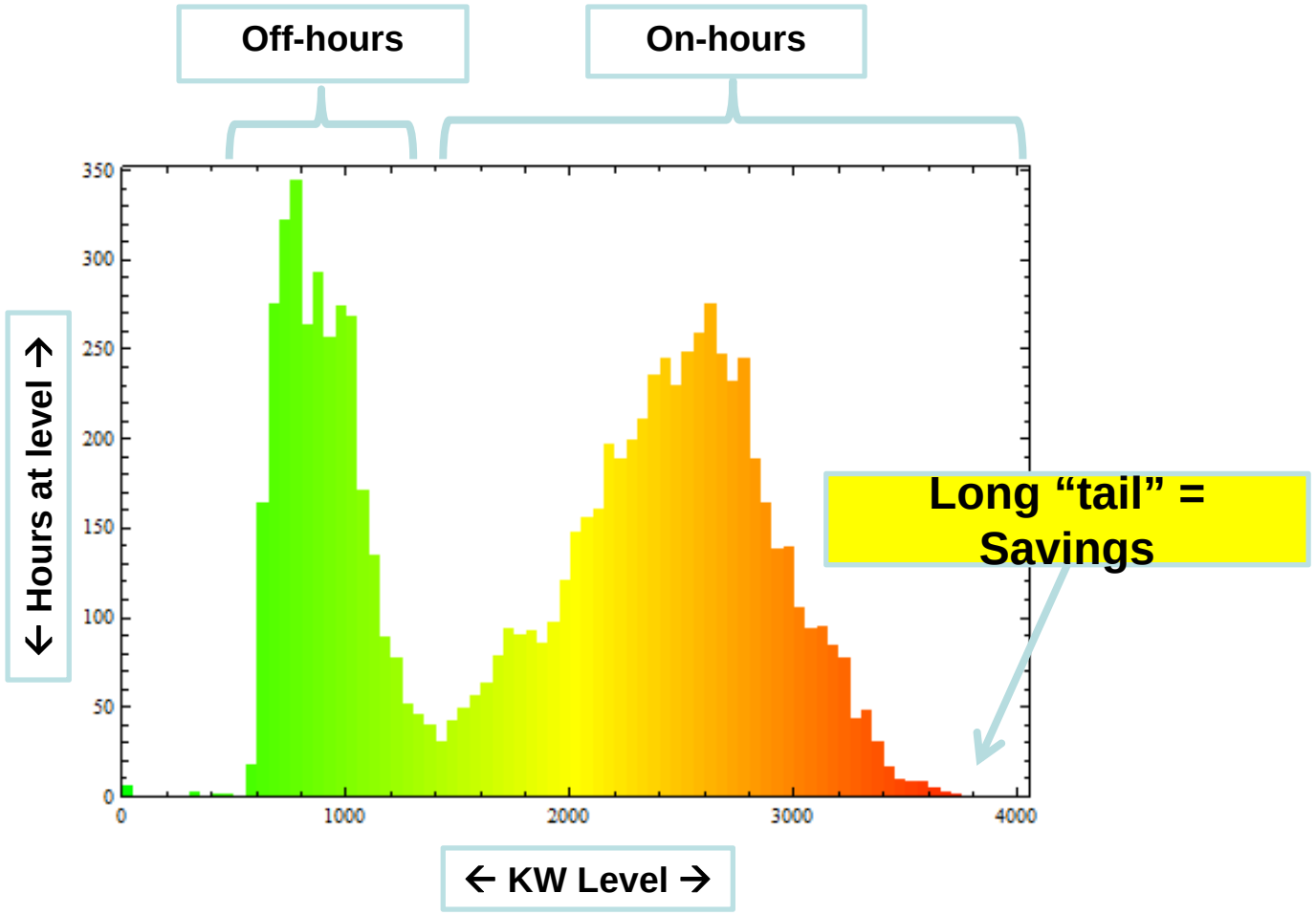
Look for patterns



Look for events



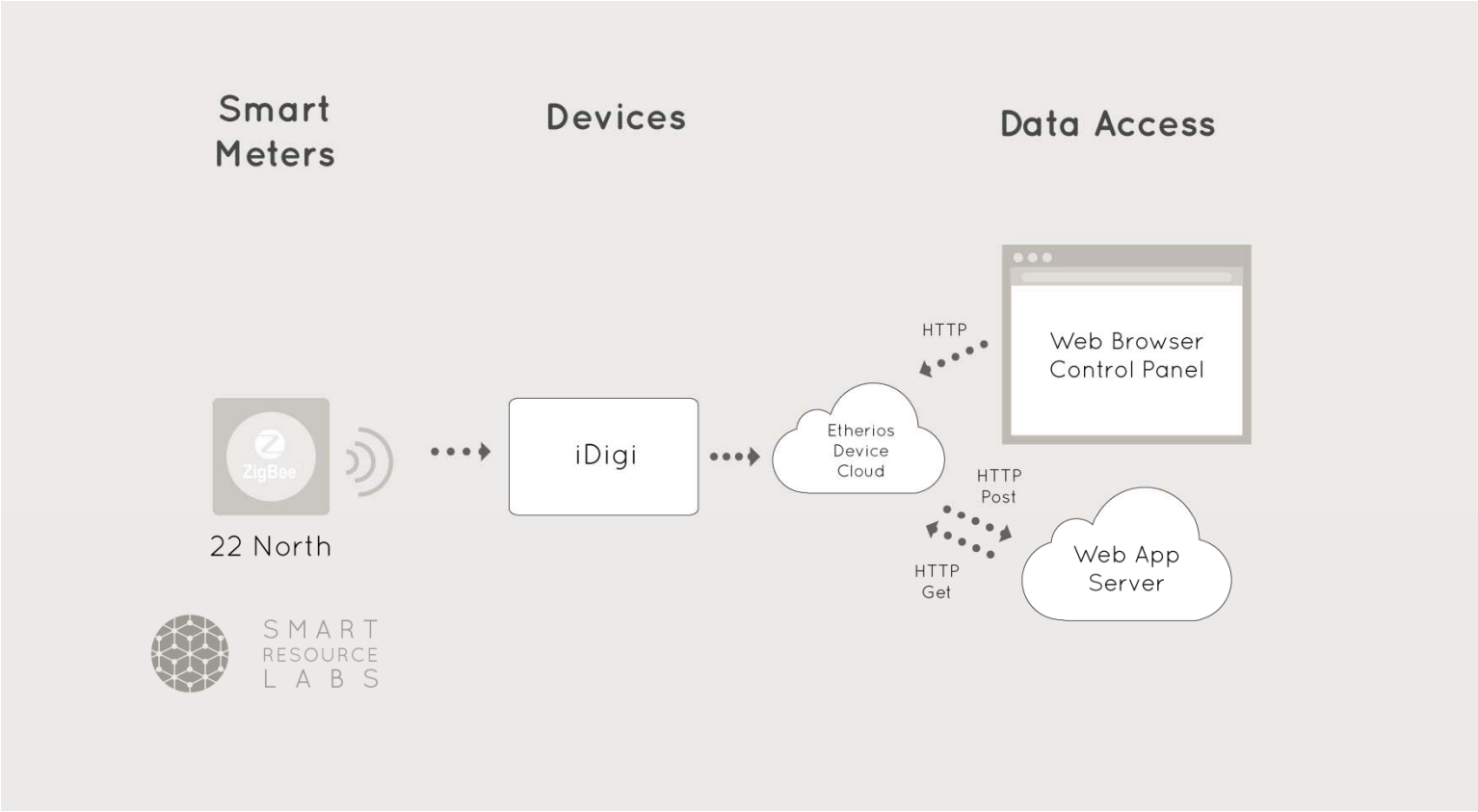
Look for trends



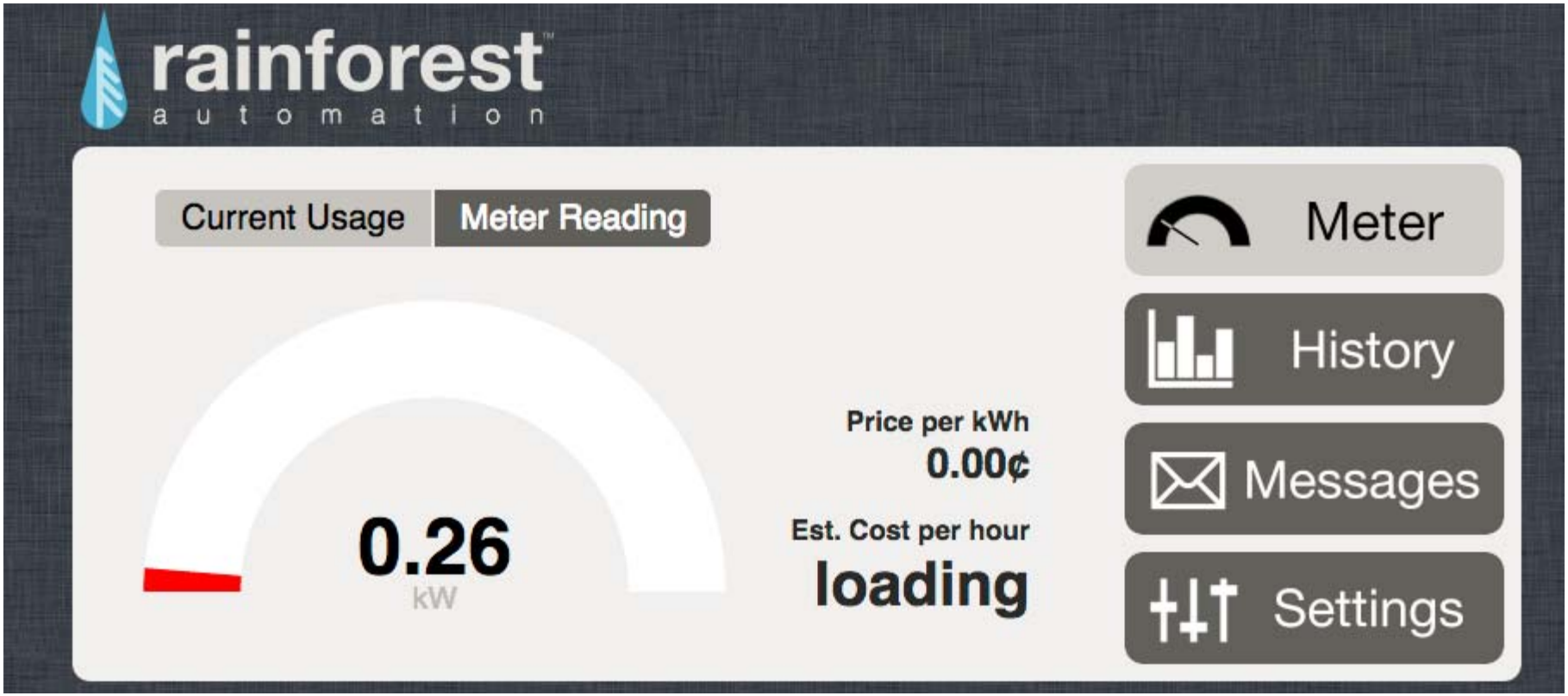
Live demo!

(Drum roll, please…)

