



AMI and HEMS: The Odd Couple?

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AMI and HEMS: Past, Present and Future

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December 13, 2017

Presentation Outline

- **Past:** Retrospective on what we expected from AMI and HEMS.
- **Present:** Evaluate the current state of AMI as it relates to HEMS
- **Future:** Explore the drivers that could make AMI and HEMS be mutually beneficial

AMI Rollout and ARRA

- Rewind several years (~2009-2010):
 - Utilities were rolling out AMI in large numbers due to \$3B+ in ARRA funding

The collage consists of three overlapping web pages. The leftmost page is from **gtm.gov** (Green Technology Magazine), featuring a sidebar with categories like SOLAR, GRID EDGE, ENERGY STORAGE, WIND, and MORE. The middle page is from the **DOE's \$3.4B Smart Grid Grant Program: The Winners**, dated April 17, 2012, celebrating the installation of 600,000 smart meters. The rightmost page is an **ABC NEWS** article titled **Boulder, Colo.: America's First 'Smart Grid City'**, dated May 10, 2008, which includes a video player showing a smart meter and quotes from Ray Gogel of Xcel Energy.

gtm.gov
A Green Technology Magazine

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DOE's \$3.4B Smart Grid Grant Program: The Winners
ENERGY.GOV
Office of ELECTRICITY DELIVERY & ENERGY RELIABILITY
ARRA Program Celebrates Milestone 600,000 Smart Meter Installations
APRIL 17, 2012

Home » ARRA Program Celebrates Milestone 600,000 Smart Meter Installations

On April 11, 2012, DOE Recovery Act funding recipient Sacramento Municipal Utility District (SMUD) celebrated a major milestone in the development of a regional smart grid: the installation of over 600,000 smart meters. For the event, Congresswoman T. Gohmert (R-TX) visited SMUD's customer service center and praised the program "that will be more efficient, more reliable, and better for consumers. Installations are nearly complete, with only a few thousand remaining. In a SMUD's grid modernization efforts will include automated distribution system communication network, and electric vehicle charging stations."

POPULAR SCIENCE
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abc NEWS VIDEO LIVE SHOWS

Boulder, Colo.: America's First 'Smart Grid City'
By LISA FLETCHER and ANDREA SEALMONT May 10, 2008

The people of Boulder, Colo., have a reputation for appreciating their environment. Biking and hiking trails, parks and open spaces make up a large portion of the picturesque western city.

But Boulder's love of the environment is taking on an innovative, technological edge perhaps more at home in science fiction than in average living rooms as the city transforms itself into America's first Smart Grid City.

Watch the story Saturday on the Discovery Channel's *Focus Earth*.

Soon, 50,000 homes in Boulder will soon be decked out with the latest in environmentally-friendly, energy-saving technology – including solar panels, electric cars and, for some, a specialized heating, cooling and lighting system – all of which will be integrated into a monitoring system that reports the home's carbon footprint to the homeowner.

"We like to think of Smart Grid as bringing the world of Thomas Edison together with the world of Bill Gates," said Ray Gogel of Xcel Energy, a utility company involved in the system's installation. Xcel, along with several green high-tech companies, has invested \$100 million to transform Boulder into a living laboratory.

"We're doing something that the whole world is looking at right now," Gogel said.

THE NEXT GRID
Rick Kauterakis and

The American electric grid is the most complex and

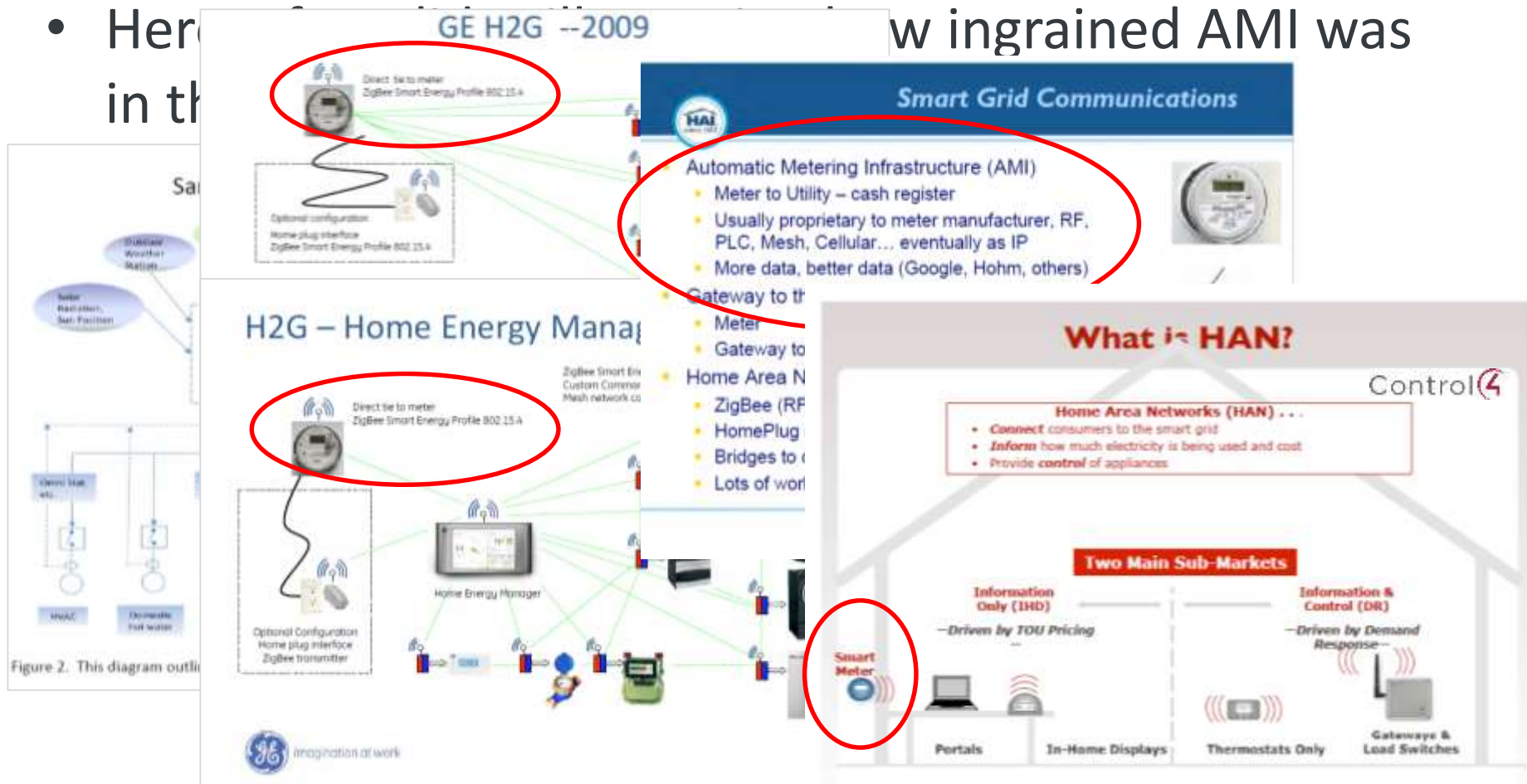
AMI Rollout via Recovery Act

- **Rewind several years (~2009-2010):**
 - Utilities were rolling out AMI in large numbers due to \$3B+ in ARRA funding
 - AMI was going to enable a whole new world of HEMS, with the meter at the center
 - Zigbee radio installed in AMI meter to communicate with HAN
 - A big selling point was that consumers would have access to their energy data and cost information via in home devices connected to AMI meter



AMI: A Central Component to HEMS

- In late 2009, NREL hosted an expert meeting on HEMS (or AHEM).
- Here, we show how ingrained AMI was in the HEMS concept.



