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**Energy Efficiency
and Renewable Energy**

Bringing you a prosperous future where energy
is clean, abundant, reliable, and affordable

Building Technologies Program



**Building
AMERICA**  SM
U.S. Department of Energy
Research Leading to Zero Energy Homes

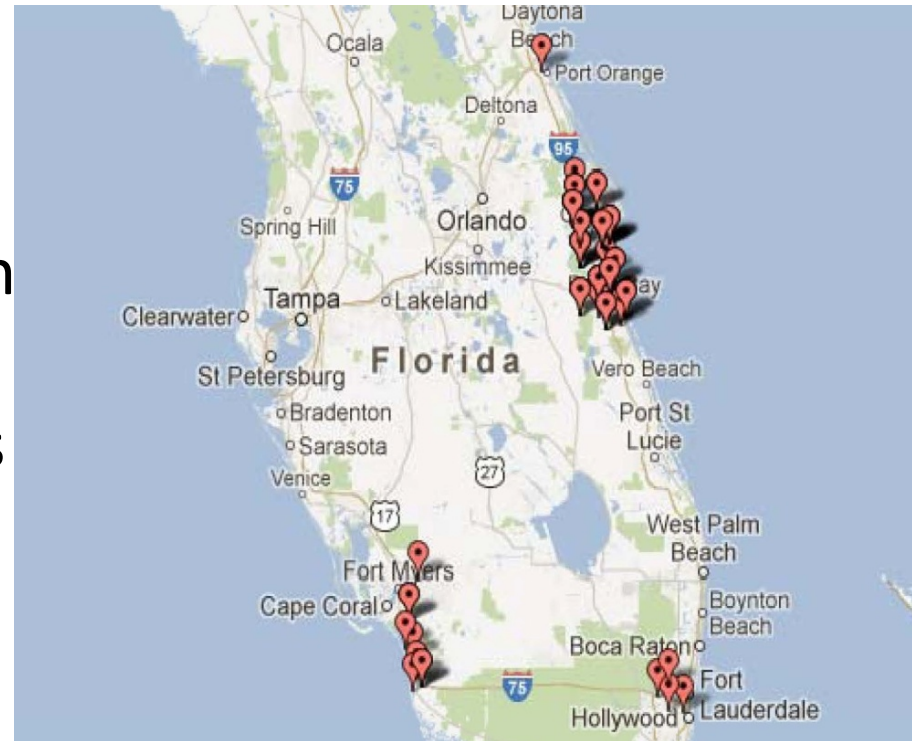
Results from Phased Deep Retrofits in Florida

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Florida Solar Energy Center
June, 2014

Phased Deep Retrofit (PDR) Project

- Detailed residential field metering project in FPL Service Territory
- Cooperative project between U.S. DOE and FPL
- Sixty heavily metered homes evaluated over 2 years
- Shallow retrofit in all & then deep retrofits in 10
- Collecting data of unique value to FPL/DOE



PDR: Extensive end-use metering

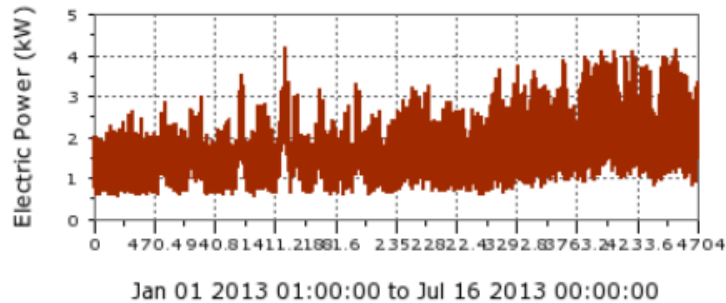
- January – July 2013: 60 homes
- 18 channels
 - Whole house power down to the TV!
 - All major end uses
 - Interior temperature & humidity
 - Hourly data
- Created analysis system for graphic summary
 - Hourly time series; hourly load shape; daily averages
 - See long term, load shape trends and seasonal changes
 - By site; by groups, over discrete time intervals
- How can you make sense of 5.8 million data points?



Hour/Daily & Demand Total Loads: Archived data available for FPL/DOE

Whole Building Power

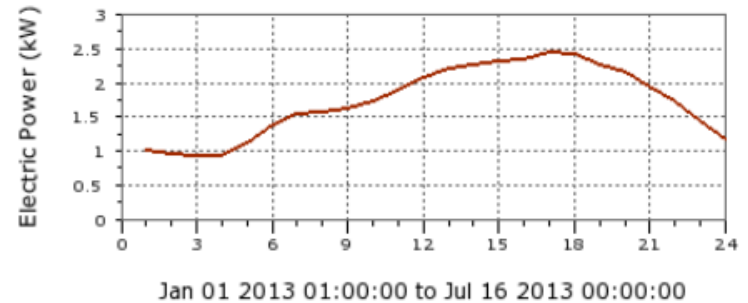
All Houses



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Whole Building Power, Demand Profile

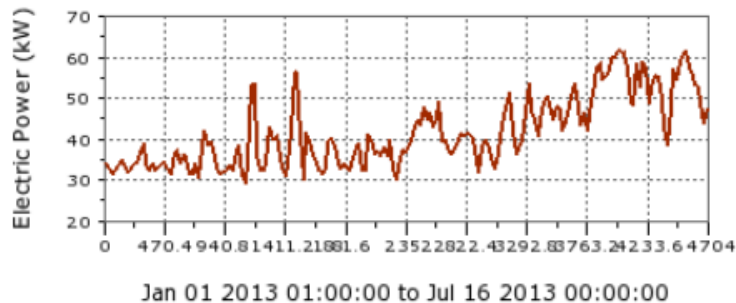
All Houses



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Daily Whole Building Power

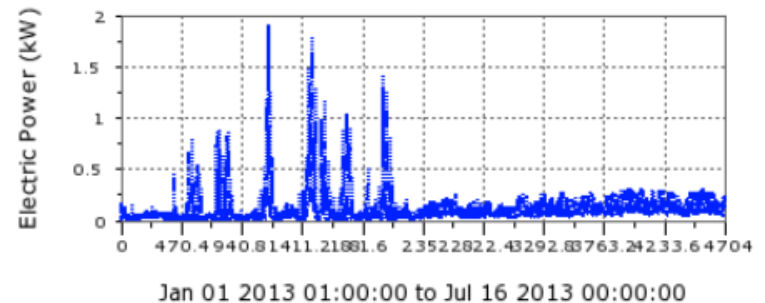
All Houses



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A/C AHU and Strip Heat Power

