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Grid Interactive Water Heater Pilot Demonstration in Oahu, Hawaii

February 23, 2015

ACEEE Hot Water Forum

Introduction

- Year-long project commissioned to demonstrate Grid Interactive Water Heaters (GIWH) for providing grid services to HECO
- Project is 70% complete
- Unique challenges in Hawaii
- Battelle software system for managing GIWH has successfully demonstrated ability to serve HECO grid services
- Customer comfort and energy use is unaffected

Unique challenges in Hawaii

- Unparalleled amounts of variable renewable generation
- Independent island grids that are not interconnected
- No significant seasonal variation, consistent daily demand
- Larger generating unit sizes relative to system demand
- Significant load shedding is utilized during major disturbances

GIWH Hardware - Sequentric and Vaughn

Retrofit controller installed on retrofit 2-element electric water heater. Controller manufactured by Sequentric

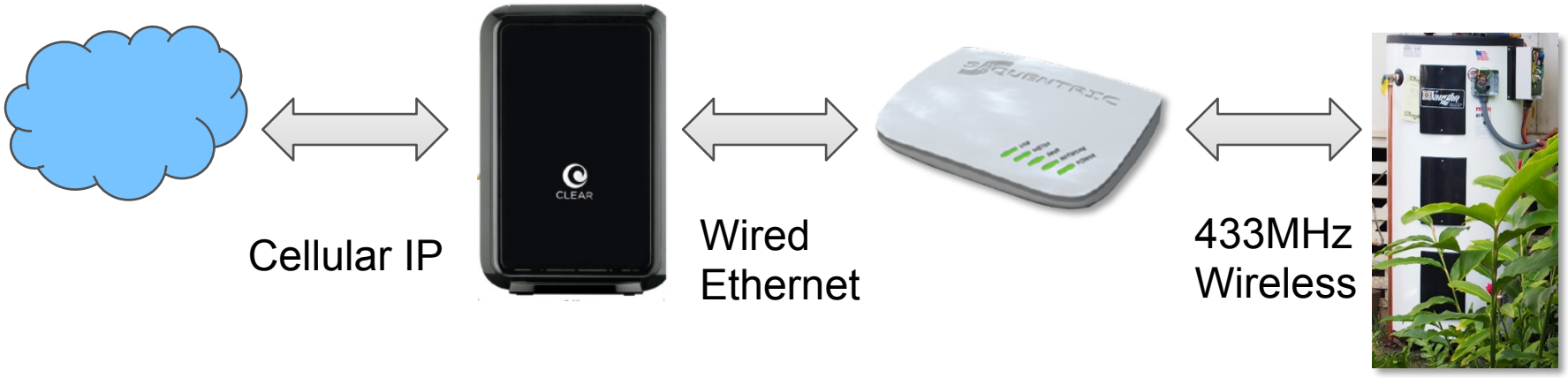
New 80 gallon 3-element electric water heater made by Vaughn under a Sequentric license patenting the technology. Tank is stone lined for long life as a grid asset.

3-element Load Controller by Sequentric.

Load Controller communicates to Gateway via a 433 MHZ wireless signal.

Gateway connects to Sequentric Management Server paired with Battelle Dispatch Engine via Internet connection. In Hawaii, a cellular router; service provided by Clearwire or end-user's landline Internet is used

