ACEEE Summer Study
PANEL 5—Utilities: Unlocking High Energy Savings
August 22, 2014

Faster, Cheaper, Better – Can Utilities Keep Up? New EM&V and Program Approaches for Smart Connected Devices

Jack M. Callahan, P.E., Senior Engineer, Bonneville Power Administration

Jamie Anthony, David Evans & Associates, Contractor for BPA

Tyler Dillavou, Contractor for BPA

Levin Nock, Aerotek, Contractor for BPA

Janice Peterson, ACS, Contractor for BPA

BPA and the Federal Columbia River Power System

- BPA markets electric power to 140+ customers, mostly public utilities
- Wholesale – no direct access to retail customer utility metering
- BPA acquires cost-effective energy conservation
  - ~$100 million annual incentives
  - "Reliable Energy Savings"
  - Meet 85% of load growth with energy efficiency
  - Limited DR program

Smart Connected Devices

- Internet connected
- Vendor collected and stored data
- Software-based performance
- Rapid product evolution

Digital Lighting Controls

Photo courtesy of Digital Lumens

Advanced RTU Controller

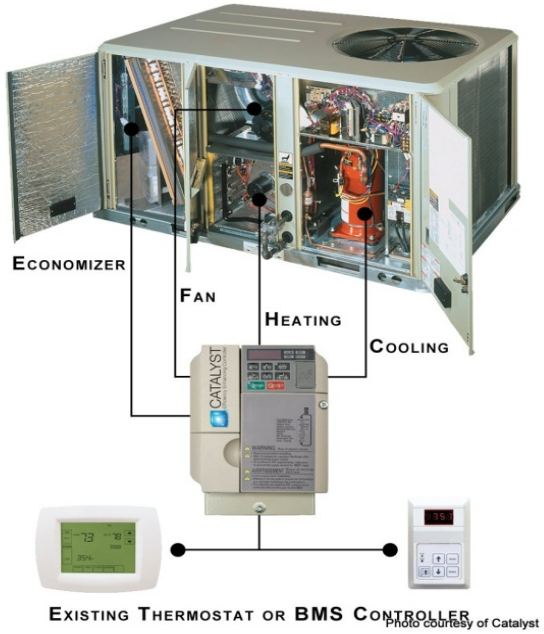


Photo courtesy of Catalyst

Smart Thermostats

Photo Courtesy of Energy Hub

Smart Connected Devices

Challenges

- Disrupts traditional program and EM&V approaches:
  - deemed-savings approaches
  - product qualifying specifications
  - field studies

Opportunities

1. Powerful feedback to manufacturers
2. Enables better data-driven M&V ?
   - Lower Cost
   - Higher resolution
   - Faster results

Our Approach

Photo courtesy of Digital Lumens

1. Select leading smart connected devices:
   a) *Digital Lighting Controls*
   b) *Smart Thermostats*
   c) *Advanced RTU Controller*

Photo Courtesy of Energy Hub

2. Get data from vendors.
3. Explore the data.
4. Develop and apply methods
5. Evaluate our methods and results
6. Consider next steps.