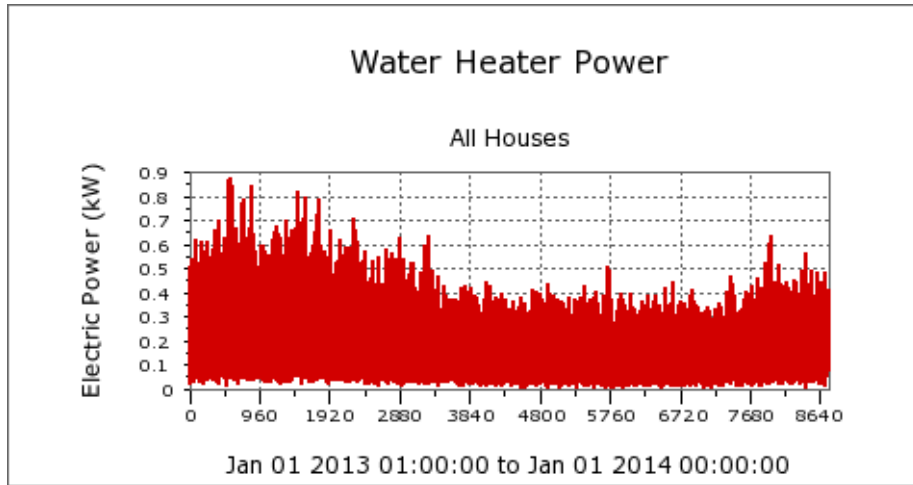
All Houses



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Hot Water: Detailed Data on Load Shapes

Hourly

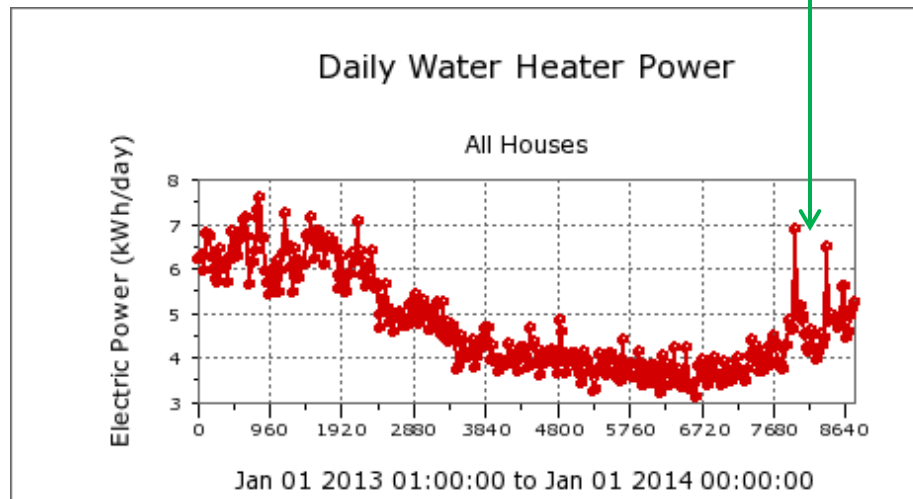


Example: High Quality Water Heating Load Shape Data: Available for Each End Use for an Entire Year