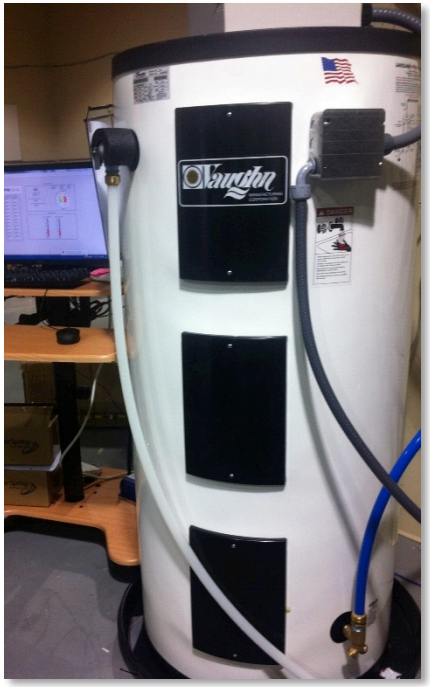
Communication



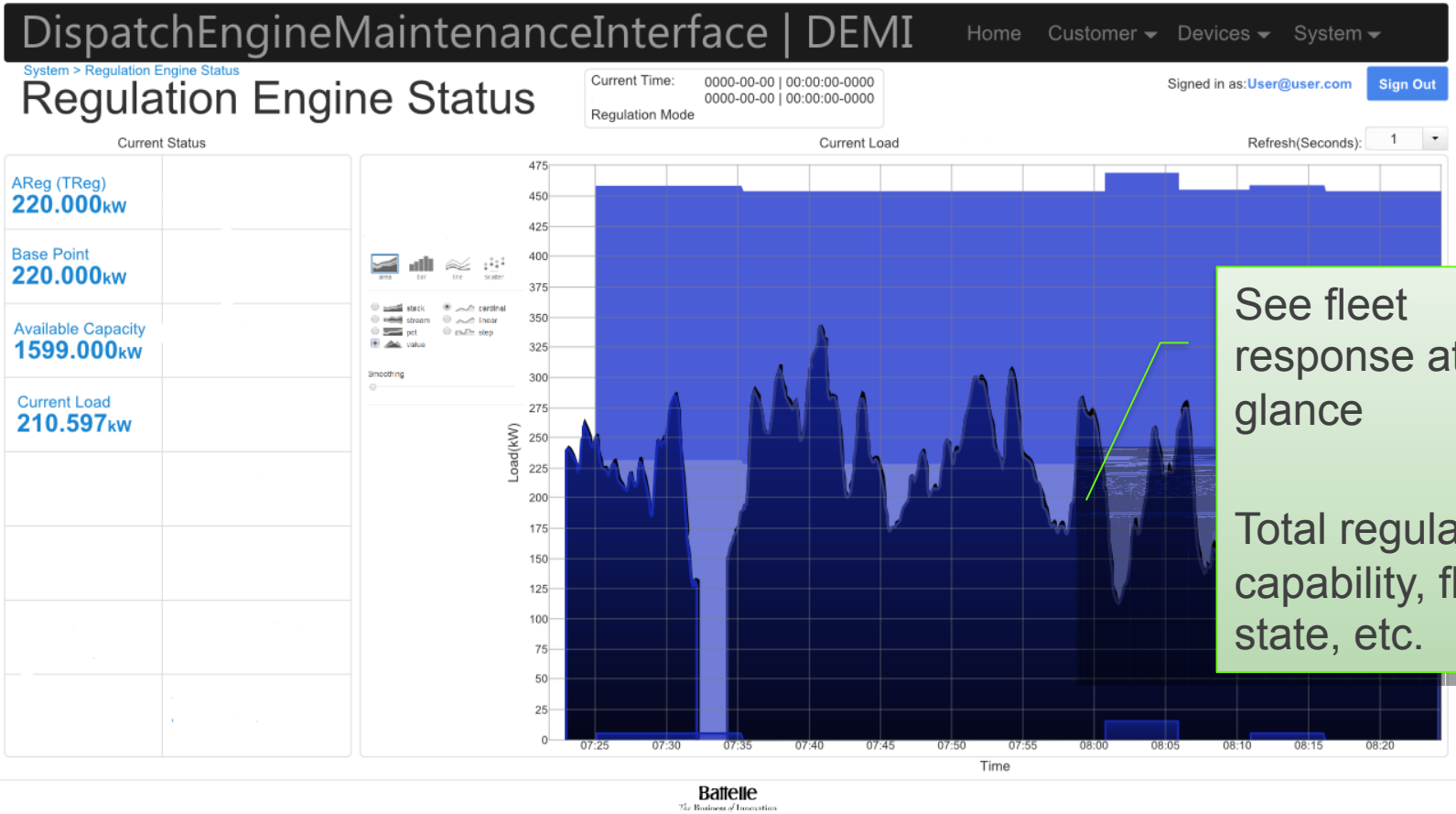
- Cloud for server infrastructure
- Clear cellular service for backhaul to house
- Ethernet to Sequentric Gateway
- Proprietary 433 MHz wireless between gateway and WH

One unit under test in EPRI facility

- Leveraging Hawaiian Electric and EPRI partnership in GIWH efforts since 2011
- Goal: preview and test the technology prior to deployment in Hawaii
- Water heaters installed at EPRI Lab in TN to gain installation and operation experience