Photo courtesy of Catalyst

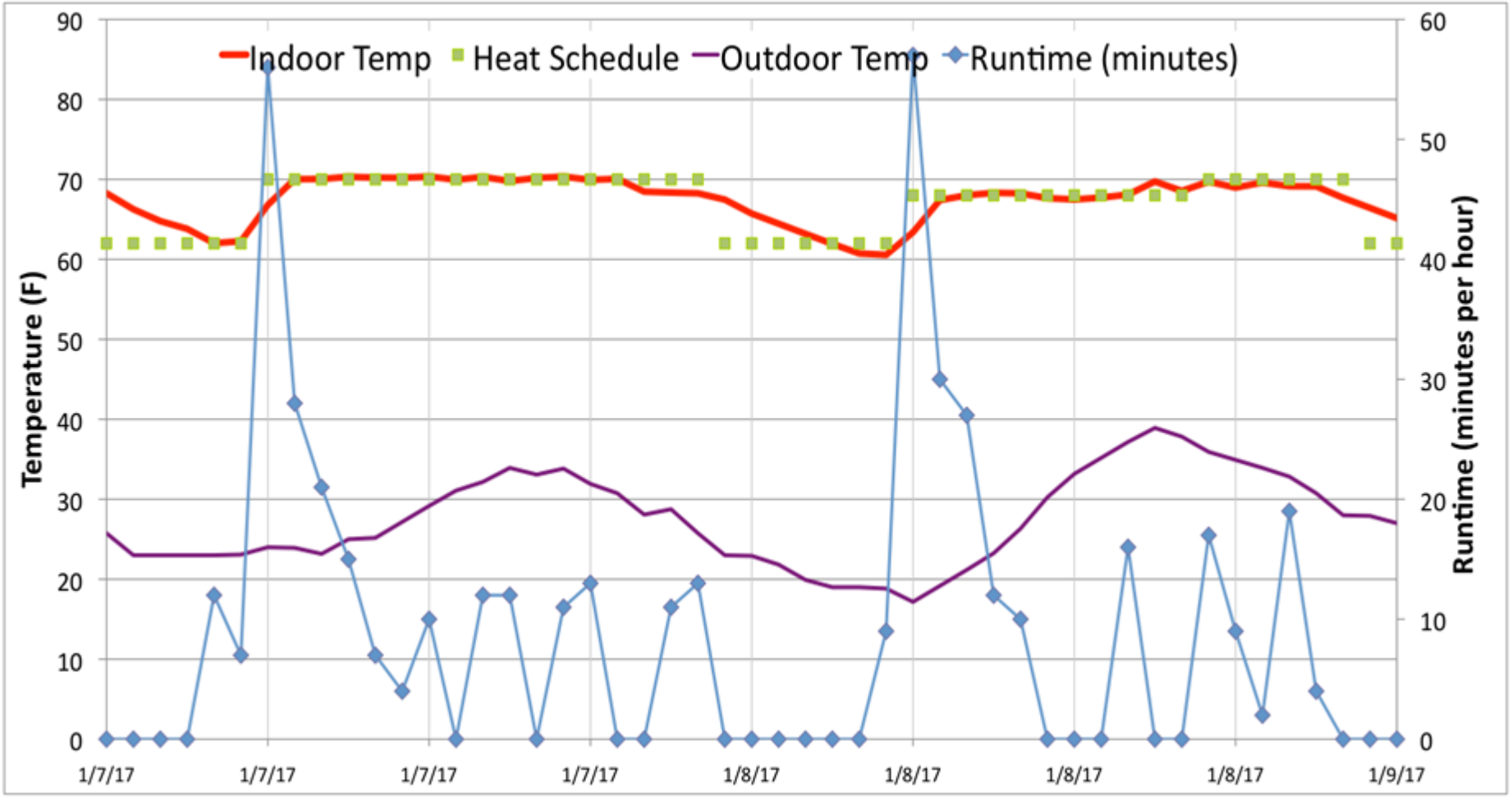
Smart Thermostats

- **Equipment**: Smart Thermostat
- **M&V Approach**:
  - Self-reported data to build regression model
  - Independent baseline indoor temperature data
- **Data**:
  - 10 homes, 7 days, January 2013, Nevada
  - Regional Indoor temperature survey data (RBSA 2012, 1,400 homes)
    - 69 degree F setpoint, 7 degree F setback
    - Assume 67 degree daily average

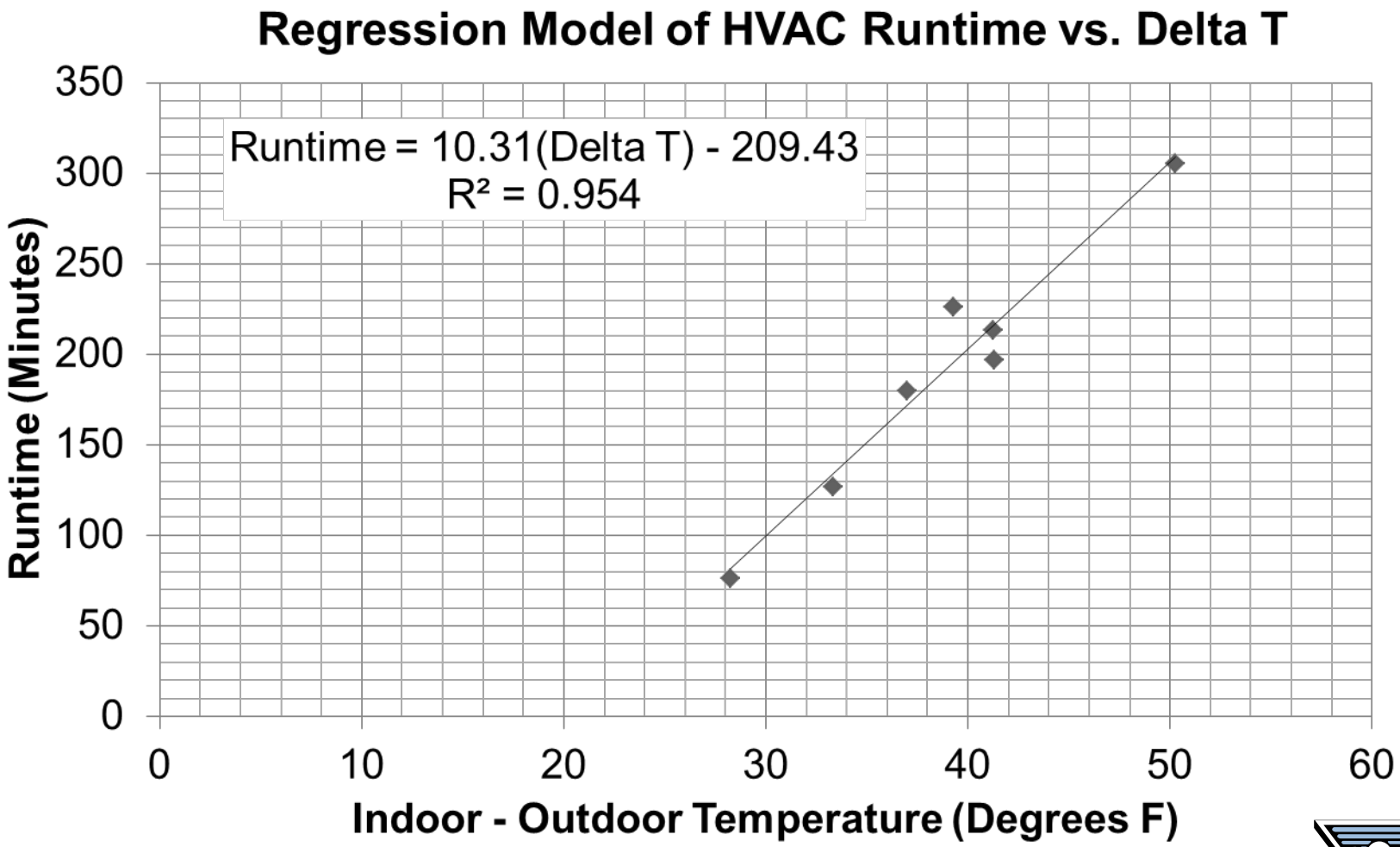
Step 1 - Data From Connected Smart Thermostat