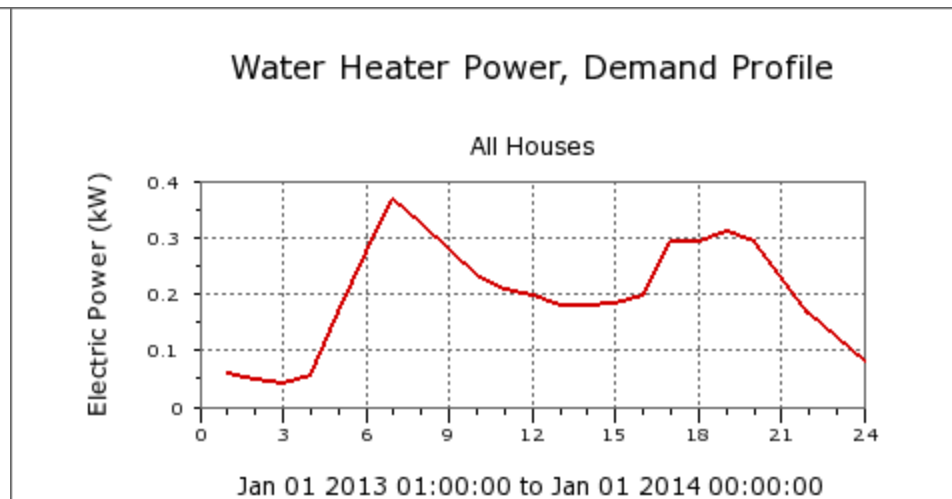
2:1 Difference winter to summer

Daily

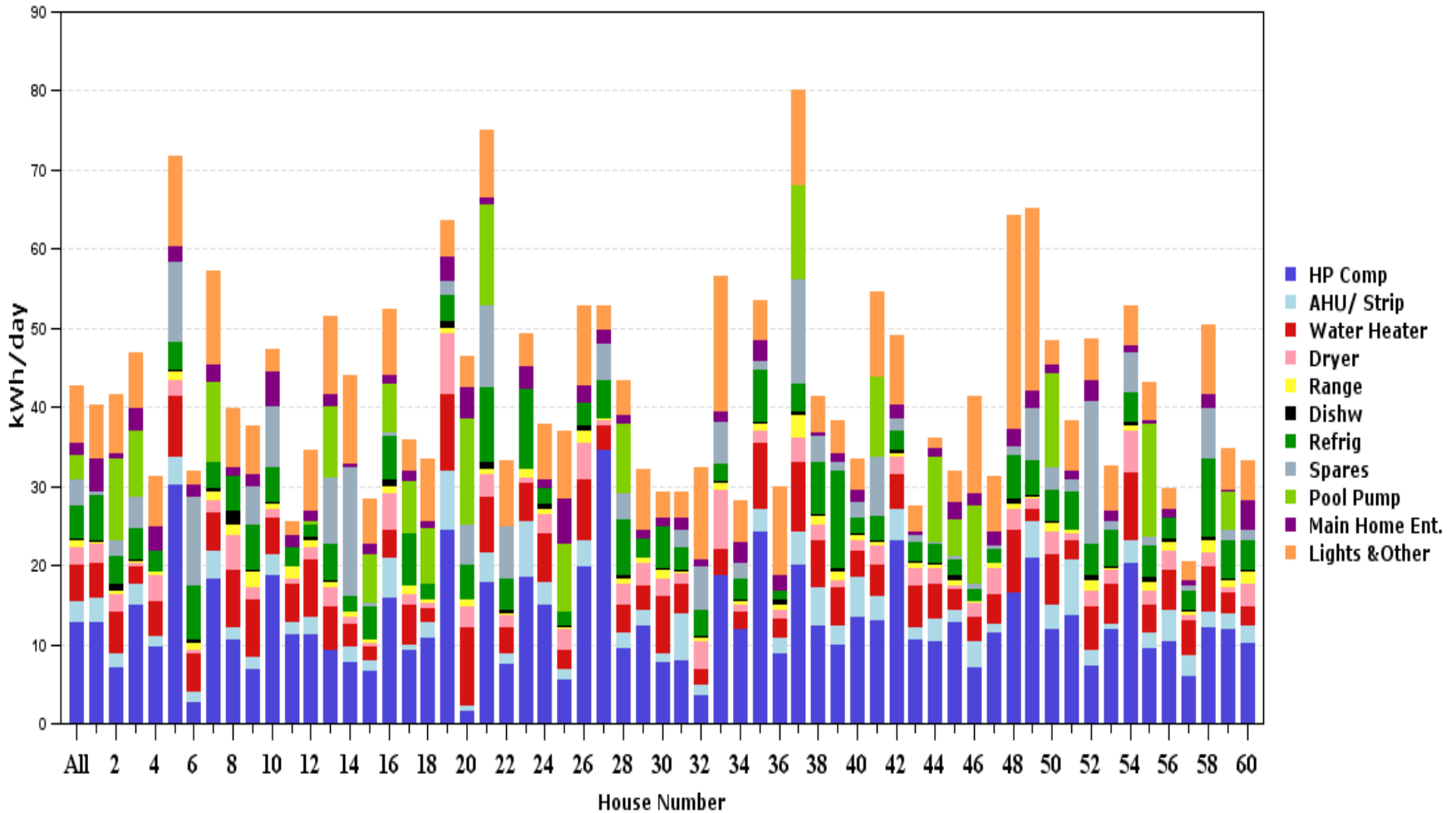
Thanksgiving/Christmas



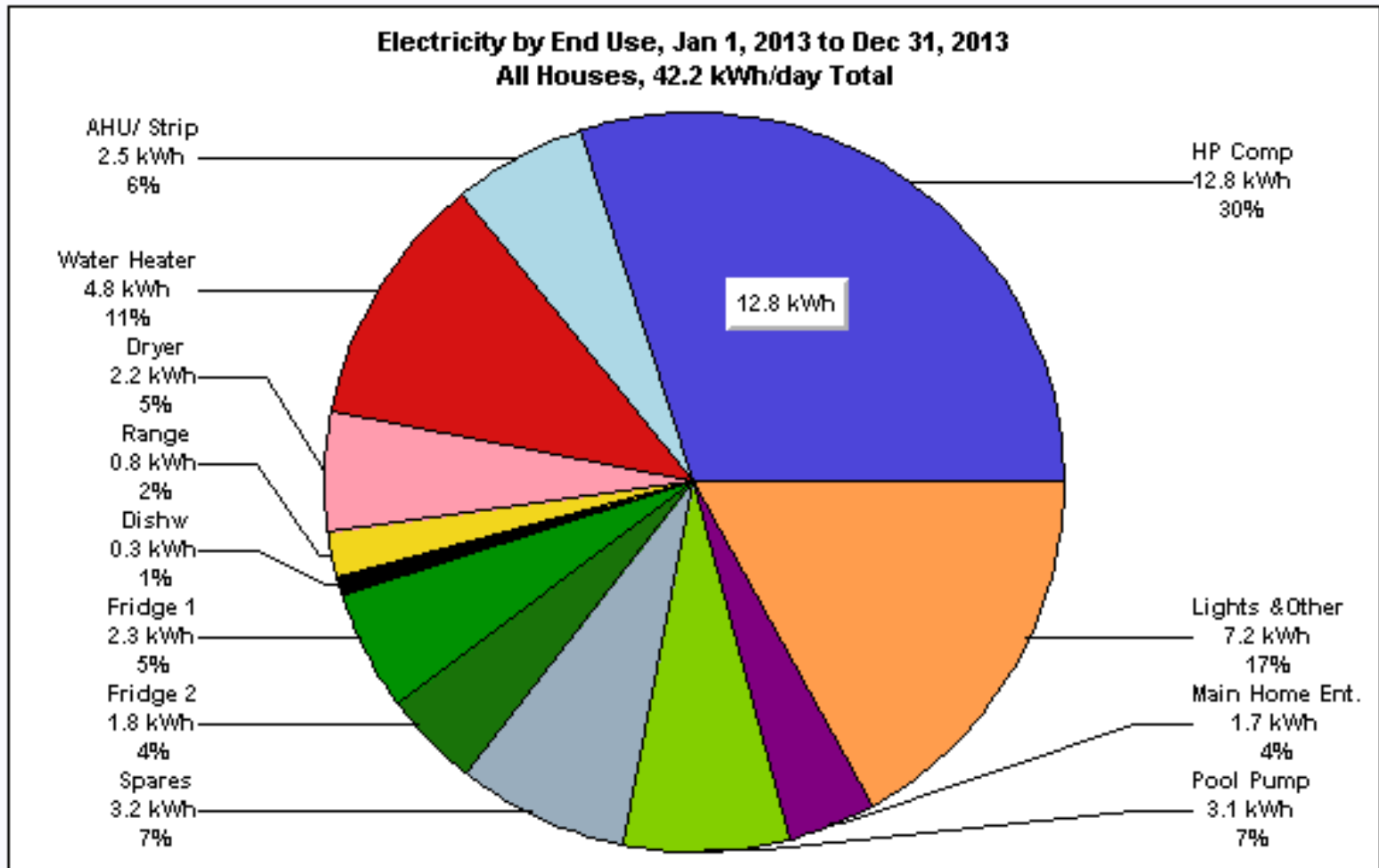
Time of Day



It's Complicated: Mix & Size of End-Uses at Each Site Unique