Software enables fast accurate fleet management



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Recruiting Hard-to-Reach Customers

- Project effectively reached and selected many underserved customers and renters
- The lowest cost recruiting methods were the most effective

About one FTE for a two month duration

25,000 individuals reached from Honolulu households

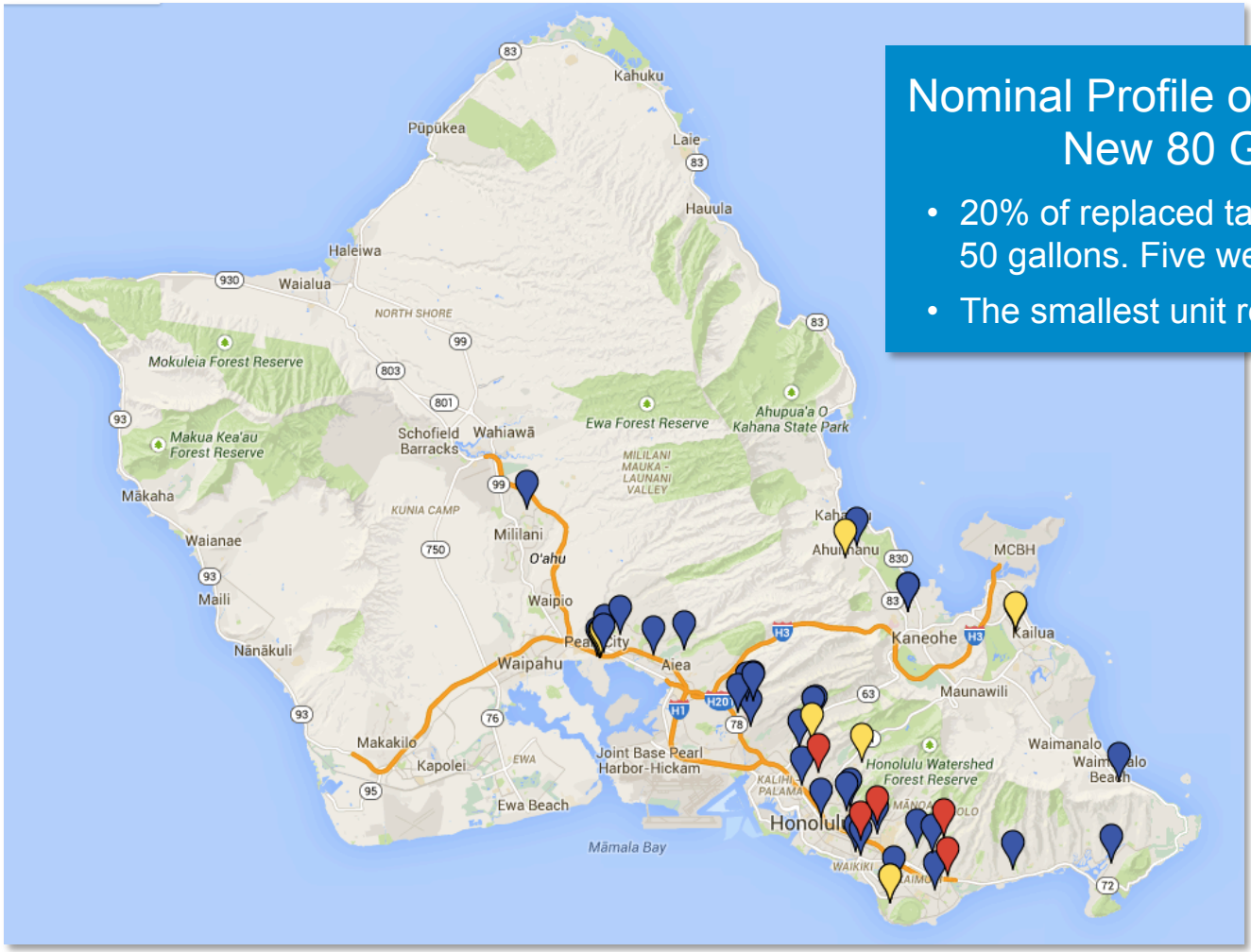
Participants asked to apply only if they met these requirements

- No Gas/On Demand at home
- No PV/Solar Thermal at home
- No Hot Water Timers
- Not an Energy Scout participant
- Not HECO employee/retiree
- Not moving for 1 year
- 3+ residents in premises
- Located near HECO initial Smart Grid
- Sufficient installation space
- Willing to participate without cash incentives

Effective Methods	Ineffective Methods
Social media, email, website, google ads	Direct mail and door-to-door in initial smart grid areas
48 participants recruited	1 participant recruited

Pool of about 350 potential installation sites:
49 participants selected
(one multifamily apt)

Installation Locations on Oahu, HI



Nominal Profile of Units Replaced by New 80 Gallon Tanks

- 20% of replaced tanks were large, over 50 gallons. Five were 80 gallon.
- The smallest unit replaced was 30 gallons.