Date & Time	Runtime (minutes)	Indoor Temp	Outdoor Temp	Tindoor - Toutdoor
1/6/13 12:00 AM	18	64.08	25.75	38.33
1/6/13 1:00 AM	16	64.05	23	41.05
1/6/13 2:00 AM	3	64.42	23	41.42
1/6/13 3:00 AM	11	64.17	23	41.17
1/6/13 4:00 AM	17	64.1	23	41.1
1/6/13 5:00 AM	15	64.03	23.08	40.95
1/6/13 6:00 AM	10	64.15	24	40.15
1/6/13 7:00 AM	31	67.79	23.92	43.87
1/6/13 8:00 AM	0	71.36	23.17	48.19
1/6/13 9:00 AM	0	72.04	25	47.04
1/6/13 10:00 AM	0	72.01	25.17	46.84

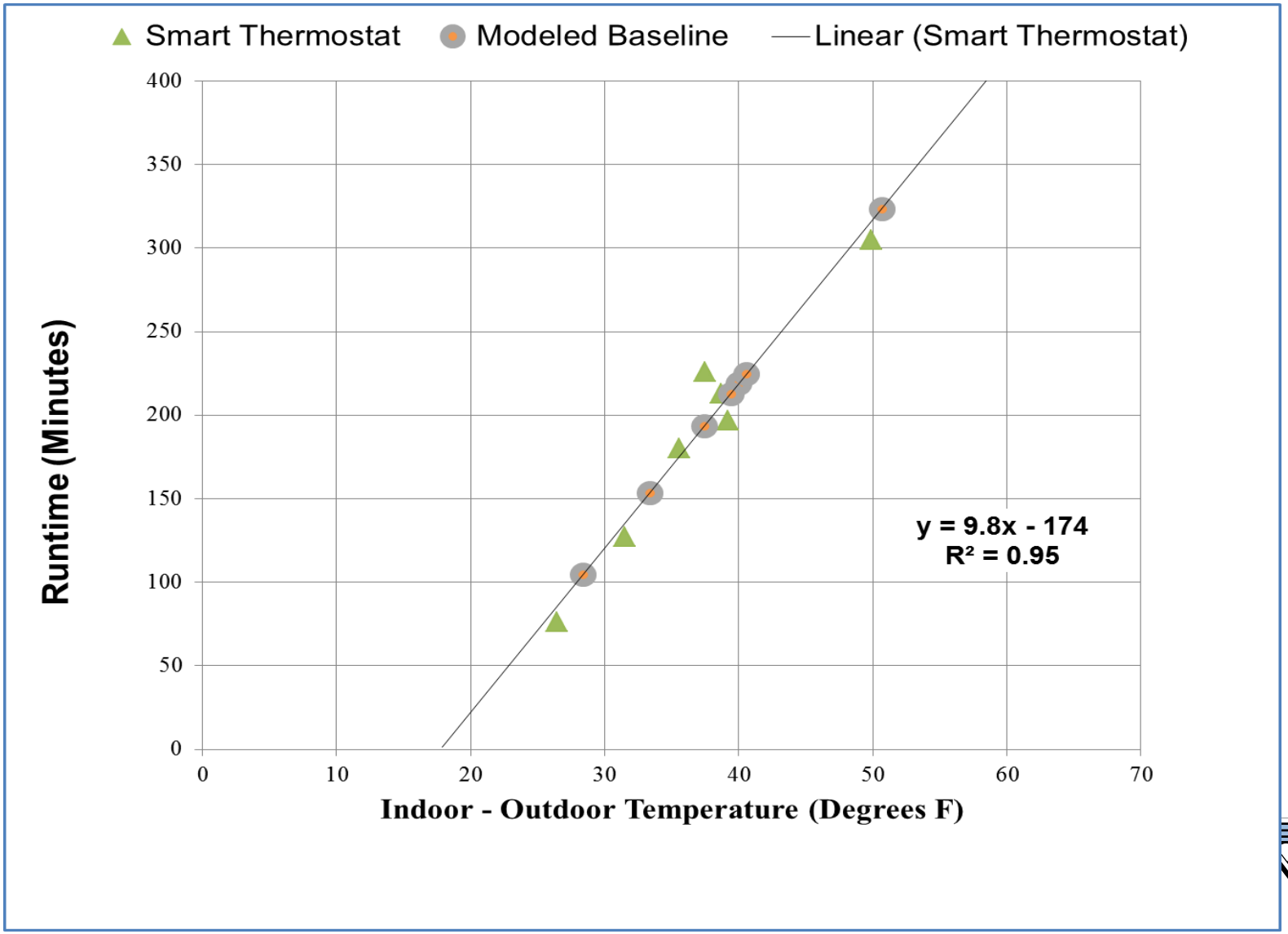
Single Home Hourly Time Series Thermostat Data