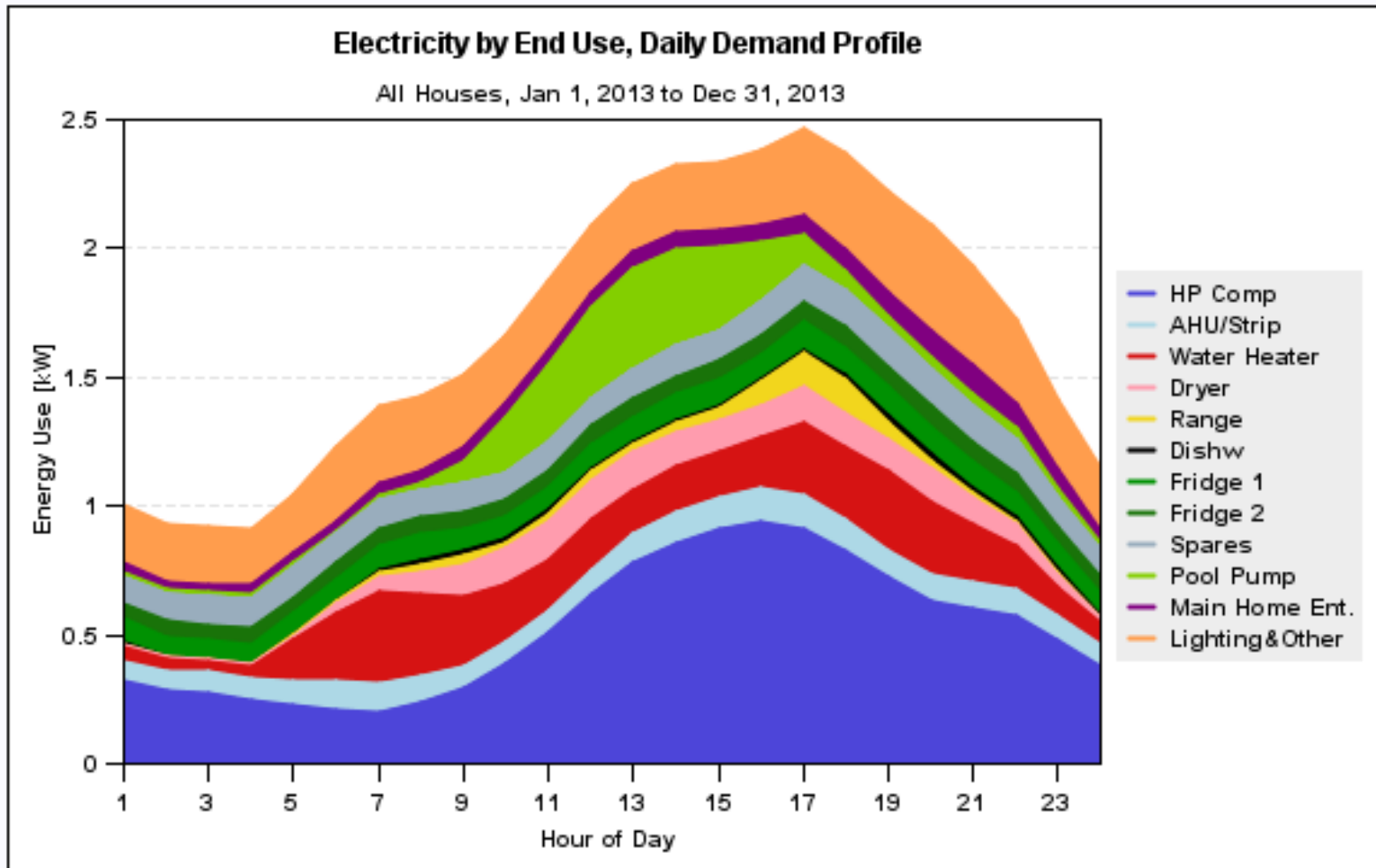
Complex Picture of Electricity Use



No single end-use dominates; Conventional loads (space heat/cool & water heat) only 45% of total; lighting & plug loads large difficult to address category

What Makes up the Peak?