Getting live data from smart meters

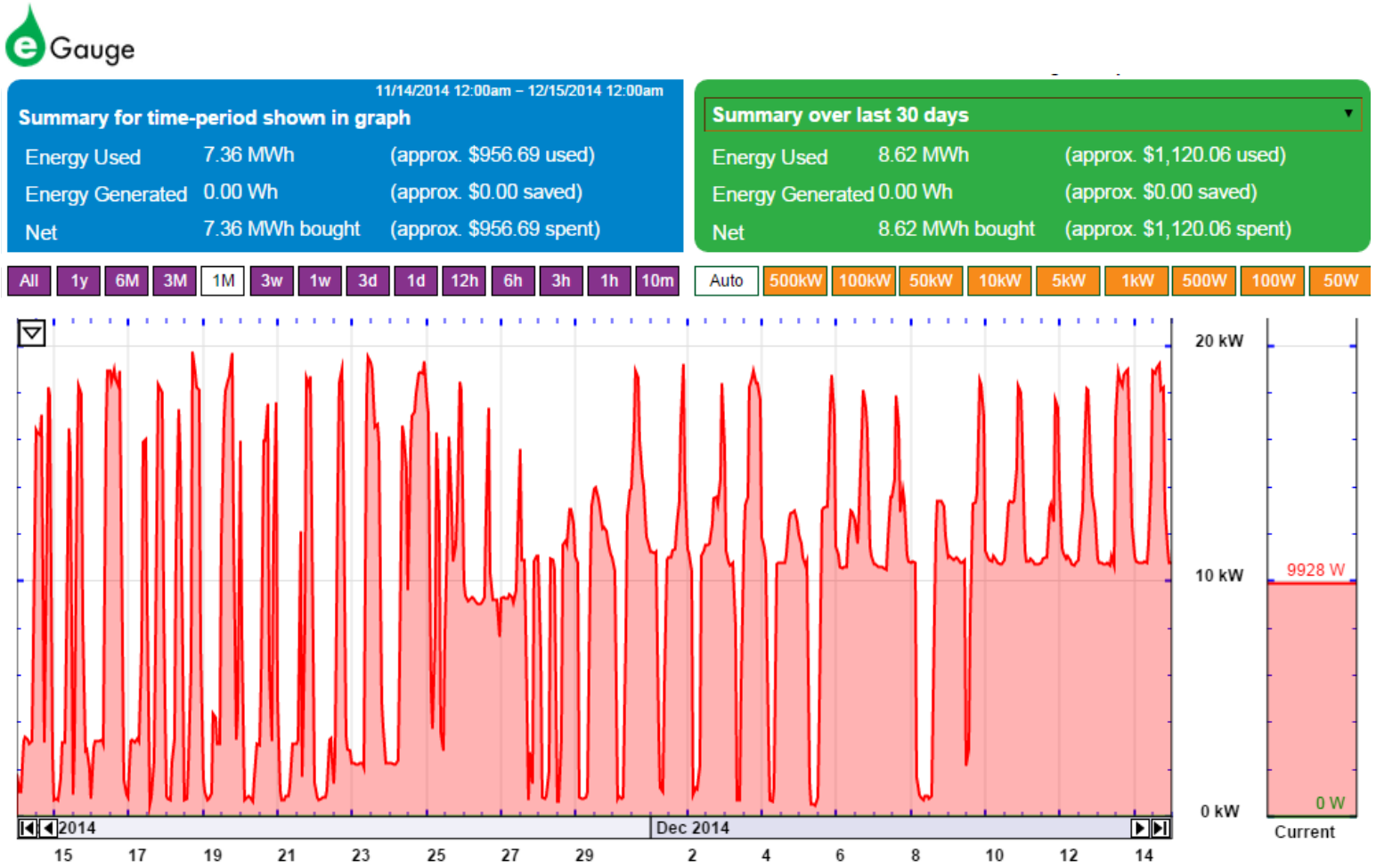


Getting live data from smart meters



Getting live data from smart meters

Remote energy analysis



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