NREL Laboratory focused on HEMS

In 2012, NREL built a lab focused on evaluating functionality, interoperability, control strategies for HEMS.

- We needed AMI meters to make it all work!! (Right??)
- It was **VERY** difficult to buy a small number of meters for research.
- Eventually, we found a good contact at Itron and we bought 5 AMI meters, including software to send signals through the meters
- ... And we've never used them.

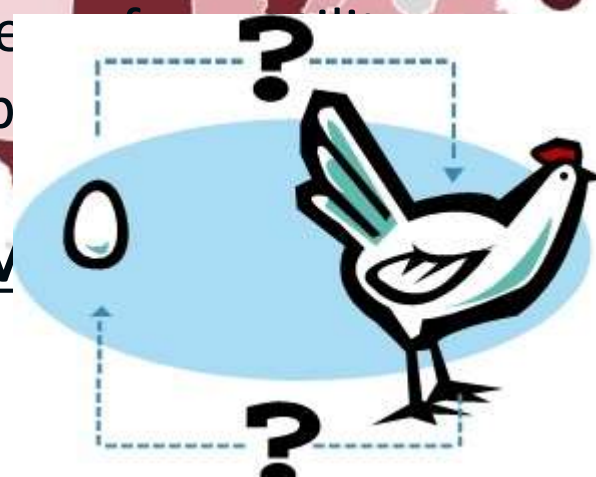
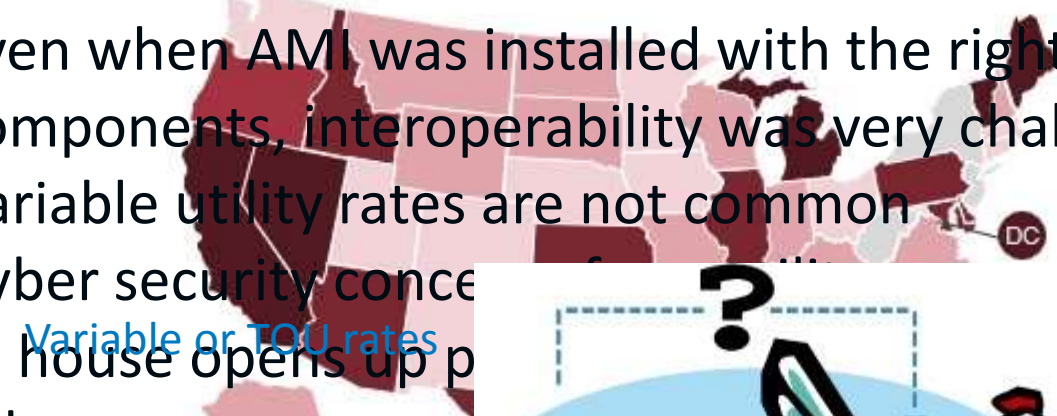


So what happened?

HEMS development has progressed without AMI. **Why?**

- AMI rollout was slower and less complete than anticipated
 - Bad publicity probably contributed to current AMI coverage levels
- Many utilities did not install the radio needed to send data inside the house
- Even when AMI was installed with the right communication components, interoperability was very challenging.
- Variable utility rates are not common
- Cyber security concerns to house opens up possibilities
- **But** Variable or TOU rates ing up \$ to talk Appliances could be accessed by yet)

Residential smart meter adoption rates by state, 2016



Percent of residential HEMS with smart meters



Current HEMS infrastructure

- The main reason that HEMS does not rely on AMI now is that it does not need to.
 - HEMS are largely focused on convenience, not efficiency or grid services.



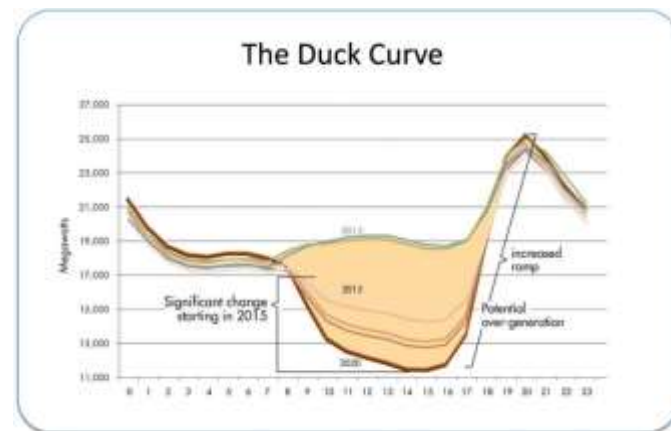
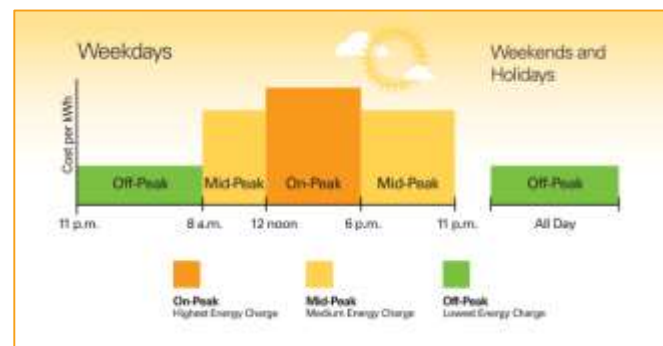
This design means that all functionality is lost if internet is down. Ideally, you want system that can function without internet (like smart thermostats) but has added features (like app control) when internet is active. Requiring cloud connections also opens cyber security vulnerabilities.

- Wi-Fi has become dominant communication protocol
 - Exception is for devices, like smart bulbs, that often come with a hub to connect to many devices – hub-to-device communication is generally Zigbee

What's next?

While HEMS have largely not needed AMI thus far, that will likely change.

- **TOU utility rates** will motivate the use of HEMS to lower shift load to cheaper times (original driver for HEMS+AMI)
- If **solar back-feeding** to grid is penalized, HEMS can coordinate consumption using real-time whole house power data.
- If utilities start paying residential customers to **provide grid services**, HEMS can control loads and communicate back to utility.



Future of AMI and HEMS

- None of these examples explicitly need a connection to the meter, but will require:
 - Real-time price information,
 - Real-time whole-house power/energy data,
 - Way to exchange signals for grid services.

Core AMI functionality?
- Utilities are swimming in AMI data – Can HEMS help make use of all that data? (M&V 2.0, identifying retrofits, energy efficiency)
- AMI is critical to the success of HEMS
 - While HEMS may enable some energy savings, bigger benefit comes from control over **when** energy is used
 - *Needed to enabling more renewable power on grid.*
 - Without AMI meters to track energy use and enable variable pricing, HEMS will be stuck where it is today: a bunch of gadgets that provide convenience.

Thank you!