Create Regression Model Using Thermostat Data



Compare Measured with Modeled Baseline

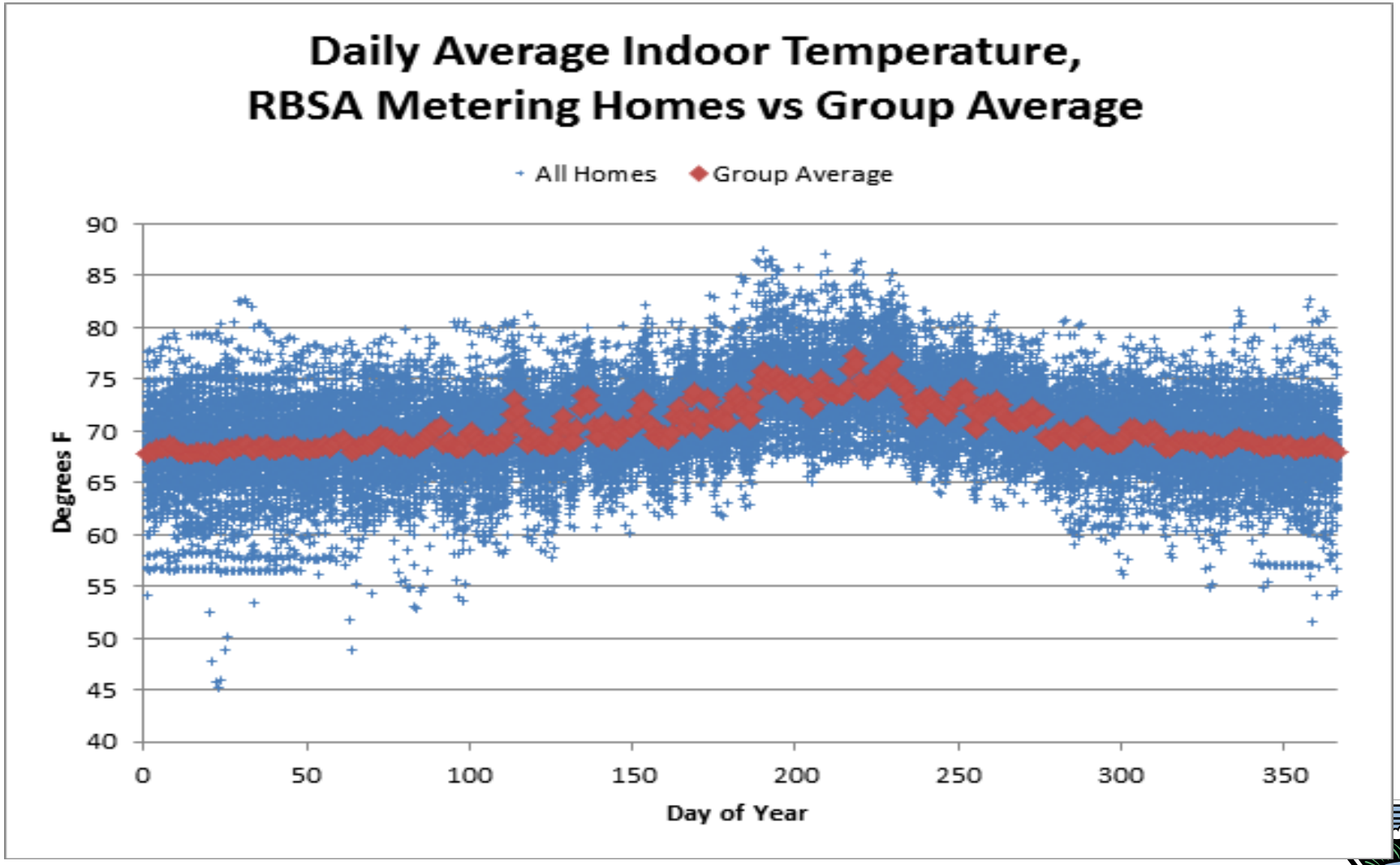


Additional Baseline Data

Residential Building Stock Assessment: *Metering Study, Larsen et. al.*

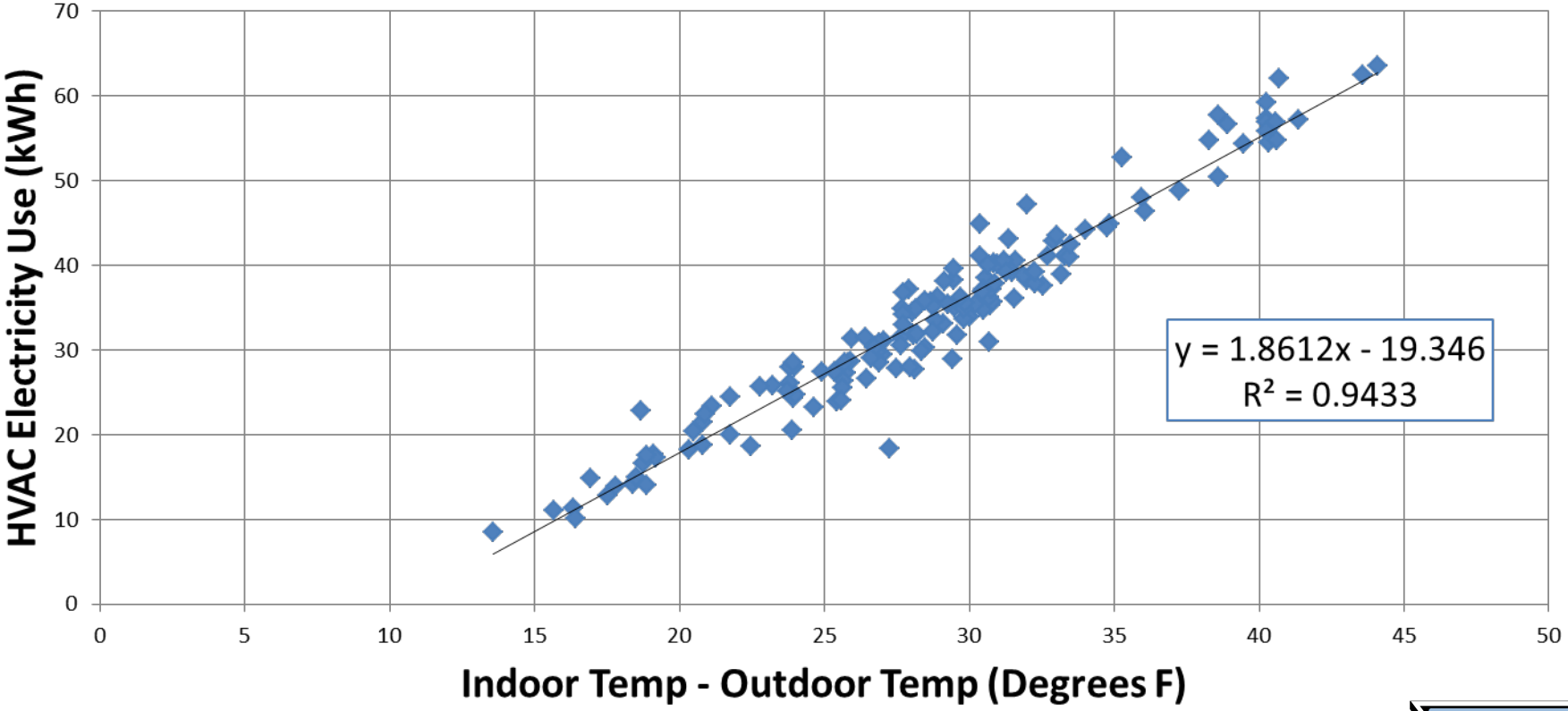
- 140 sub-metered homes, all end-uses
- Indoor Temperature
- Outdoor Temperature
- Sub-metered HVAC