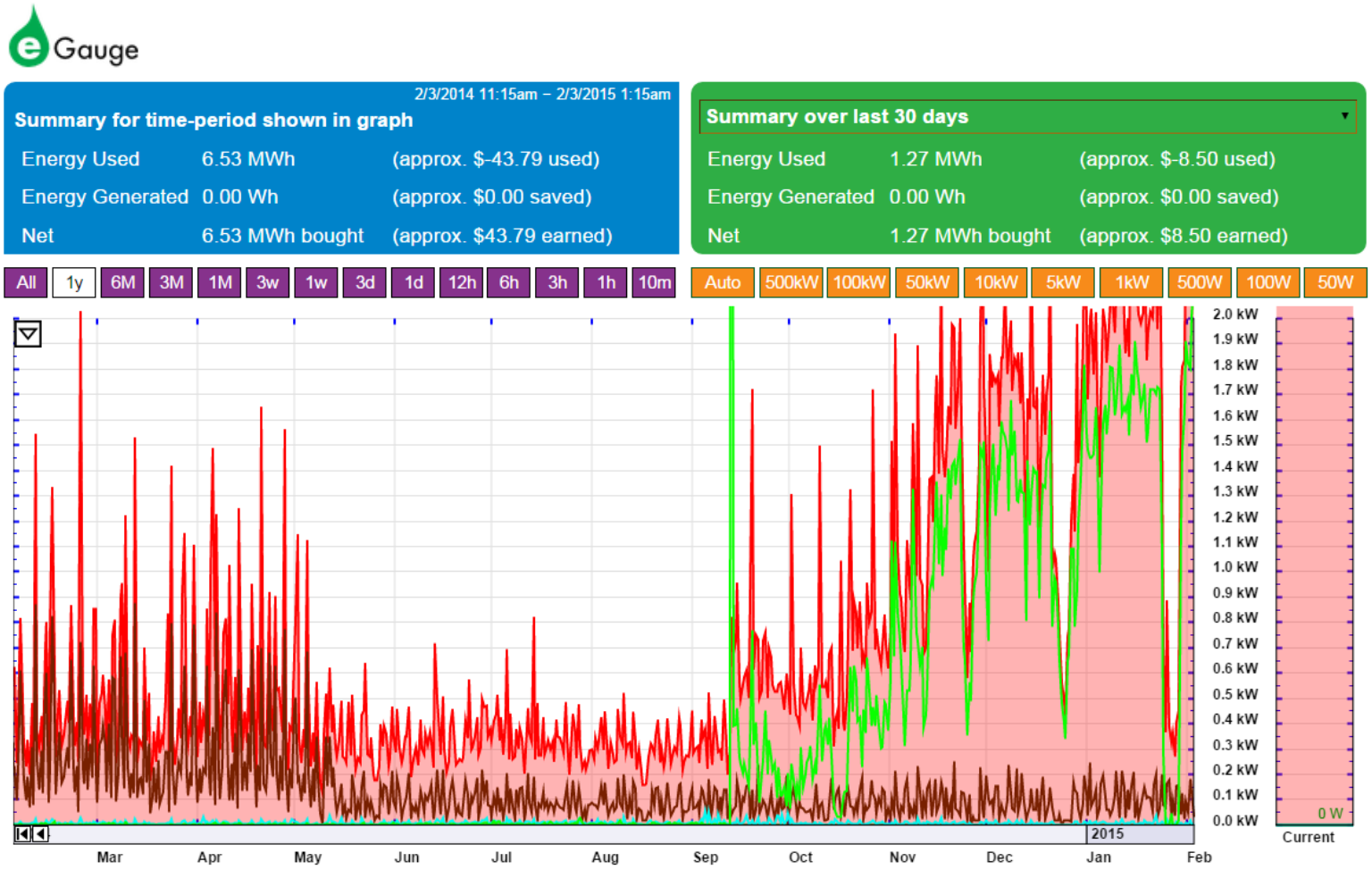
Remote energy analysis



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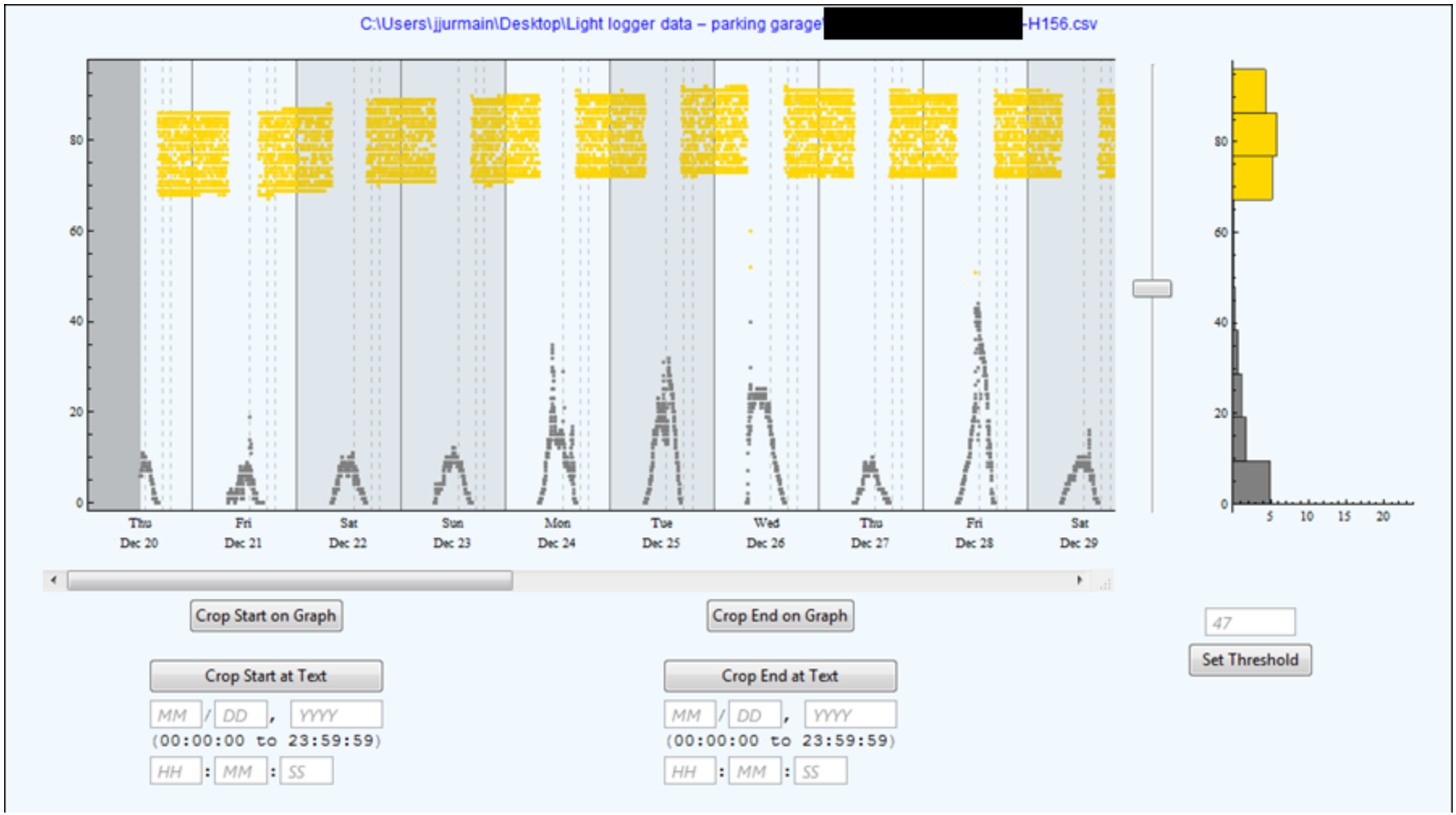
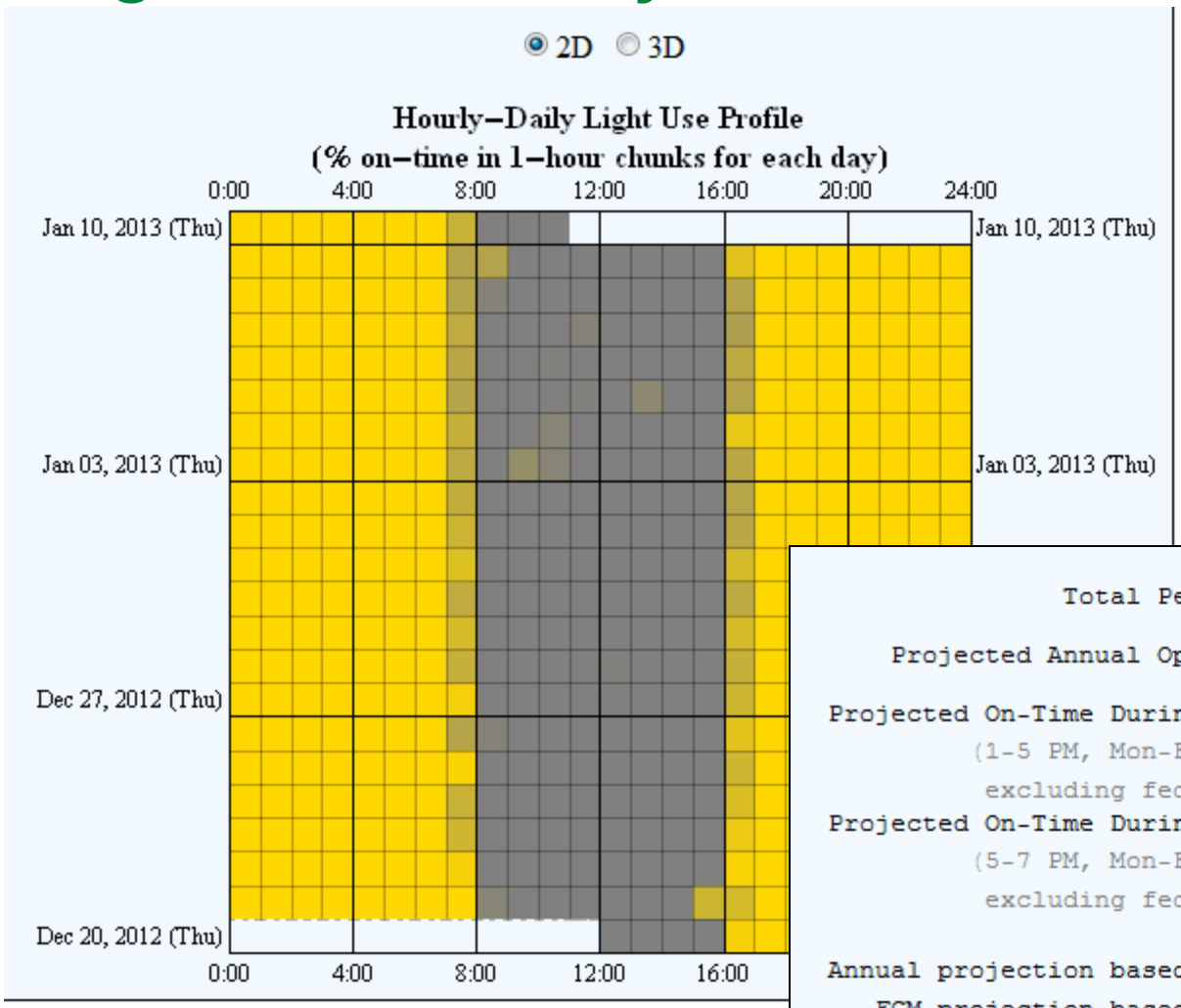
Light-level analysis