Ann. Time of Day: Load Shapes

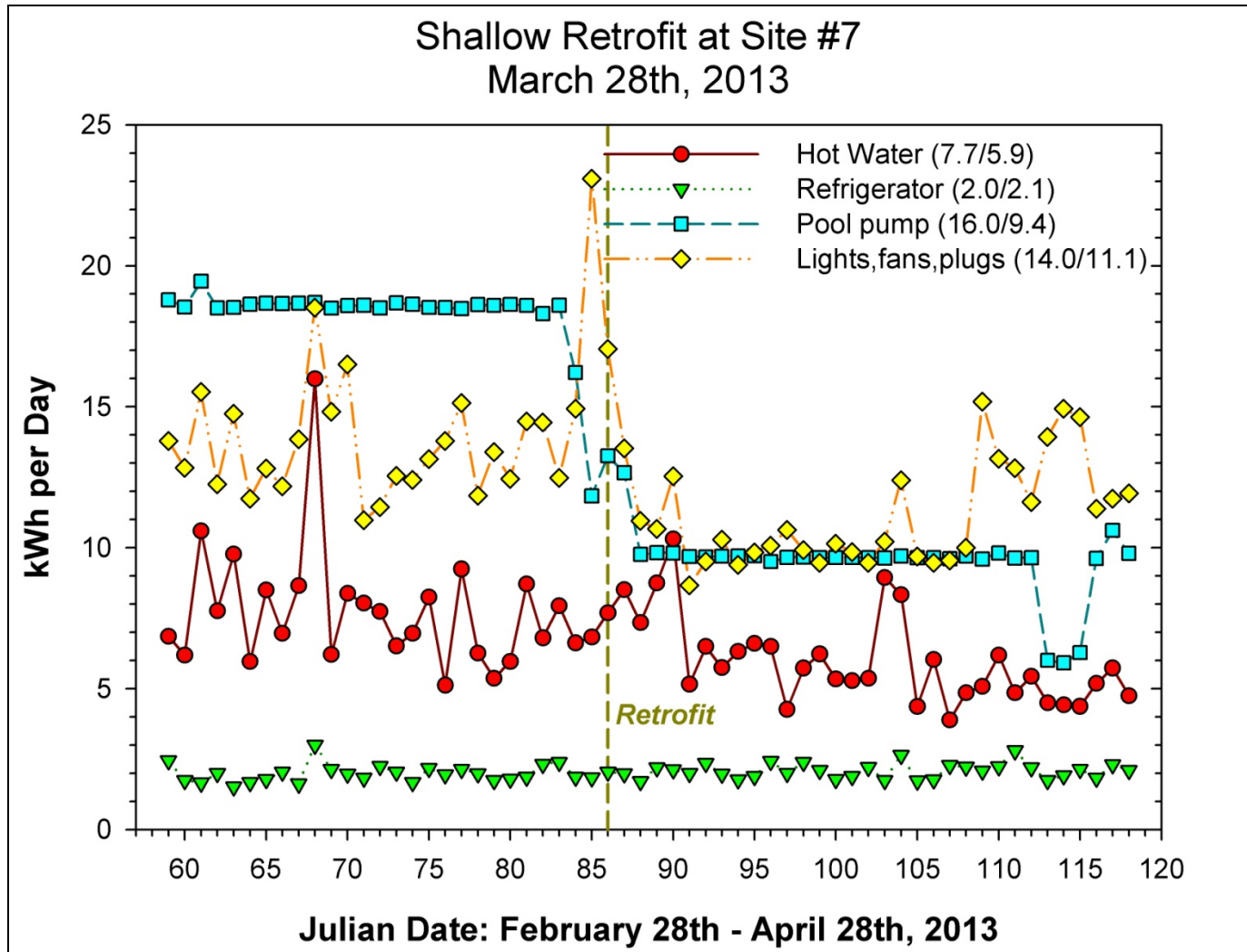


Shallow Retrofit Measures

- Collect detailed audit data
- Change all incandescent lighting to CFL or LED lighting
- Add exterior insulation tank wrap to hot water tank
- Replace shower fixtures with hi-efficiency head if measured flow is greater than 2.2 gpm
- Set pool pump hours to no more than 5 hours per day
- Clean refrigerator coils if dirty
- Provide smart power strip to any standby power loads greater than 10 Watts continuous