Locations of Installed New Tanks and Retrofit Kits

- Retrofit, Residential
- New, Residential
- New, Small Business

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Hawaii Specific Considerations

Tanks are often installed outdoors and partially covered. Tanks are required to be raised on blocks

The 80 gallon footprint of this model was larger than some locations could handle

Weight of the stone lined tank makes installation more challenging

Hawaii Specific Advantages

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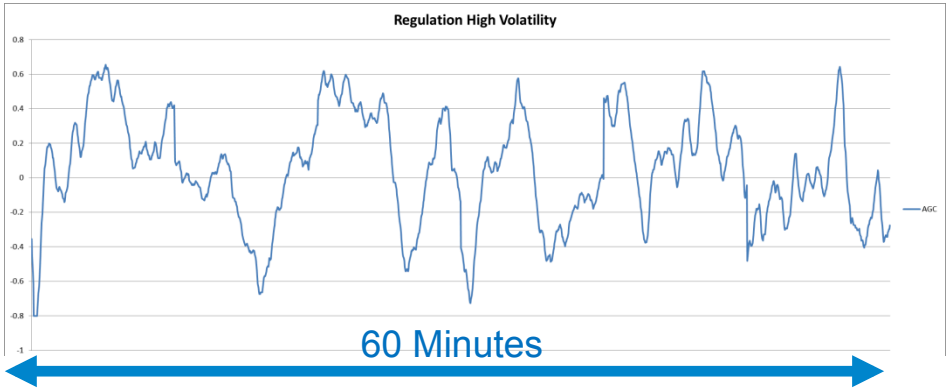
- Large pool of trained installers from Solar industry
- Low cost recruiting methods like social media and email were effective
- Messages that explain “exchange of value” in regards to helping the grid are better than “free water heater”

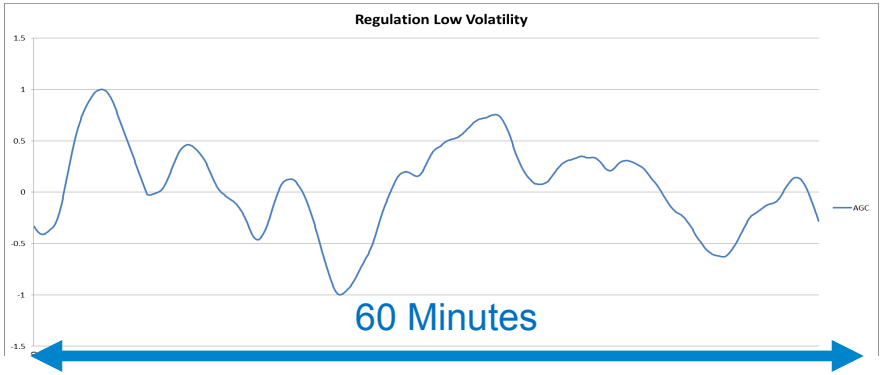
Grid Services Evaluated: Frequency Regulation and Wind Firming

- Multiple sources of test control signals are used
  - PJM fast regulation signals
  - Maui system frequency and wind data
- Gathered stakeholders at HECO, EPRI, and Battelle to develop comprehensive design of experiments