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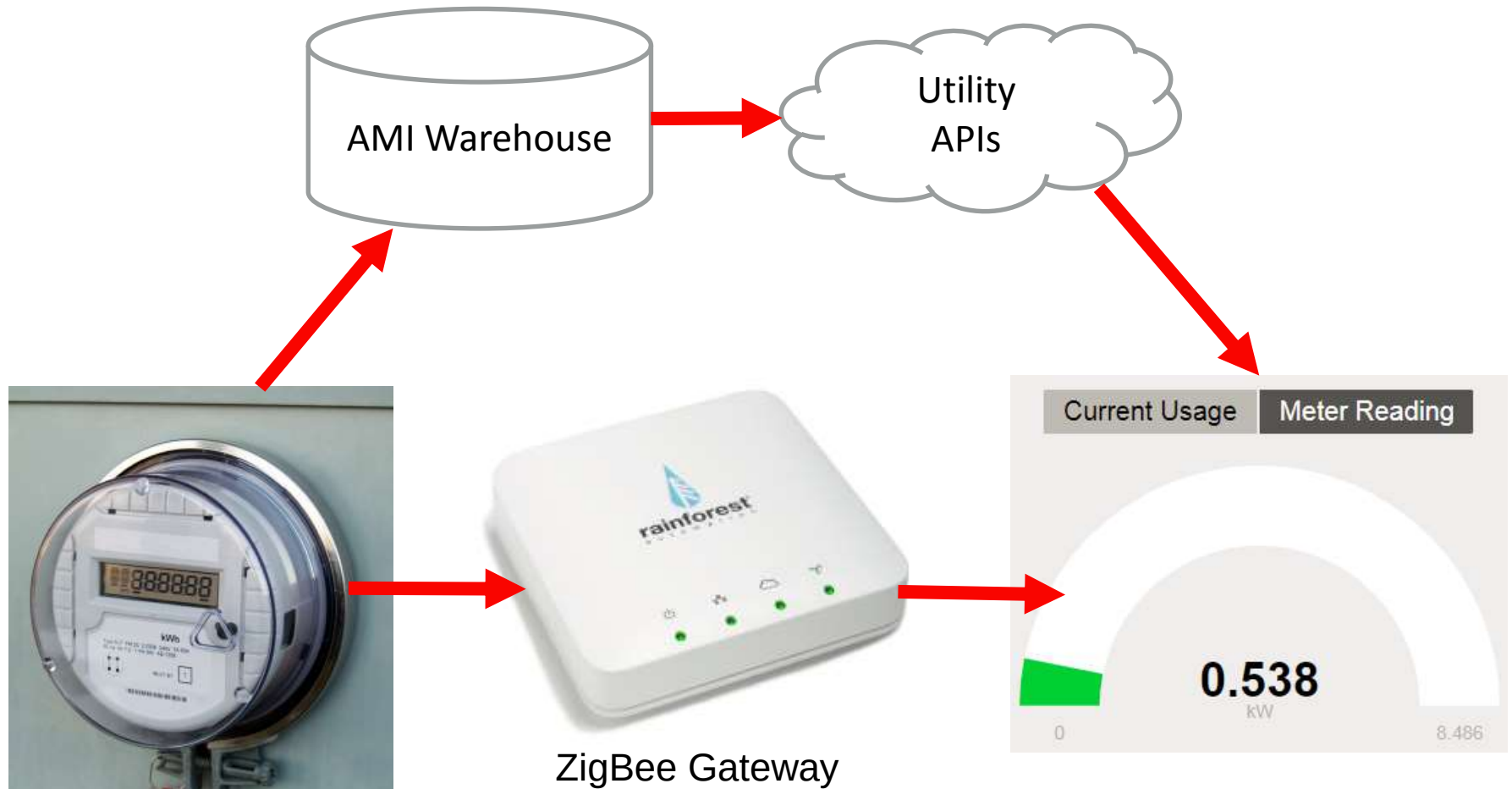
www.nrel.gov



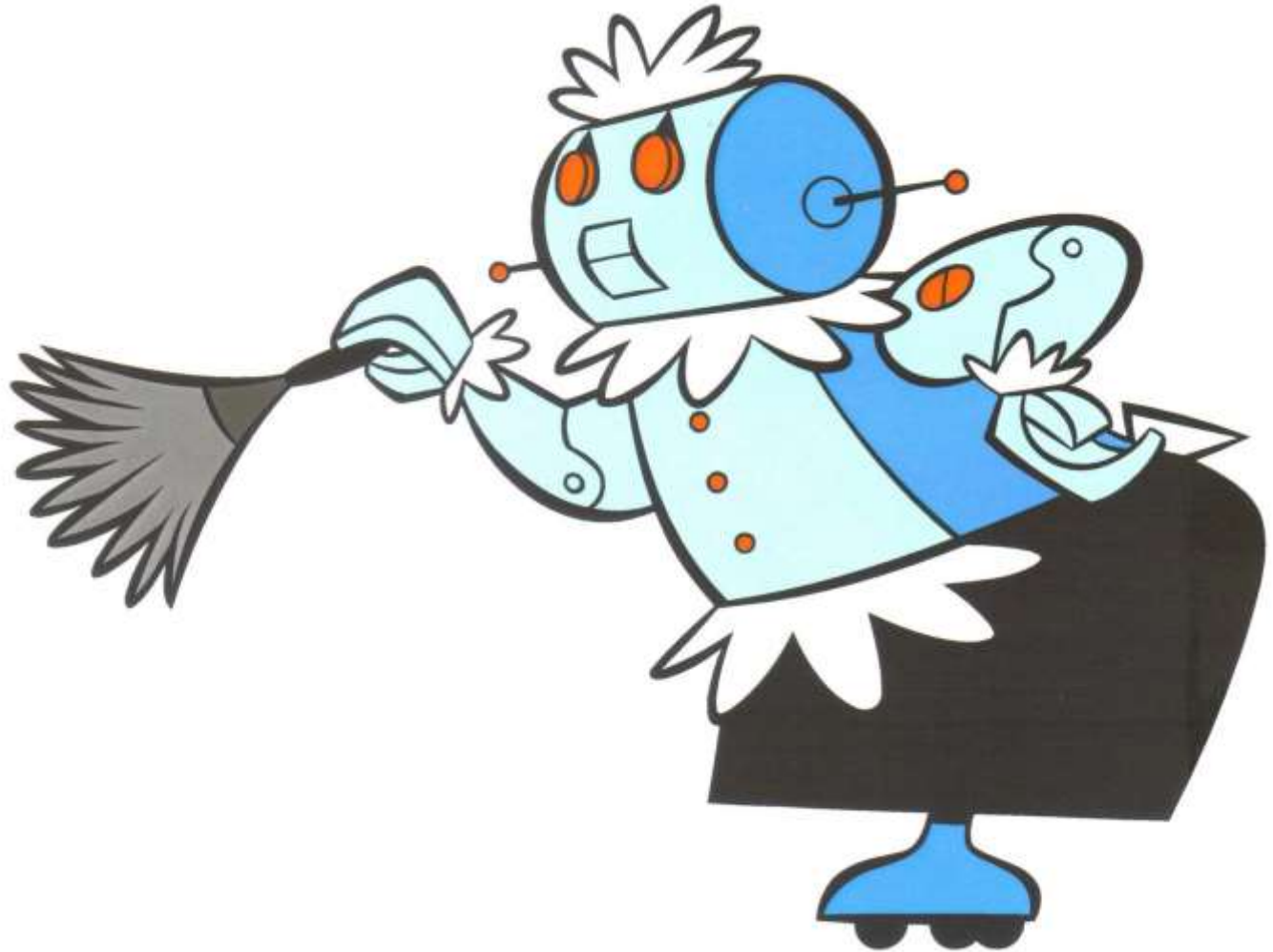
AMI and HEMS: Are We Asking the Right Questions?