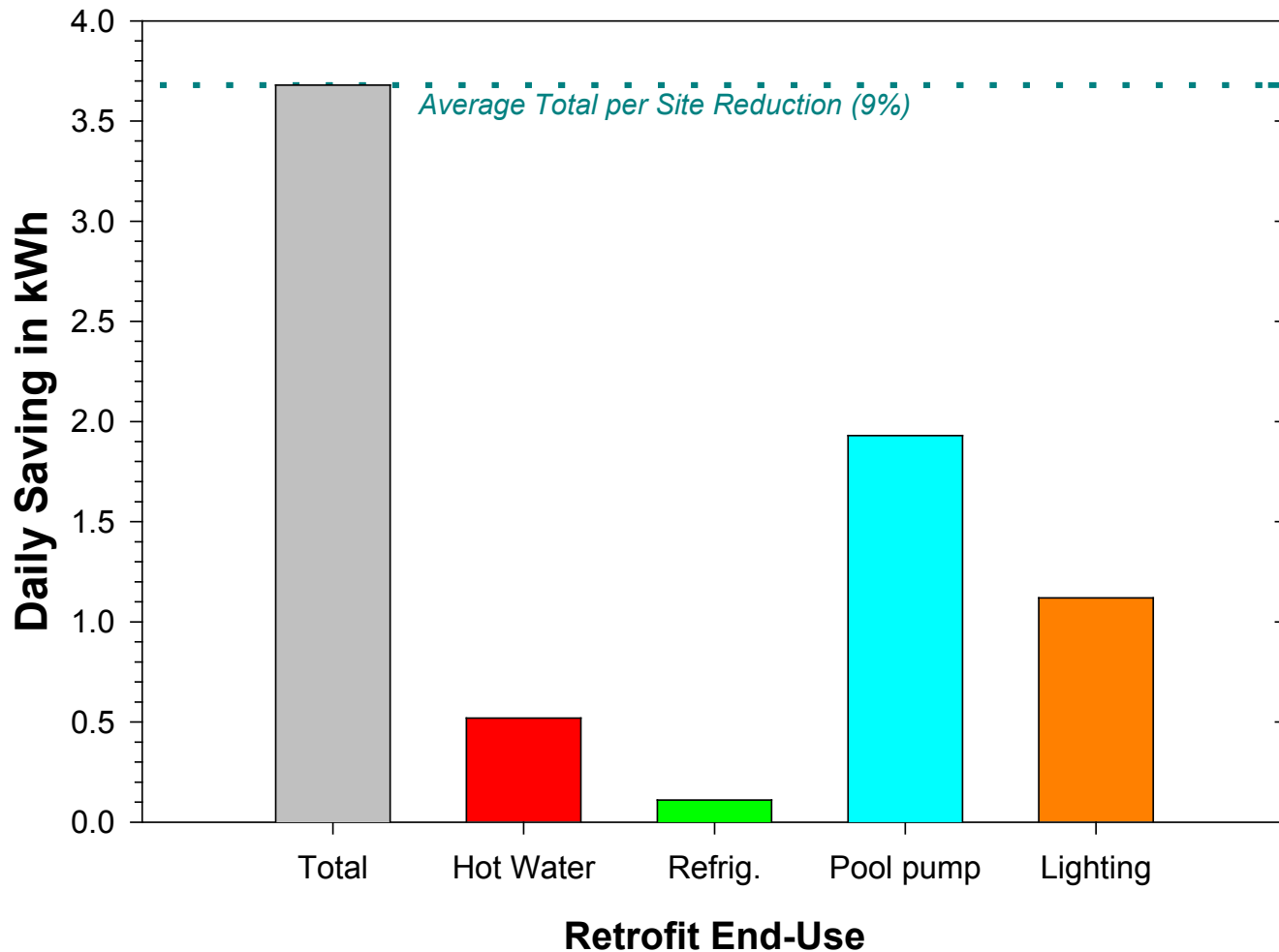


Shallow Retrofit Evaluation: 30 days before & after



Preliminary Savings by Measure: 9%

Preliminary Savings by Measure
for Shallow Retrofits in PDR Project



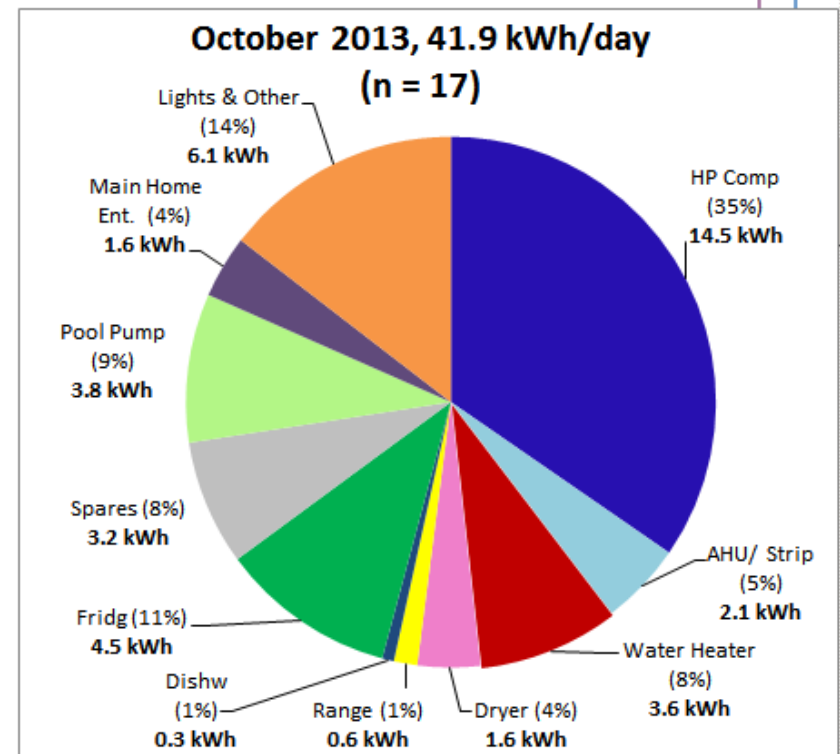
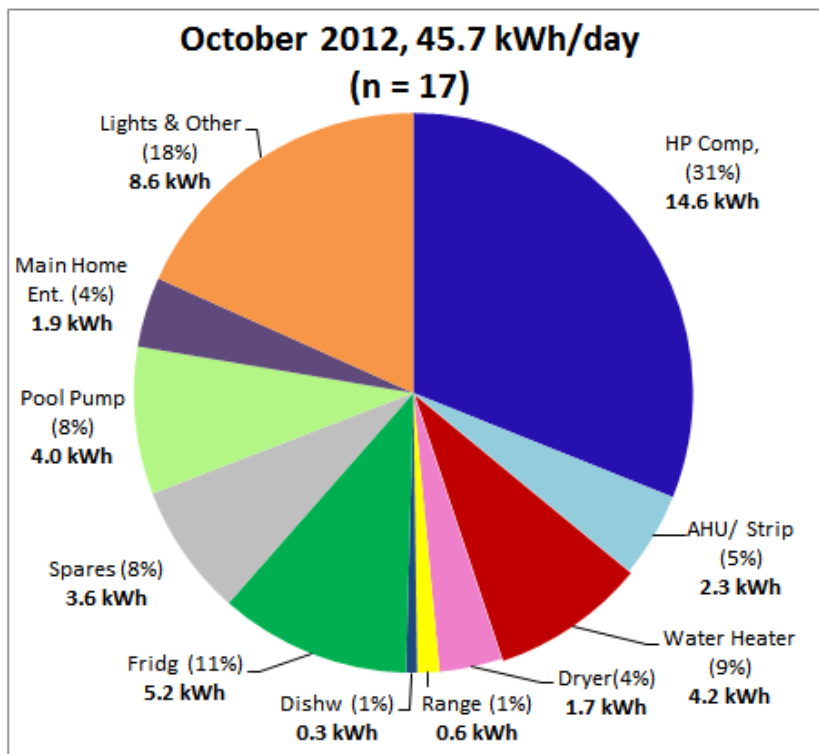
Shallow Retrofit Savings: Two Evaluation Method Results

Shallow Retrofit Average Daily Savings	Hot Water (kWh)	Refrigerator (kWh)	Pool Pump (kWh)	Lights & Other (kWh)	Whole House (kWh)	% Whole House Savings
30 Days Pre-Retrofit	5.6	2.4	10.7	7.7	40.5	
Weather-Adjusted, 30 Days Post-Retrofit	5.2	2.3	8.0	6.4	36.3	
Weather-Adjusted, 30 Day Pre- vs. Post-Retrofit	0.4	0.1	2.7	1.2	4.2	9.2%
October 2012	4.2	3.2	7.4	8.6	45.3	
October 2013	3.6	2.3	7.2	6.1	41.7	
October 2012 vs. October 2013	0.6	0.9	0.2	2.5	3.6	7.9%