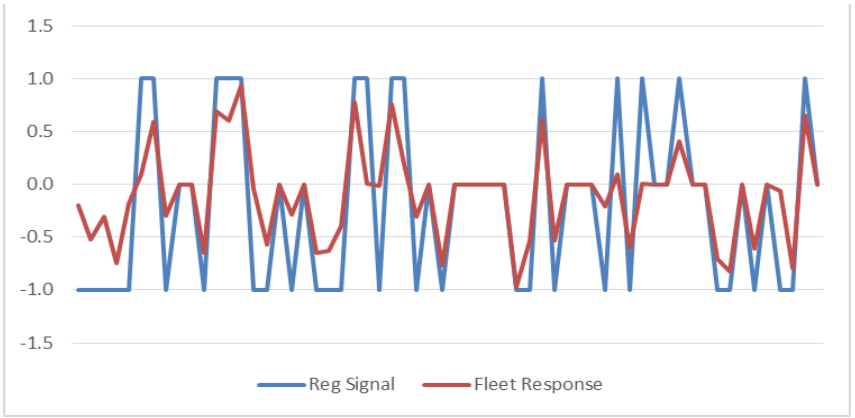
High Volatility



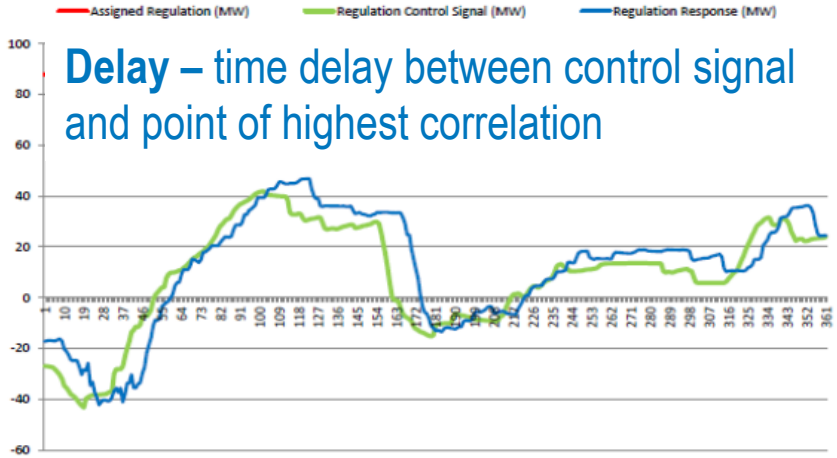
Low Volatility



Performance of Fleet Reported Based on PJM Scoring Methodology*

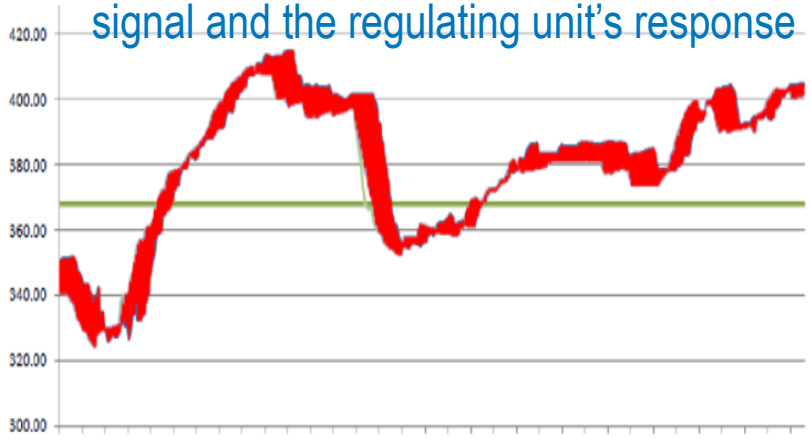


Accuracy – correlation between control signal and regulating unit's response



Delay – time delay between control signal and point of highest correlation

Precision – difference between the control signal and the regulating unit's response



*Ref: http://www.pjm.com/~/media/committees-groups/task-forces/rpstf/postings/pbr-training-phase-2.ashx