Ethan Goldman
December 2017

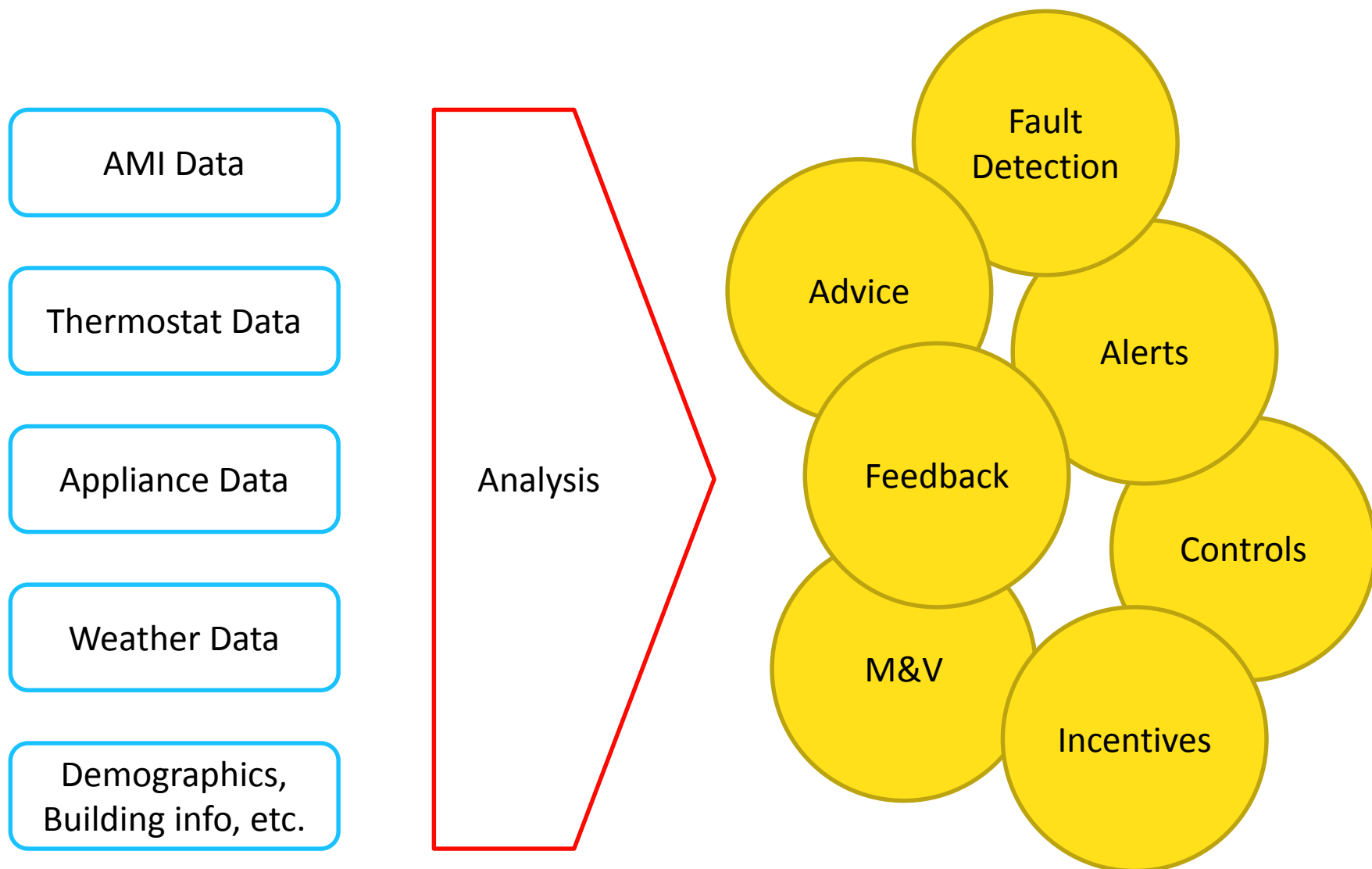
How Can We Get AMI to Talk to HEMS?



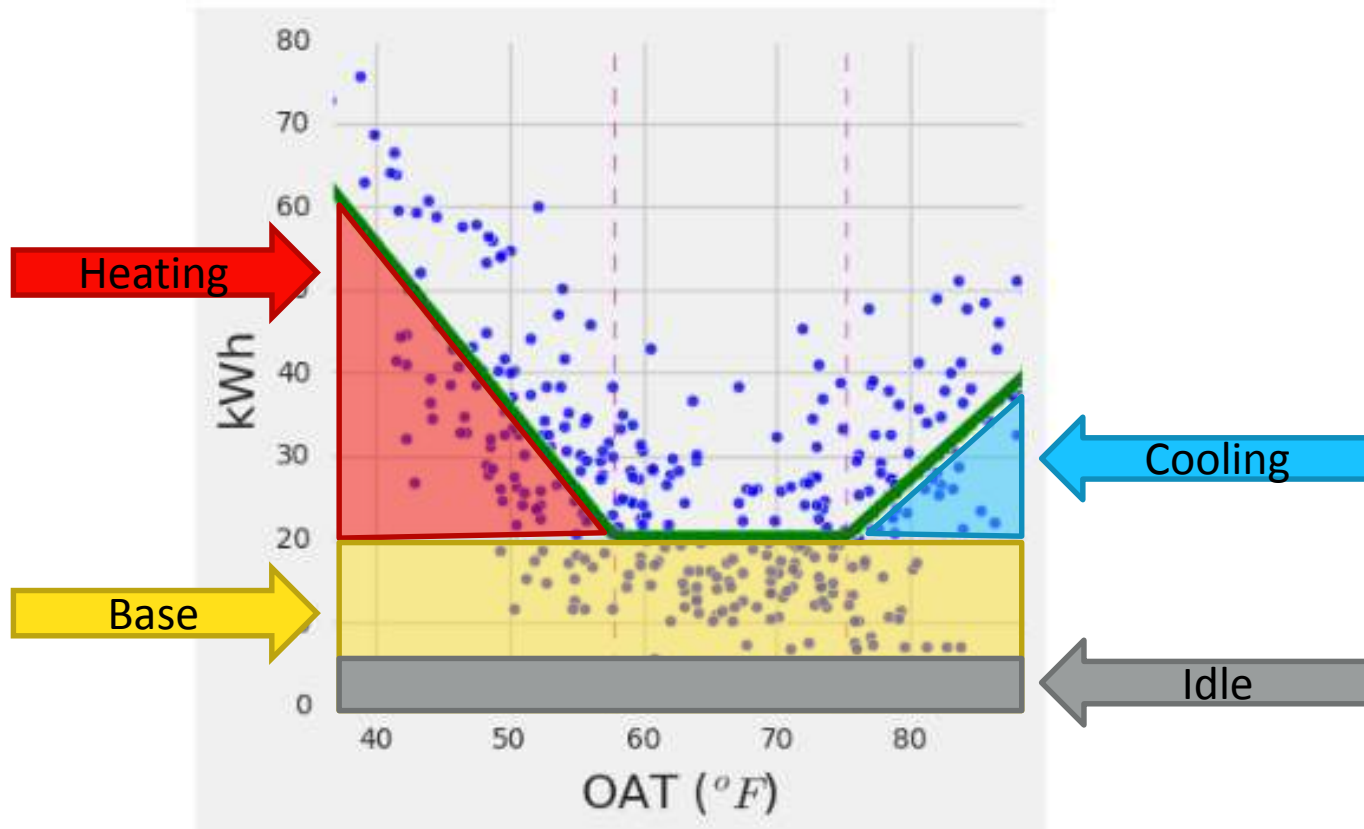
Will HEMS be Used for More Than Convenience?