Baseline Residential Indoor Temperature Data



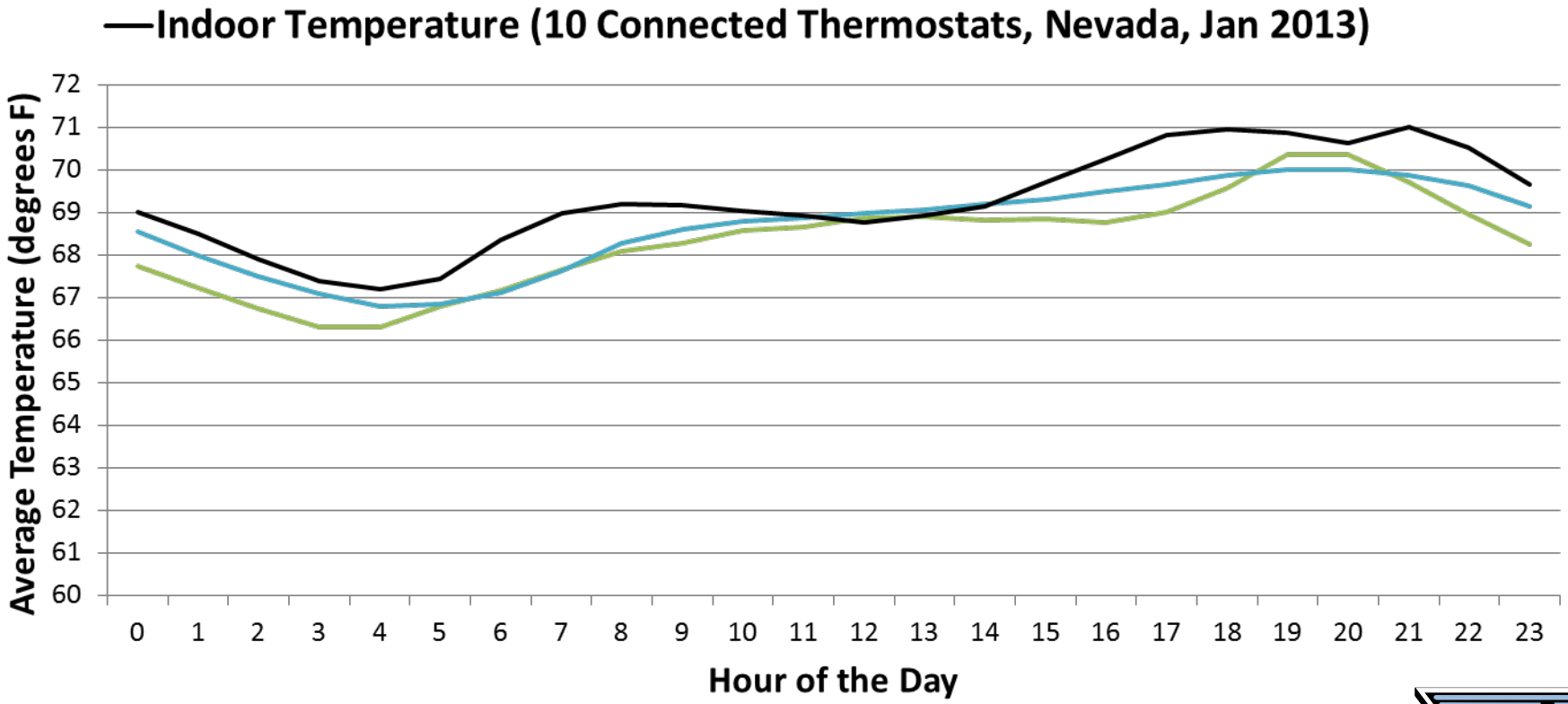
Correlation of Metered Residential HVAC Electric Use with Temperature

(Daily averages for 42 electrically-heated homes in PNW Nov - Mar 2012)