Light-level analysis




```
                Total Percent On-Time:    63.93 %

    Projected Annual Operating Hours: 5600.00 Hrs

Projected On-Time During Summer Peak:    16.92 %
          (1-5 PM, Mon-Fri, Jun - Aug,
           excluding federal holidays)
Projected On-Time During Winter Peak:   100.00 %
          (5-7 PM, Mon-Fri, Dec & Jan,
           excluding federal holidays)

Annual projection based on 20.96 metered days
   FCM projection based on 13 metered business days
```

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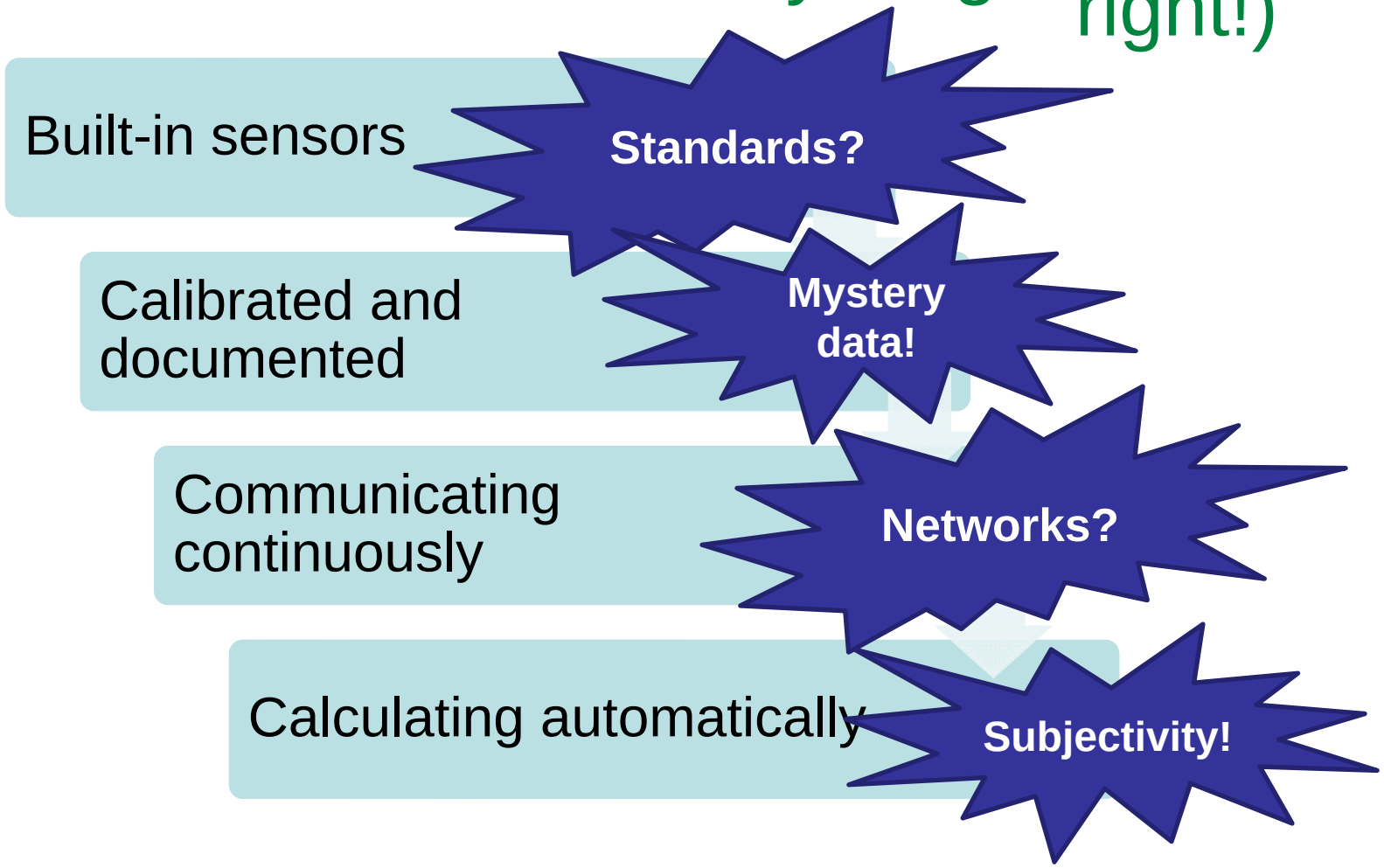
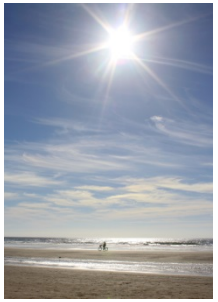
Now we will measure everything! (Yeah, right!)