What Are We Going to Do With the Data?



What Can AMI Interval Data Do for HEMS?



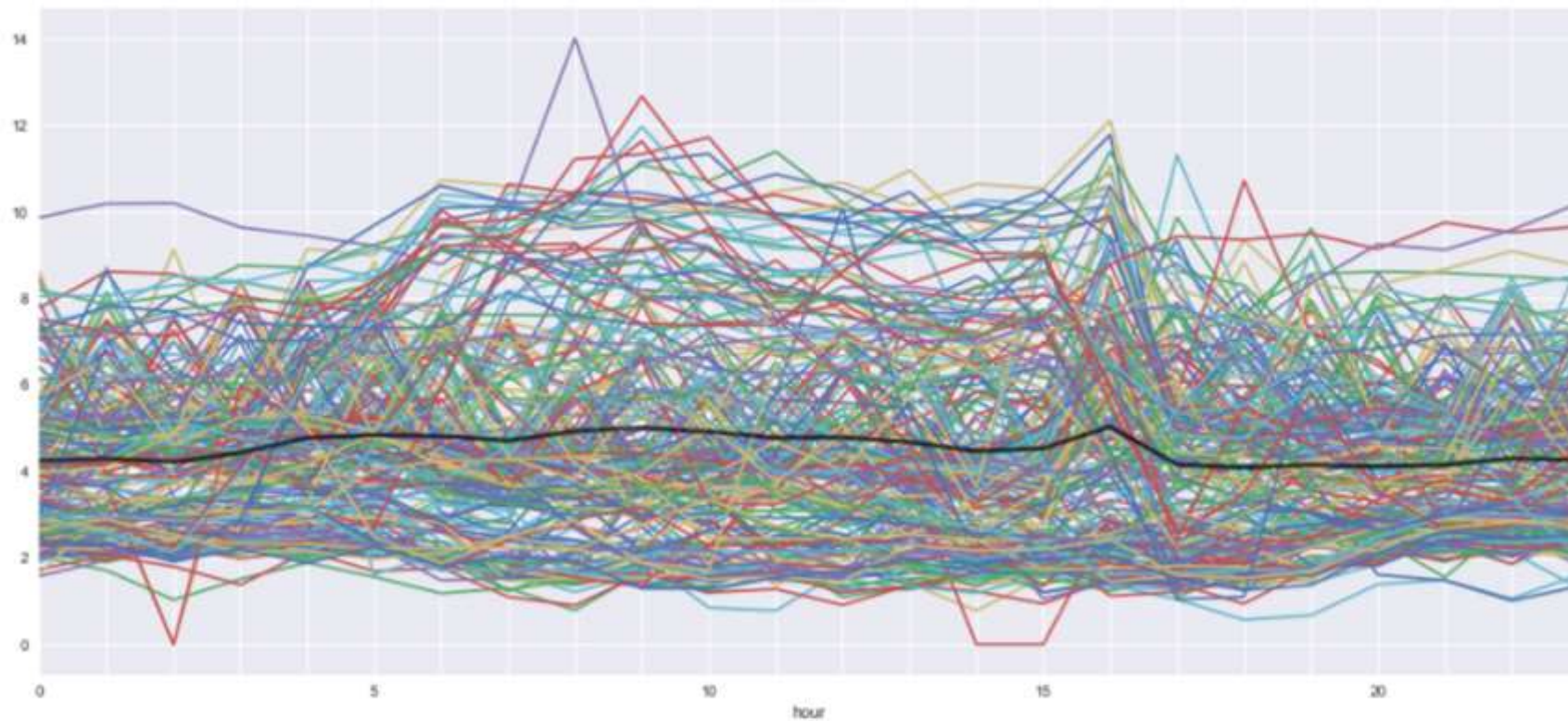
Data Tsunami!



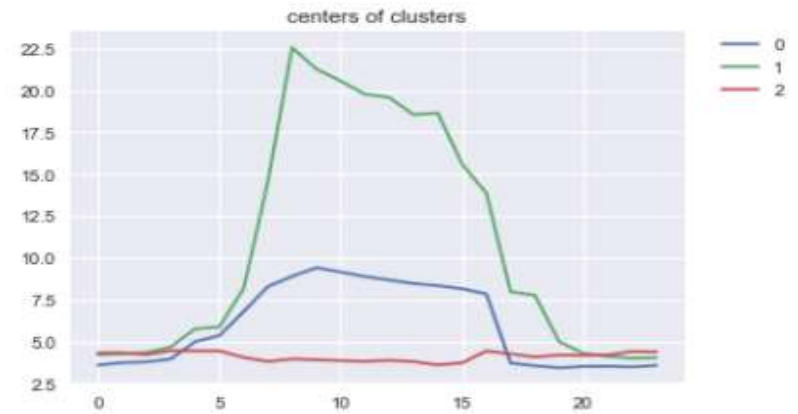
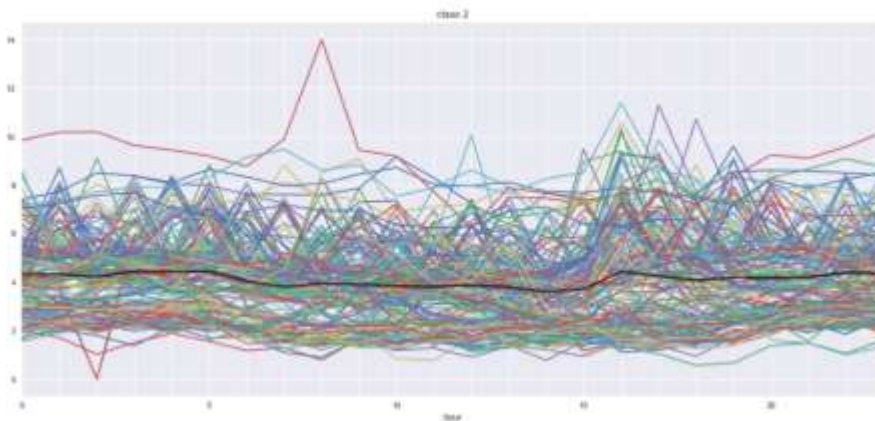
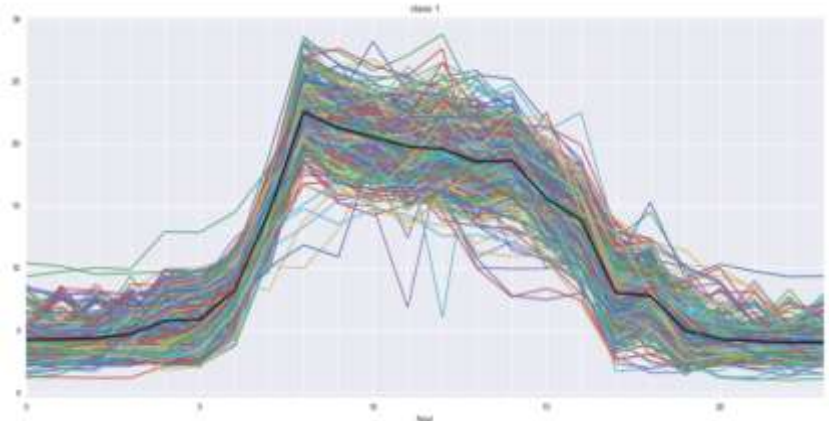
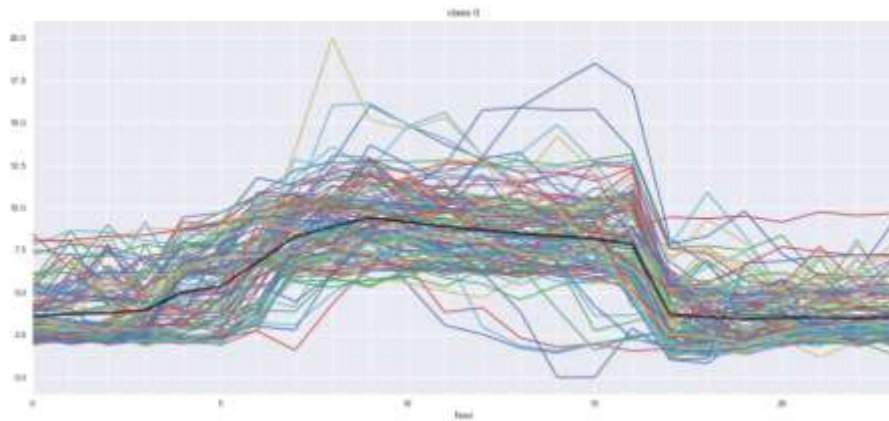
Finding Subtle Patterns