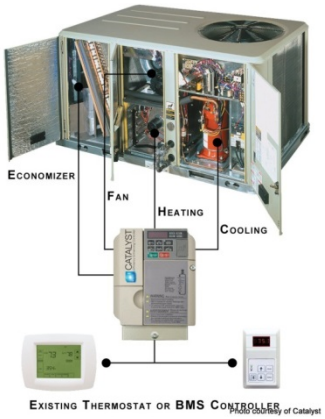


Source: Residential Building Stock Assessment: *Metering Study, Larsen et. al.*

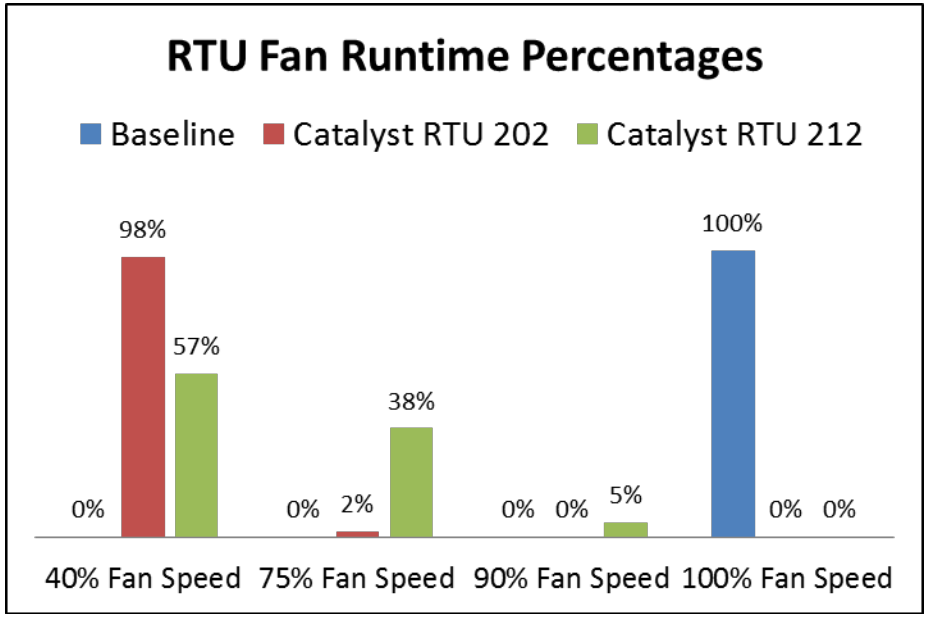
Comparison of Daily Indoor Temperature Profiles of Groups of Thermostats