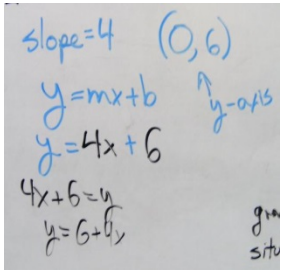
Energy Models: Industrial and Commercial

- Efficiency Vermont has been working with customers at large industrial and commercial facilities to develop energy models
  - Enables prediction of energy usage in future periods
  - Takes into account external and internal variables



  - Weather normalization is the most basic (external)
    - Dry bulb or wet bulb temperature
  - Internal variables are numerous
    - Production levels – can be multiple products
    - Occupancy or schedule

Energy Models: Industrial and Commercial



- Linear models typically used
  - Energy usage is modeled as a function of multiple variables

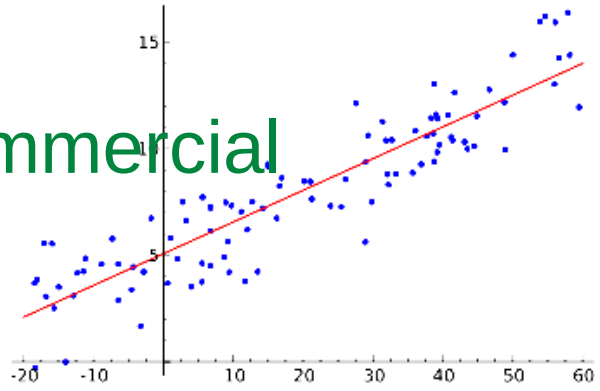
Energy = f(baseload, heating load, cooling load, schedule, $production_n$)

$$E = B + C_1 * HDD + C_2 * CDD + C_3 * S + C_4 * P_1 + C_5 * P_2 + \ldots + C_N * P_N$$

Caution: Math Ahead

- Linear models are easiest to understand

Energy Models: Industrial and Commercial



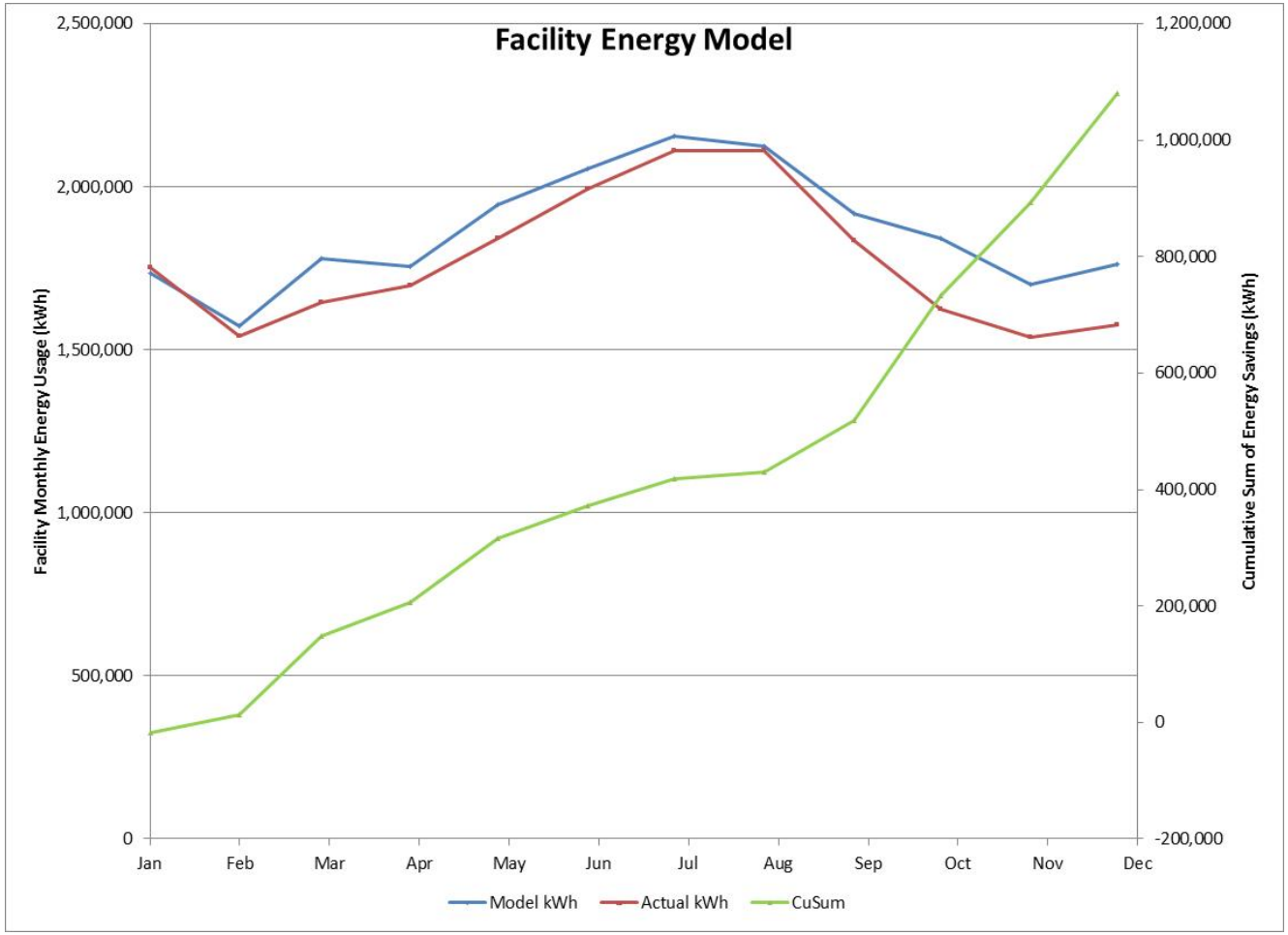
- Example linear model
  - A simple model for a facility with one main product and a process-related cooing load, no production on holidays

Energy = 50,000 + 600 * CDD – 20,000 * Holiday + 50 * Widgets

  - The baseload is 50,000 kWh per day
  - 600 kWh are required for each cooling degree day
  - Facility energy usage drops by 20,000 kWh on holidays
  - 50 kWh are required for each widget that the facility produces

(Total annual usage 22 million kWh)