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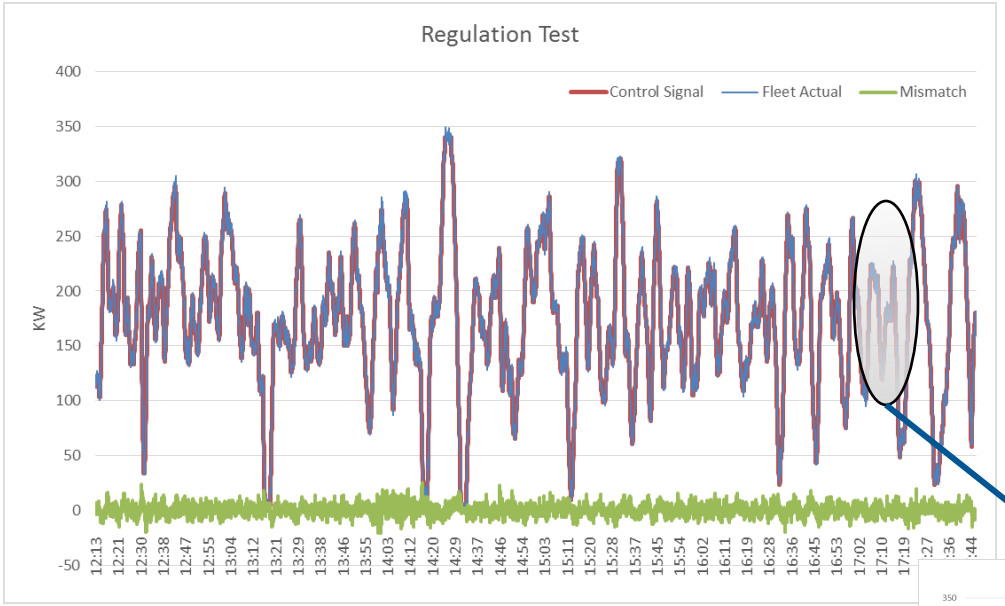
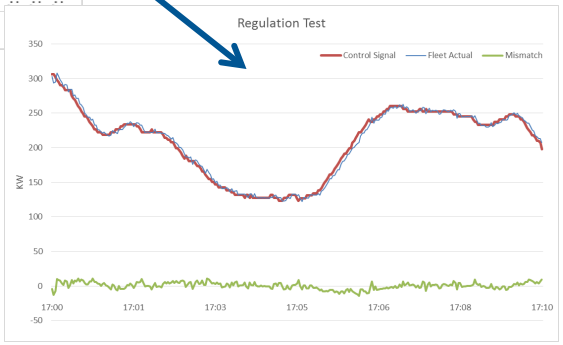
Regulation Test Results: Sustained, Precise Regulation Provided



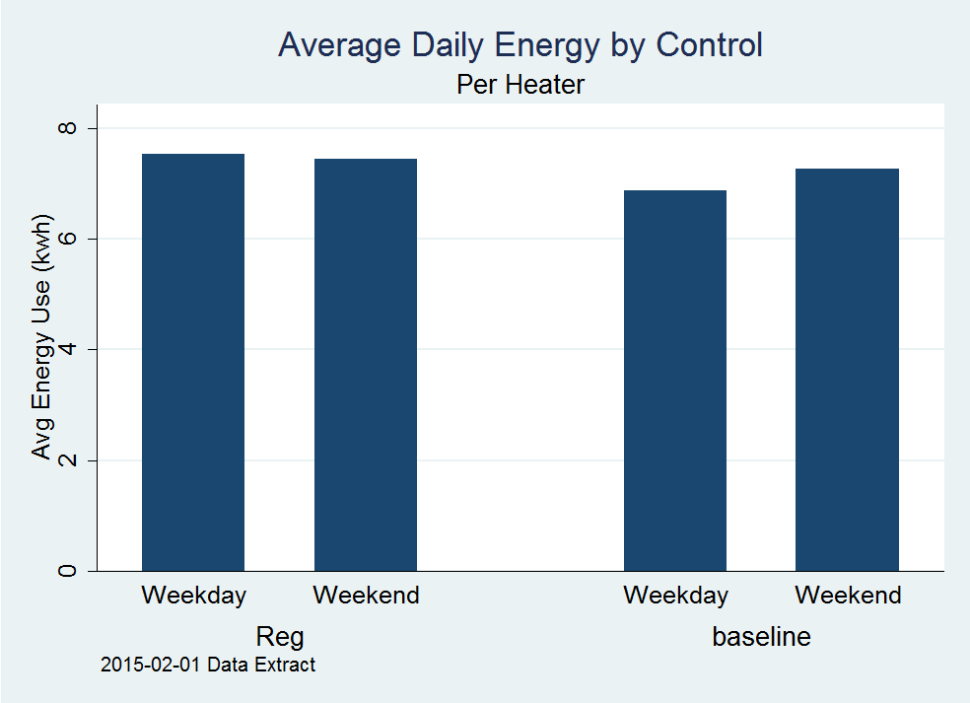


Focus to 10 minute interval

Interim Results. 6 hour view
Blue Line – *Actual Fleet Output (kW)*
Red Line *– Regulation Control Signal*
Green Line – *Mismatch between control and actual*