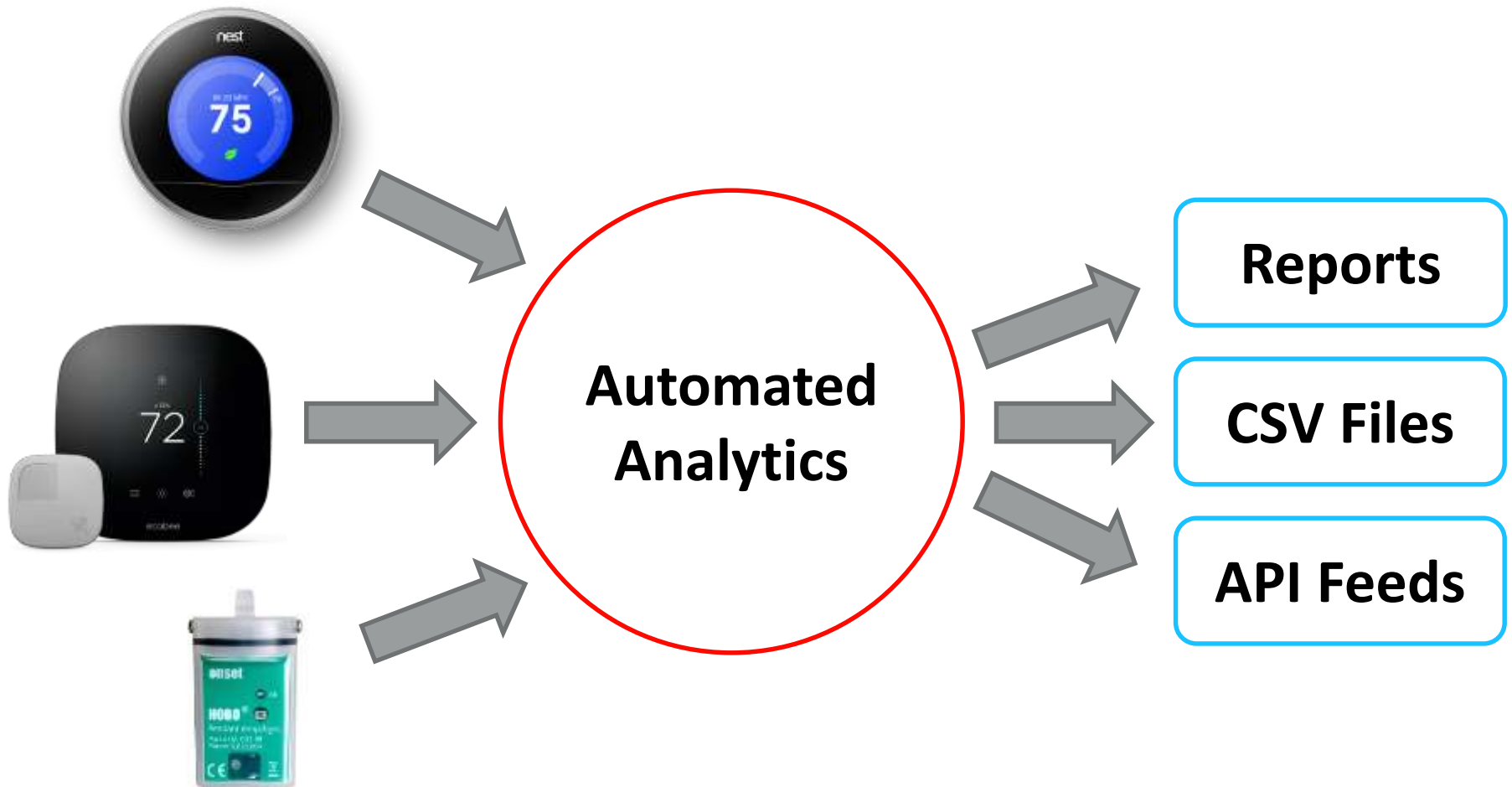
Raw Data is Messy



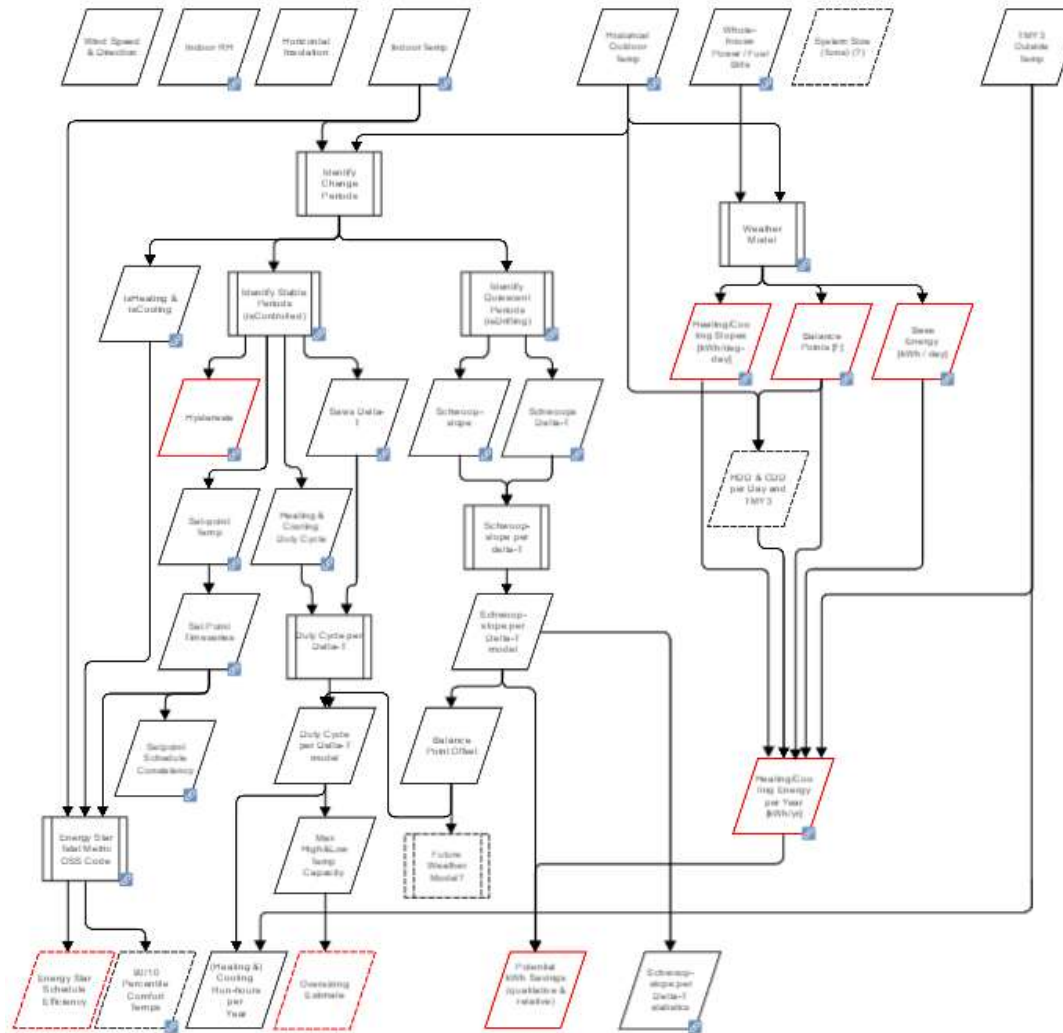
Solution: Cluster Days by Loadshape



STAT: Smart Thermostat Analytics Toolkit



Managing and Automating Iterative Analysis



Metrics Calculated by STAT

Thermal