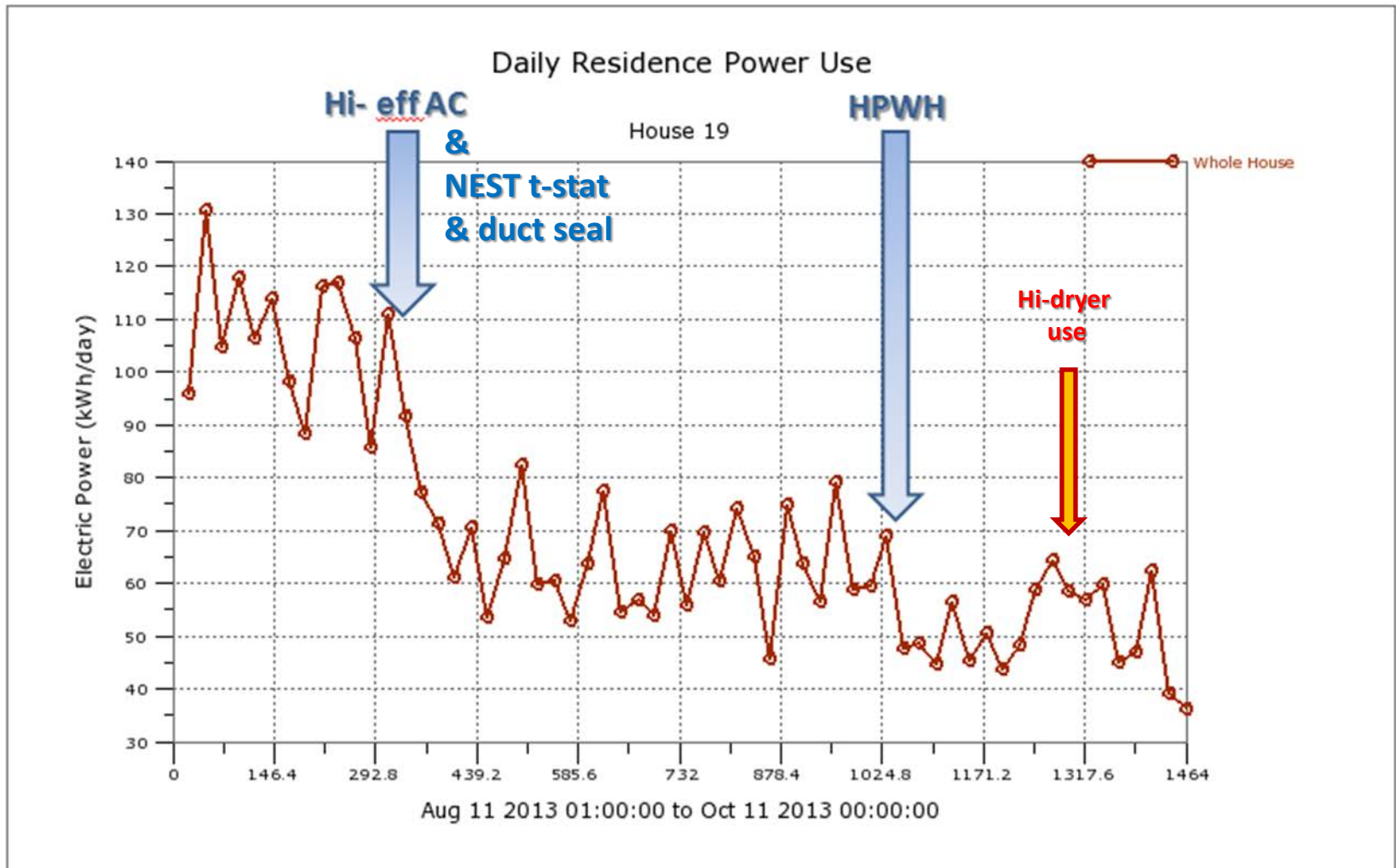
9% Savings were Durable

Largest: Lighting, water heating, refrigerator

Implication: Simple utility pass through audits can make a difference



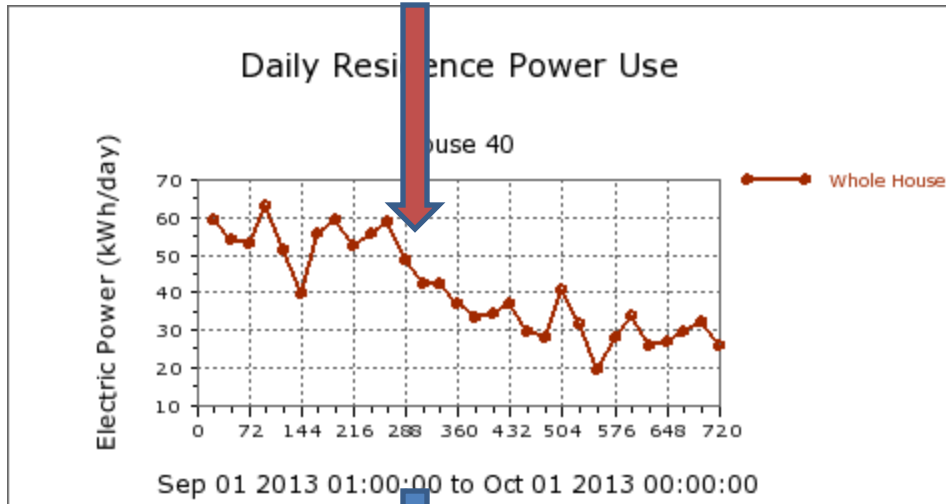
Deep Retrofit in Site #19



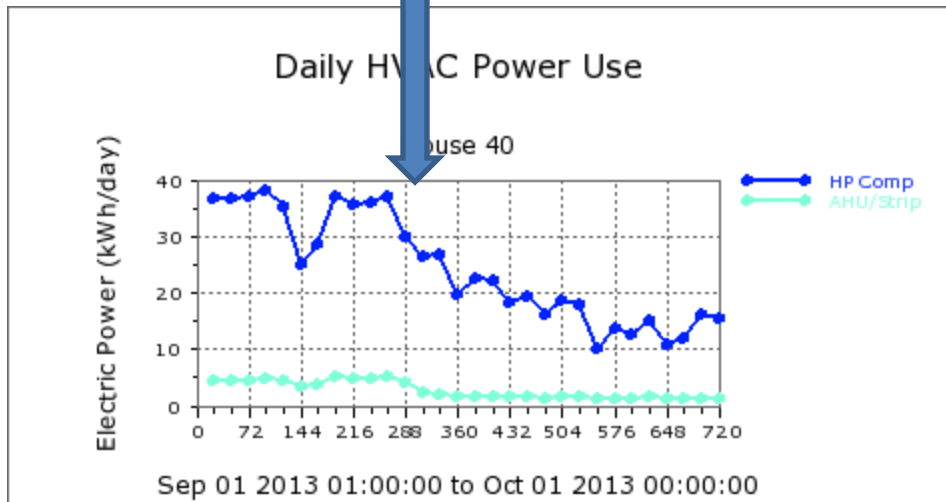
Total Consumption from 110 kWh/day to 50 kWh/day: >50% reduction & not done, Insulation & appliances yet to go...