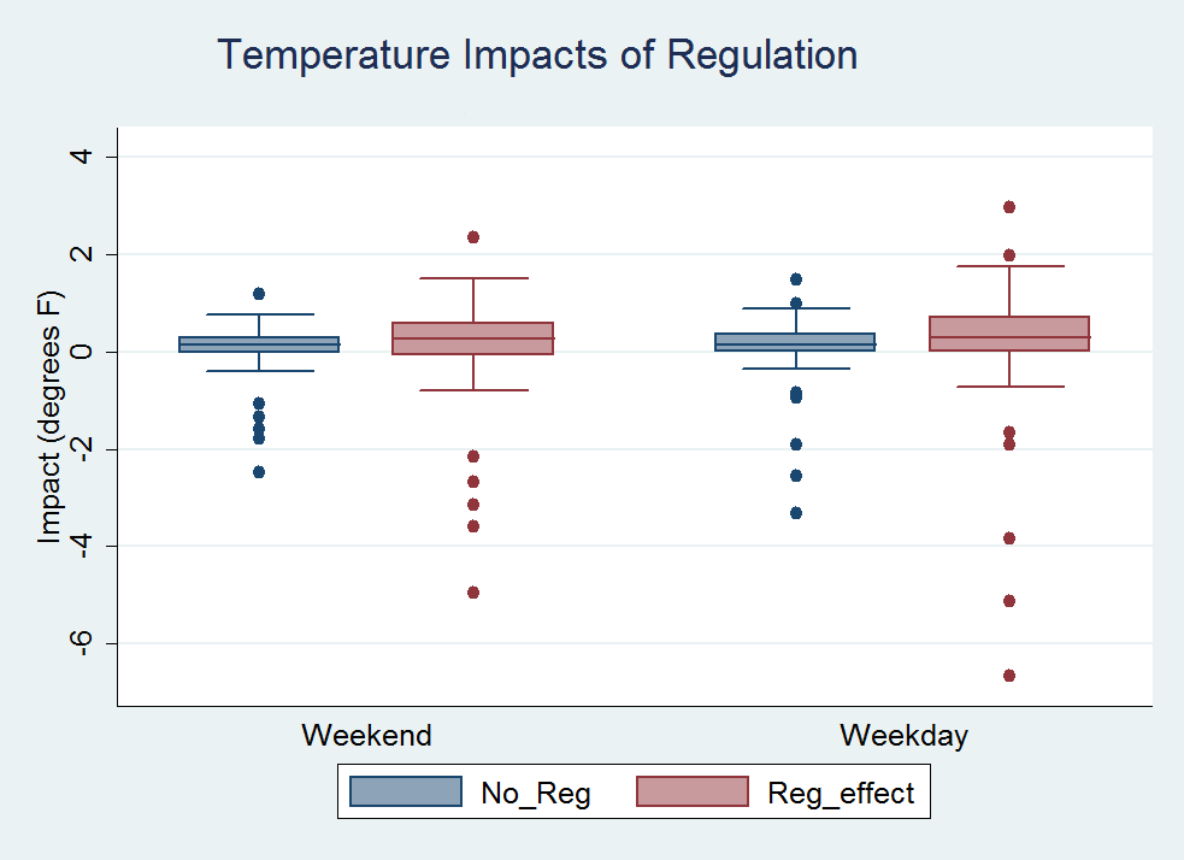
Minimal Impact on Energy Use of Water Heaters

- Of 50 water heaters analyzed:
- No statistically significant changes in daily kWh observed between baseline and regulation mode to date.



Baseline operates 55 gallon effective capacity
Regulation operates 80 gallon effective capacity

Minimal impact on customer comfort



Results from 7 months of operation

- Battelle's software system integrated with Sequentric controllers effectively follow the AGC signal to perform and qualify as a fast acting resource
- No software downtime experienced during testing
- Fleet able to maintain consistent availability,
- Delivered water temperatures (top element) not observably impacted due to regulation control
- System successfully meets HECO grid services requirements for ancillary services

Next Steps

- Additional testing with installed water heater at EPRI site
- Continued testing of the fleet against the design of experiments through April
- Development of additional Hawaii specific control signals
- Final report to be published in July 2015

Thank You

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