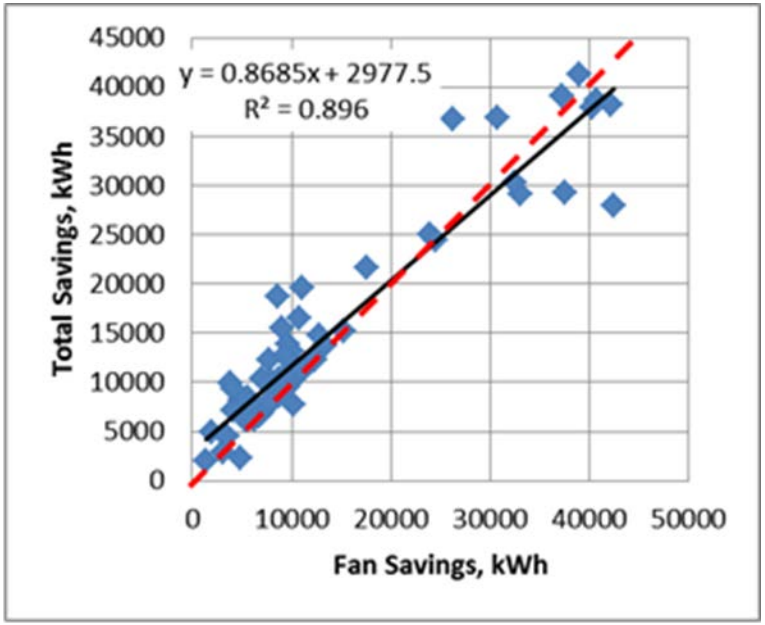


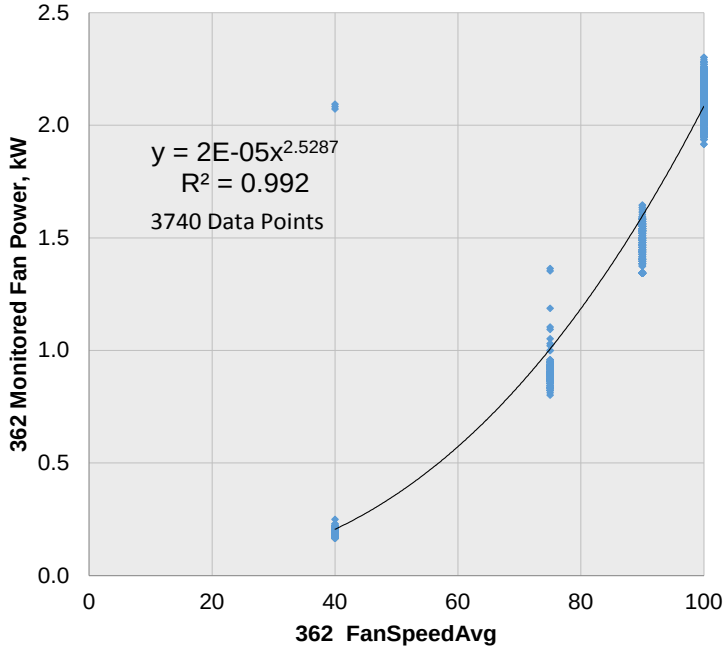
Advanced Rooftop Unit Controller

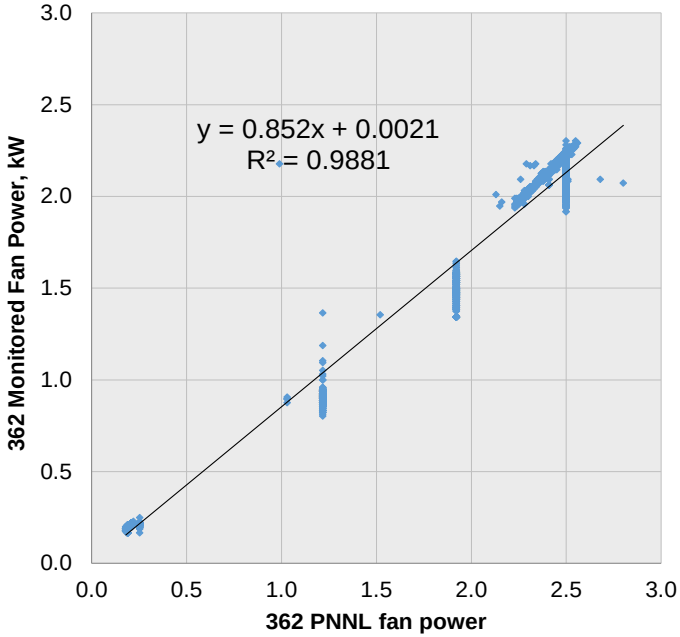


- **Equipment**: Catalyst Controller: Variable speed fan, DCV, economizer, web-connected eIQ Platform
- **M&V Approach**: "Post-Post", daily cycling between baseline mode and Catalyst mode
- **Data**: PNNL/BPA study of 66 RTUs with true-power monitoring
- **Results**: Post-post method is conceptually valid and "simplest reliable" fan speed savings method is within +/- 20% of best practice per RTF requirements.


RTU Fan Runtime Percentages
Baseline
Catalyst RTU 202
Catalyst RTU 212
0%
98%
57%
0%
2%
38%
0%
0%
5%
100%
0%
0%
40% Fan Speed
75% Fan Speed
90% Fan Speed
100% Fan Speed


y = 0.8685x + 2977.5
R² = 0.896
Total Savings, kWh
Fan Savings, kWh
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
0
10000
20000
30000
40000
50000


y = 2E-05x^2.5287
R² = 0.992
3740 Data Points
362 Monitored Fan Power, kW
362 FanSpeedAvg
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100


y = 0.852x + 0.0021
R² = 0.9881
362 Monitored Fan Power, kW
362 PNNL fan power
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Progress with Challenges

Challenge	Conclusion for Each Trial		
	Digital Lighting Controls	**Smart Thermostat**	**Advanced RTU Controller**
1. Data Availability	Access granted by 1 vendor	Several vendors did not provide data.	Existing sub-metered data set.
2. Data Proprietary and Privacy Barriers	Data made anonymous and shared.	Data made anonymous and shared.	Data made anonymous and shared.
3. Quality of Self-Reported Data	Low Resolution	Adequate	Excellent
4. Measurement of Existing Baseline	Not addressed.	Regression approach shows promise, but need more baseline data.	Resolved with “post/post” approach
5. Lack of metrics	Not an issue.	Some progress in defining metrics, but lacked needed data.	Addressed in follow-up
6. Measurement accuracy of power and energy	Not addressed.	Not addressed.	Addressed in follow-up

Conclusions

- Acquired data at no direct cost: Dramatically faster, cheaper, however, limited access
- Smart Thermostats
  - Data: Temperature, Runtime, and Setpoint are useful
  - Method: promising, but more work needed
- Advanced RTU Controller
  - Data: Available, complete
  - Method: Simple, reliable
- Digital lighting Controls
  - Data: Available, but not standardized
  - Method – “post-post” for controls is viable

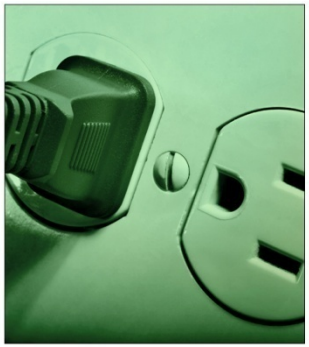
Next Steps: An Approach for Smart Connected Devices

Leverage large scale self-reported performance data.

Successfully outcomes might include:

1. Standard ways to access and aggregate data
2. Metrics for comparing energy performance.
3. Standard testing for qualifying products
4. Ongoing monitoring to validate performance.

Further Reading: Energy Star June 9th 2014 Memo: HVAC Climate Controls Proposed Approach



CONTACT INFO

Jack Callahan, P.E., CEM, CMVP
Senior Engineer
Bonneville Power Administration
jmcallahan@bpa.gov
503-230-4496
www.bpa.gov/energy/n/emerging_technology/
www.e3tnw.org