Energy Models: Industrial and Commercial

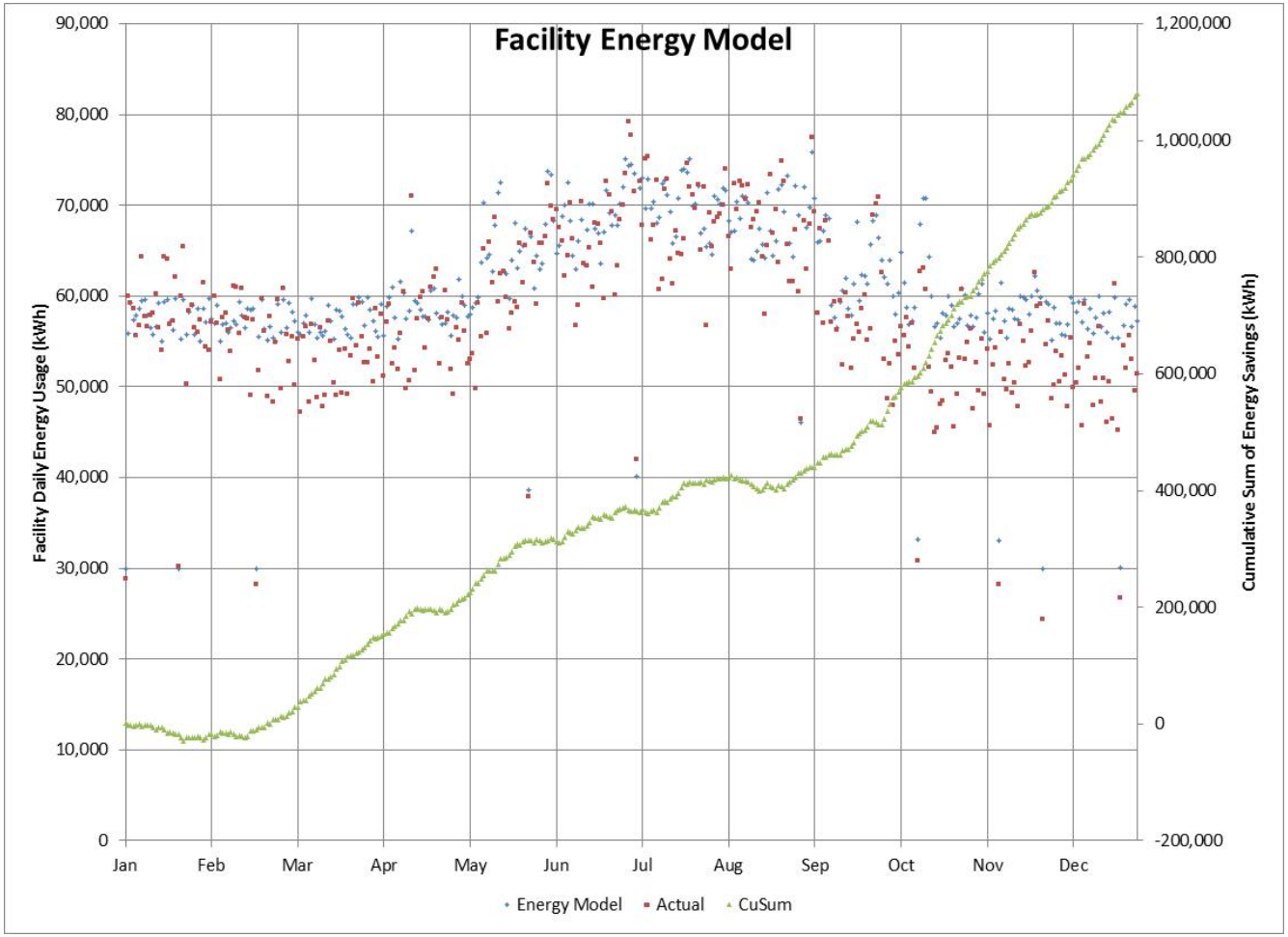


Energy Models: Industrial and Commercial

- Initial models based on monthly data
  - Production data were available with monthly resolution
- Showed general trends
  - Large time delay lacked usefulness as a diagnostic tool

- Daily data provides faster feedback
  - Ability to dispatch team to investigate changes
    - Good: What are we doing better?
    - Bad: What slipped out of control?

Energy Models: Industrial and Commercial



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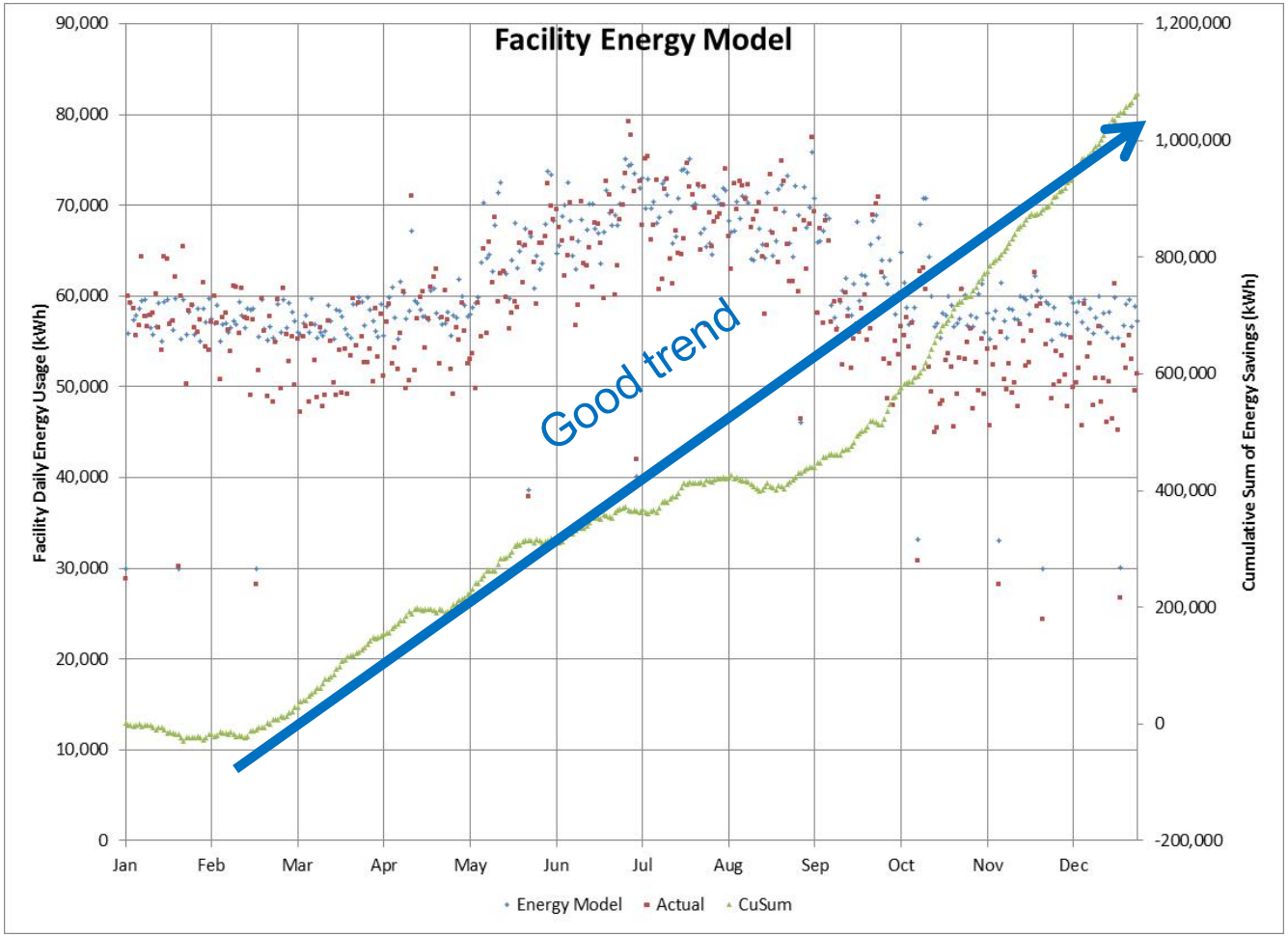
Energy Models: Industrial and Commercial

- What does it tell us?
  - Are we making long-term progress?
    - Is the overall trend in the right direction?