flow rate

Estimated
savings

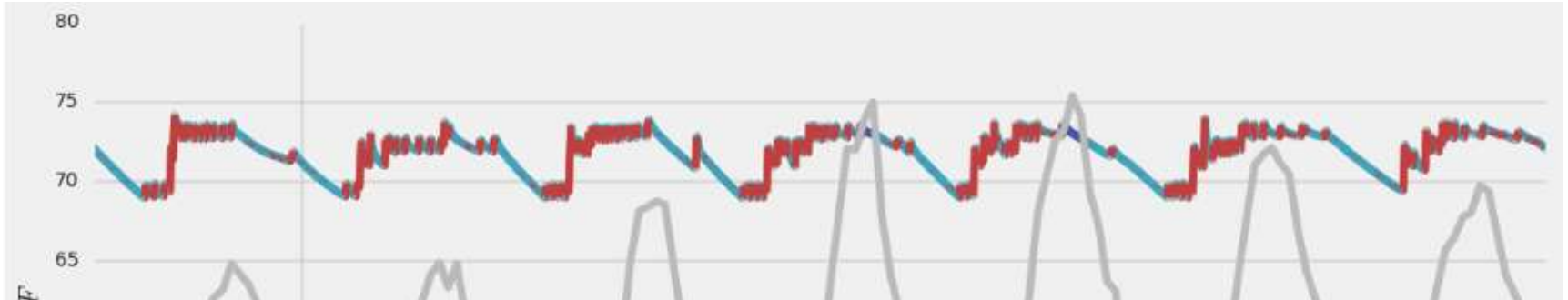
Oversizing

Runtime
reduction

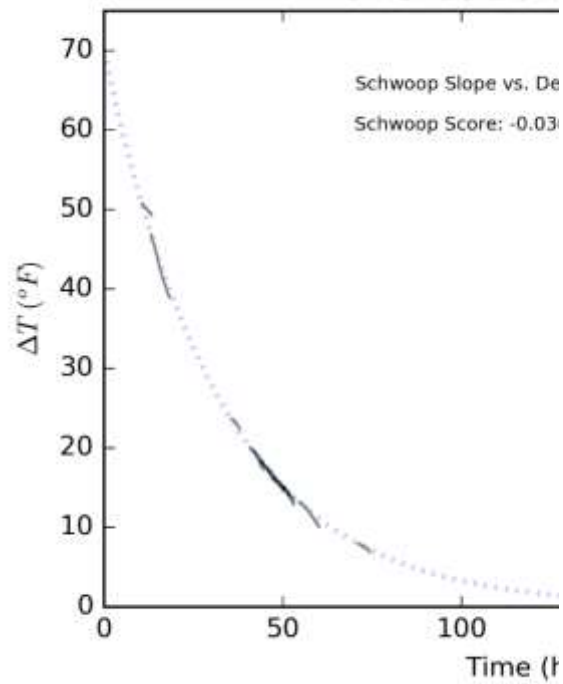
AMI
disaggregation

kW & kWh
savings

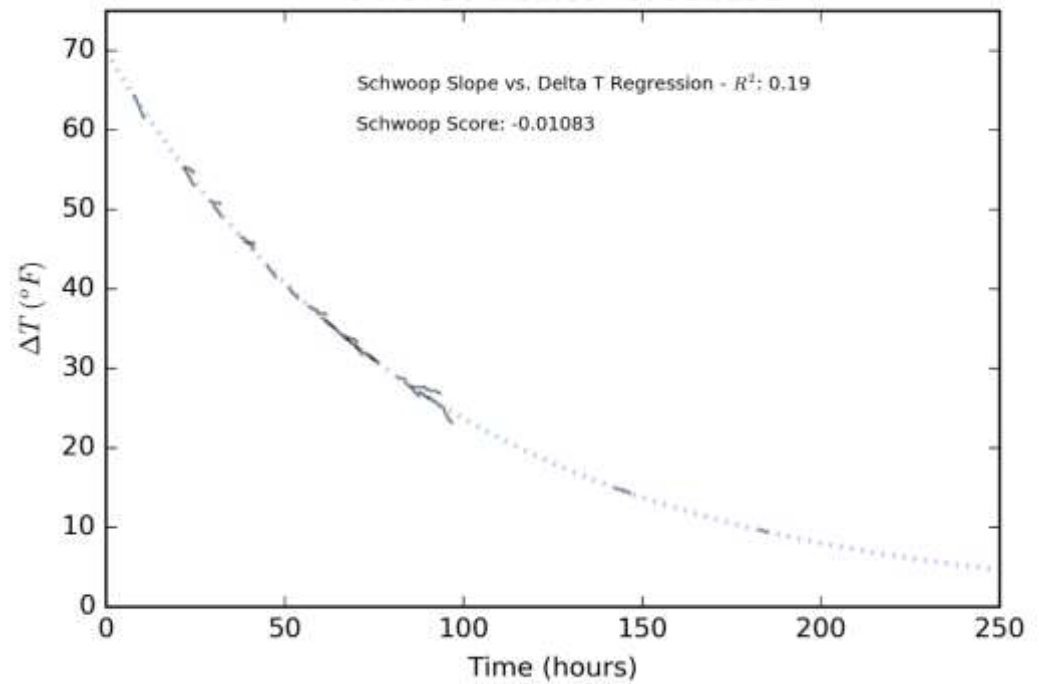
Shell Performance from Temperature Trends



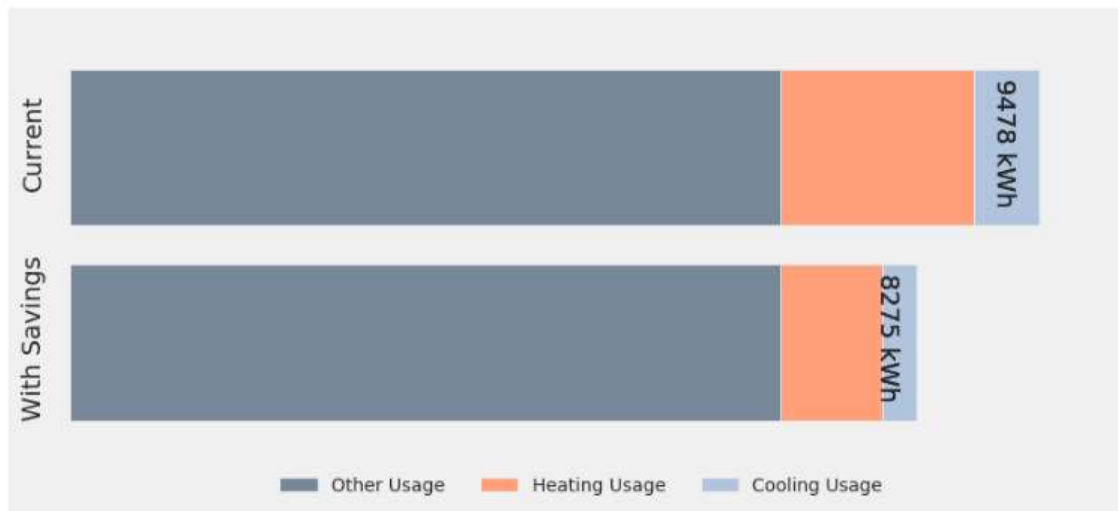
Home: 26 Devi



Home: 50 Device: 10612131



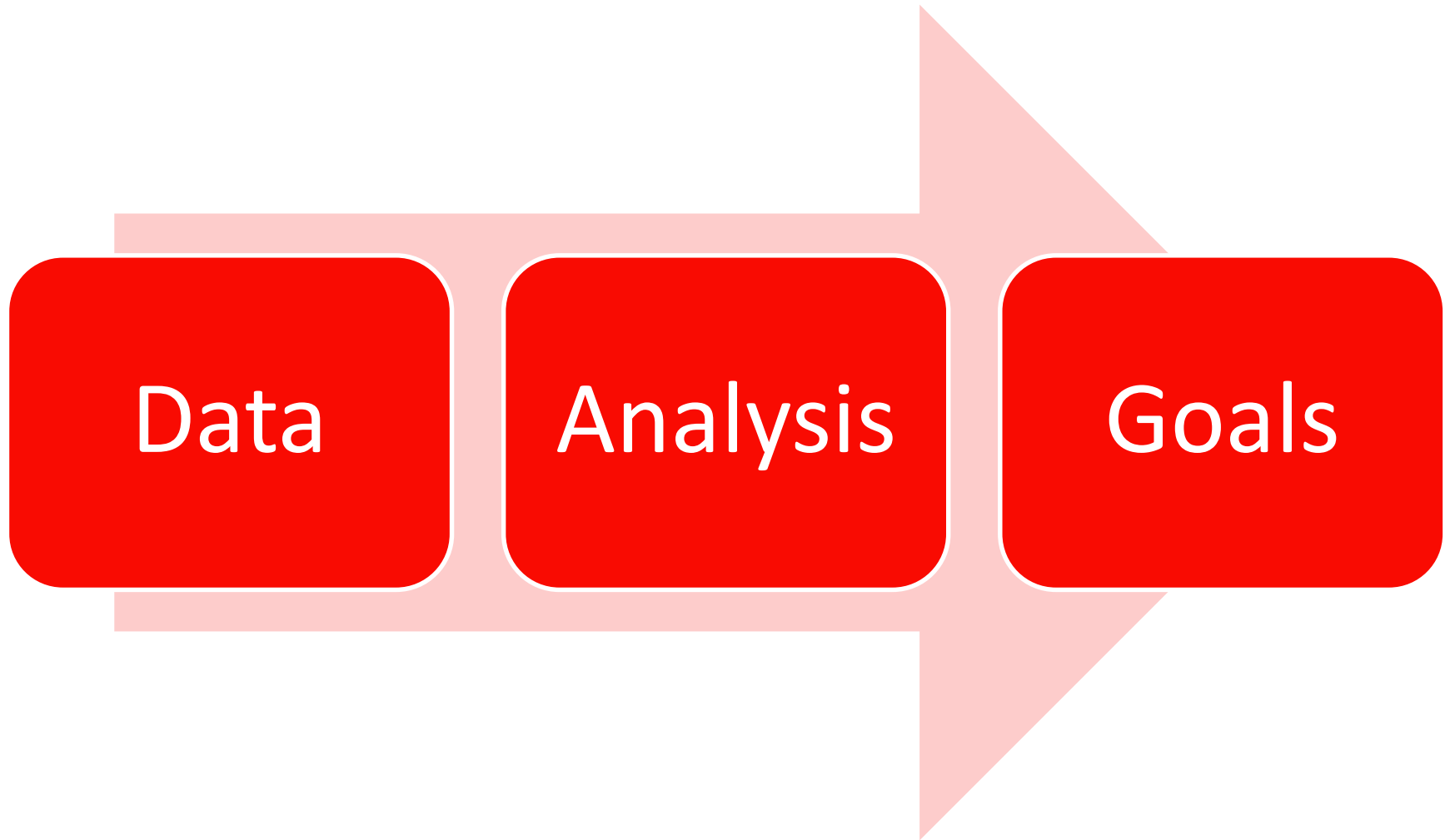
Annual Savings Potential from Tstat Analysis, Scaled to kWh and Dollars with AMI-Weather Models

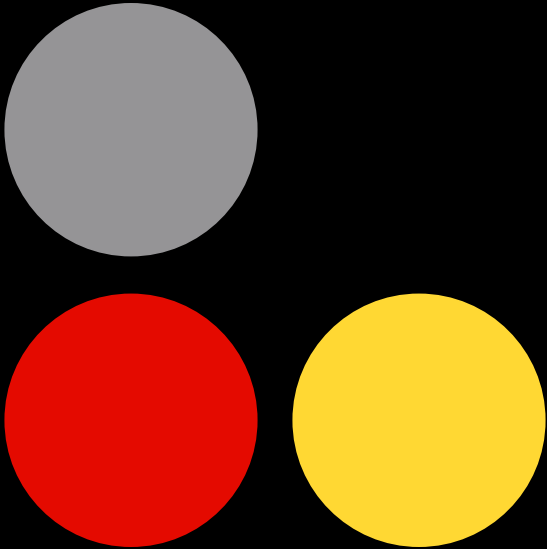


	Current Modeled Use		Estimated Savings	
	kWh	\$	kWh	\$
Heating	1,895	\$236	901	\$112
Cooling	637	\$79	302	\$37
Other	6,946	\$868	0	\$0
Total	9,478	\$1,183	1,203	\$149

Total Savings: 48%

Work Backwards





Thank you



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PRESENTATION FINISHED

...ANY QUESTIONS?