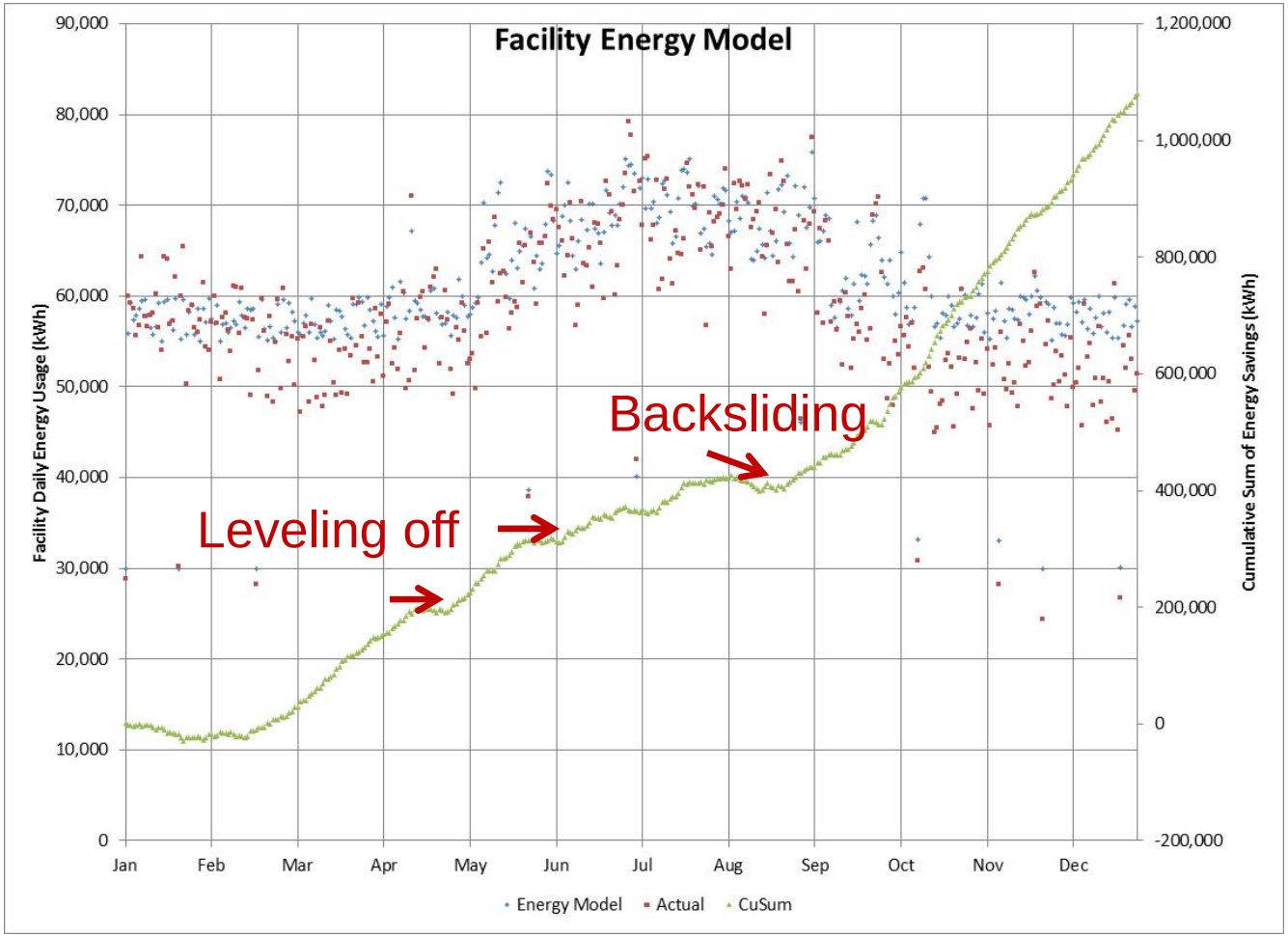
Energy Models: Industrial and Commercial



Energy Models: Industrial and Commercial

- What does it tell us?
  - Are we experiencing short-term challenges?
    - Is backsliding evident?

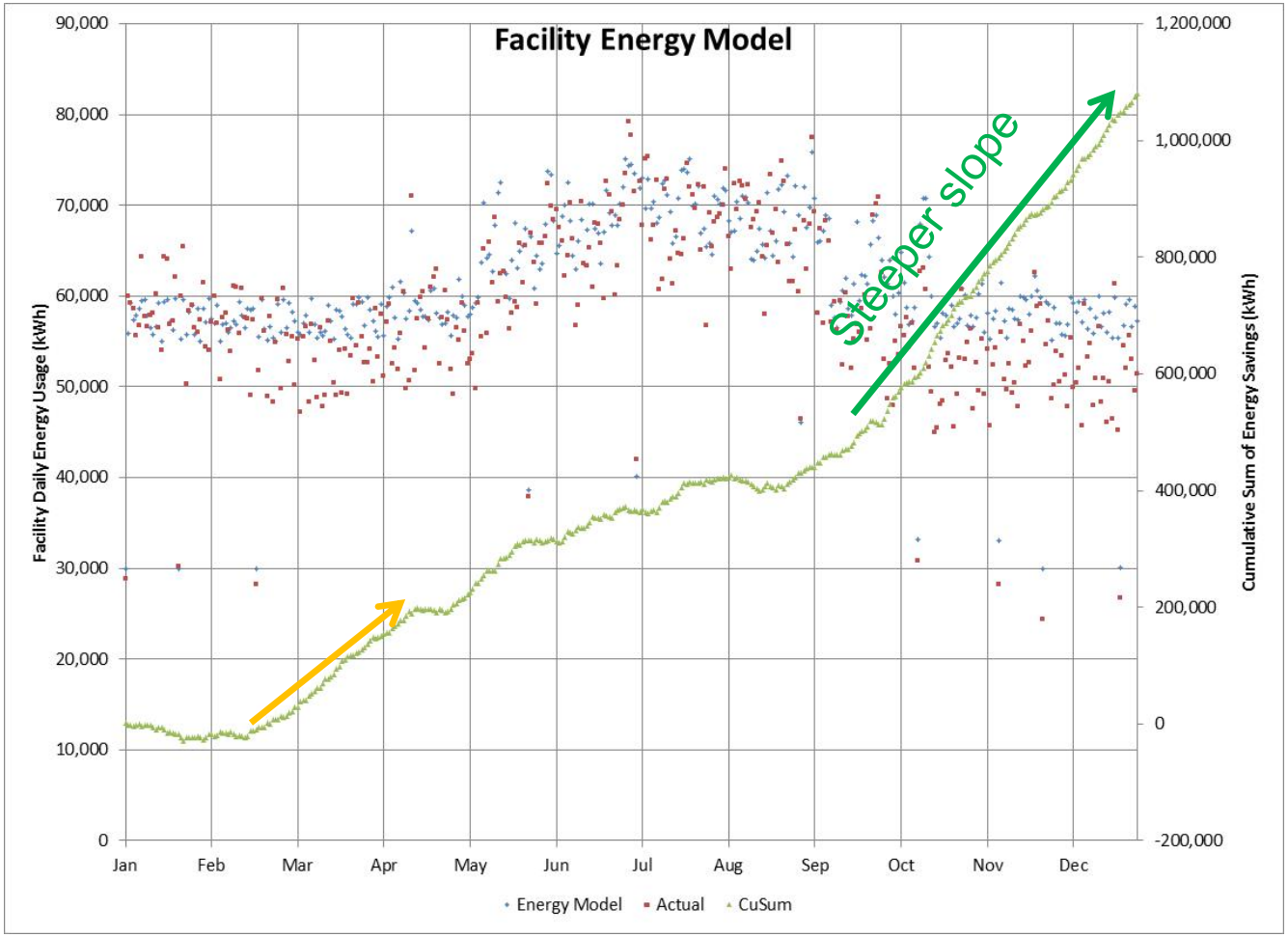
Energy Models: Industrial and Commercial



Energy Models: Industrial and Commercial

- What does it tell us?
  - Do we see evidence of the specific energy efficiency efforts?
    - Is the slope changing?

Energy Models: Industrial and Commercial



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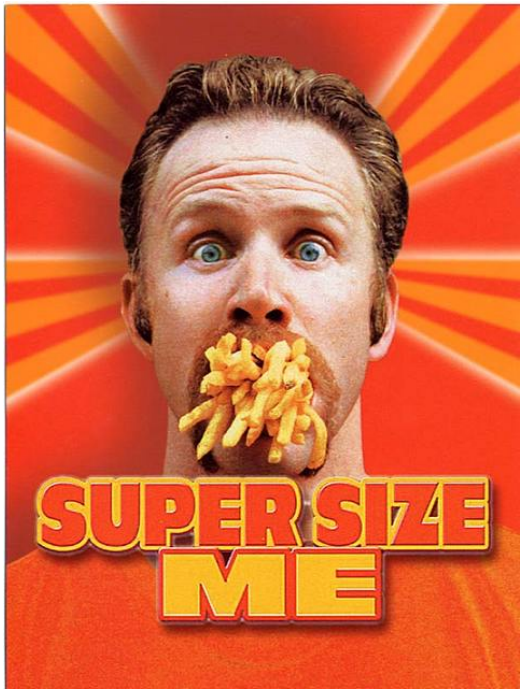
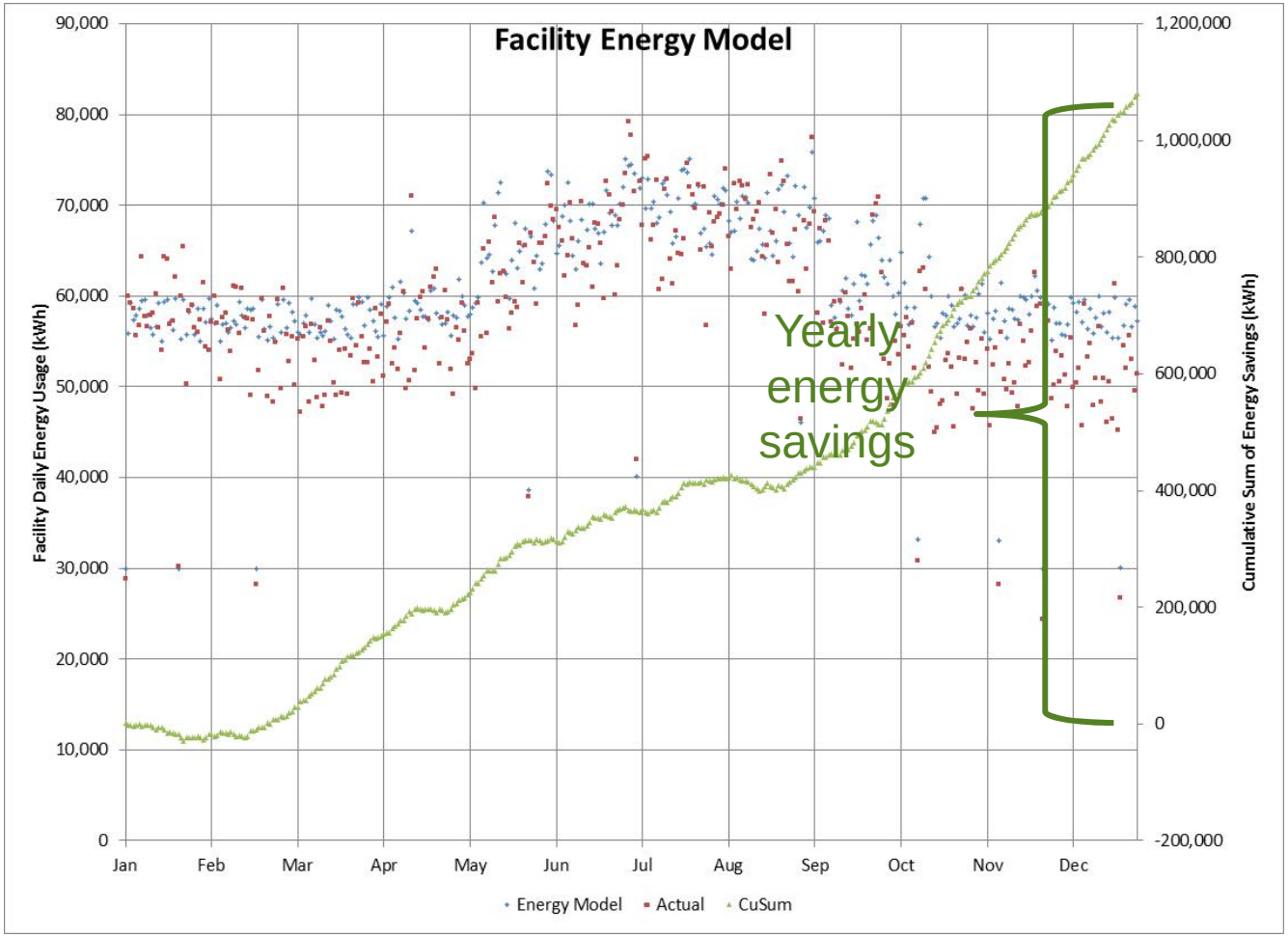
Energy Models: Industrial and Commercial

- What does it tell us?
  - What is the magnitude of energy savings?
    - Does it match our expectations?



Energy Models: Industrial and Commercial



Energy Models: Industrial and Commercial

Third-party tools are available

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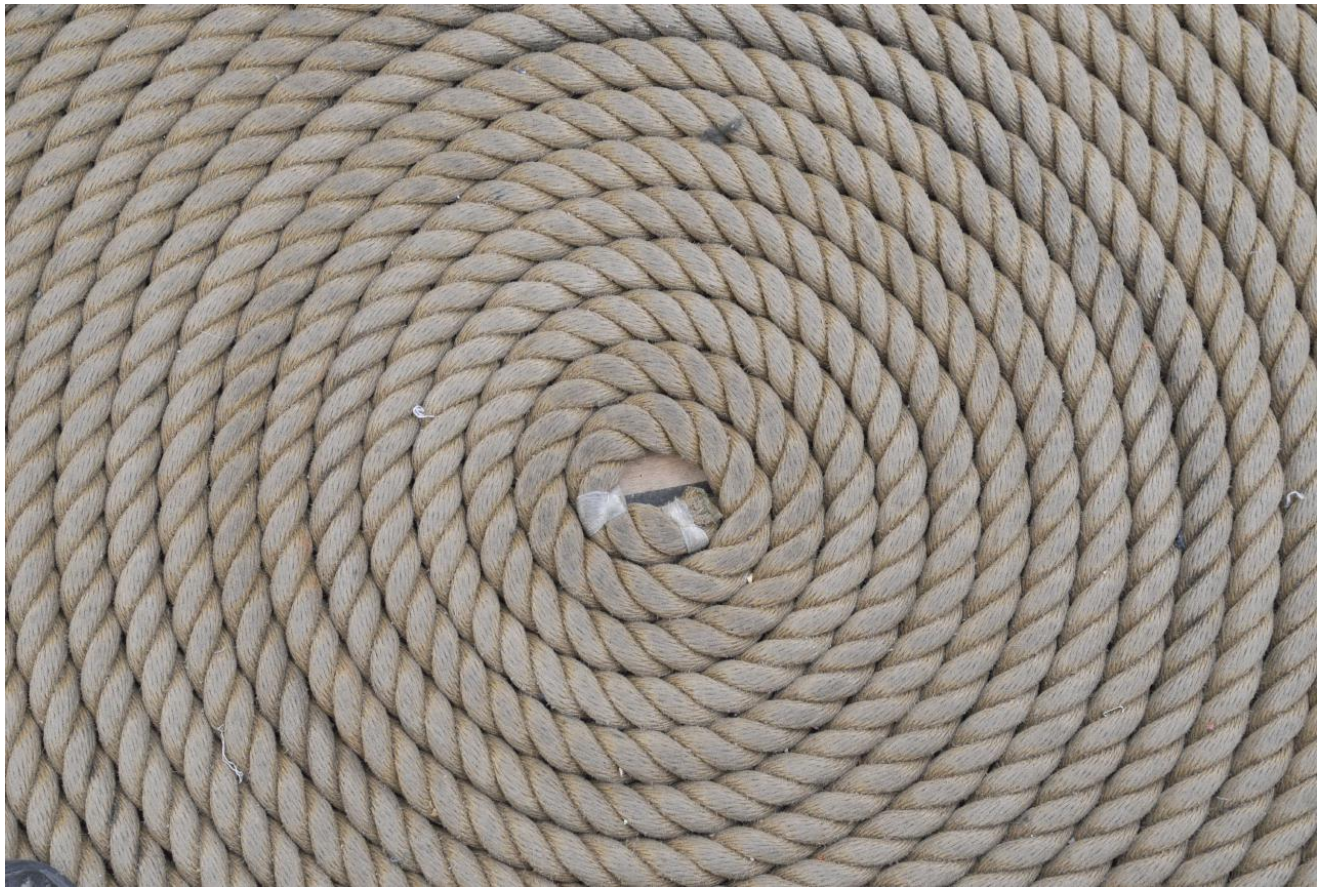
Energy Models: Industrial and Commercial

What's next?

- Hourly models
  - Moving towards real-time data display
- Energy dashboards
  - Whole facility
  - Individual production line

Real-Time Efficiency-O-Meter

Thank you for staying until the bitter end!



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