Site #40 Deep Retrofit: 40% Savings

AC/NEST/Ducts

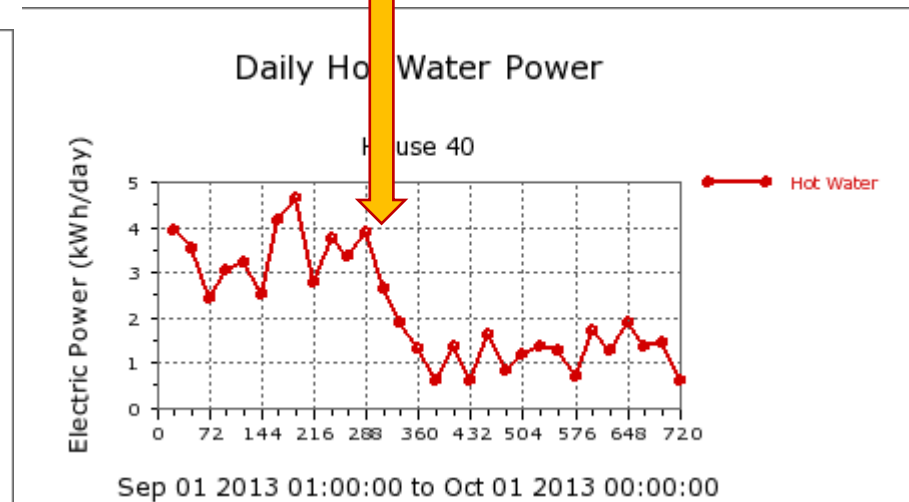


35->15 kWh/day: 57%



HPWH

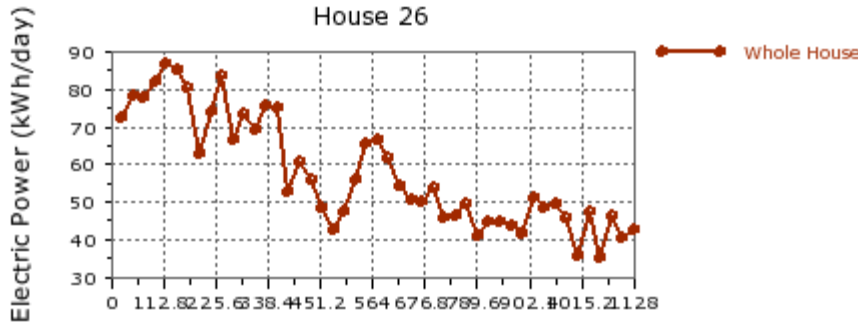
3.5->1.2 kWh/day: 65%



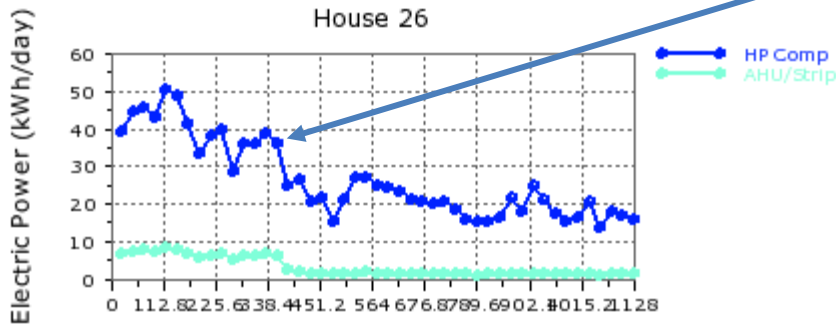
Site 26: Deep Retrofit

74 kWh/day-->50 kWh/d
~ 33% savings

Daily Residence Power Use

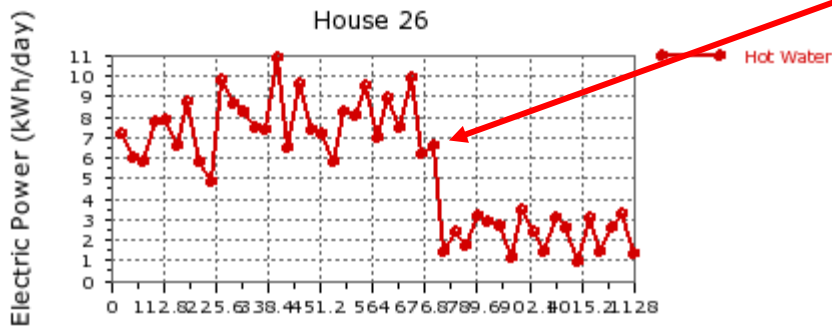


Daily HVAC Power Use



AC retrofit+ Nest t-stat+ duct sealing
saves ~20 kWh/day

Daily Hot Water Power



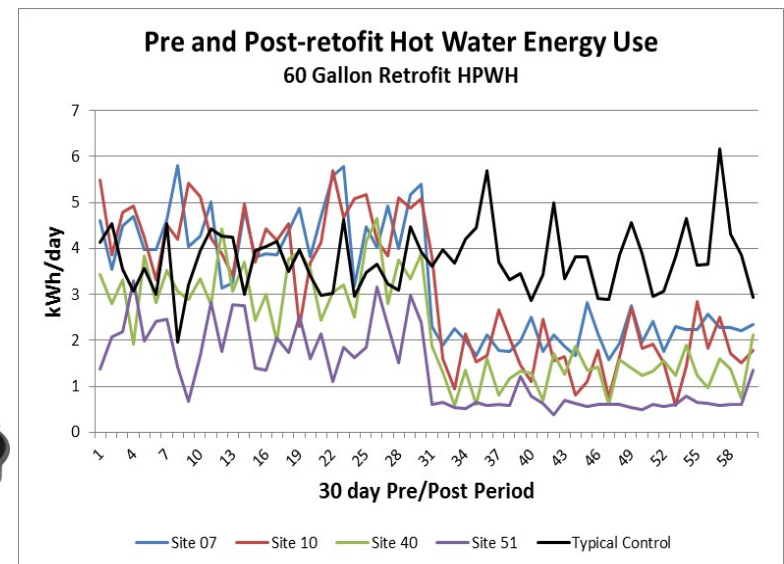
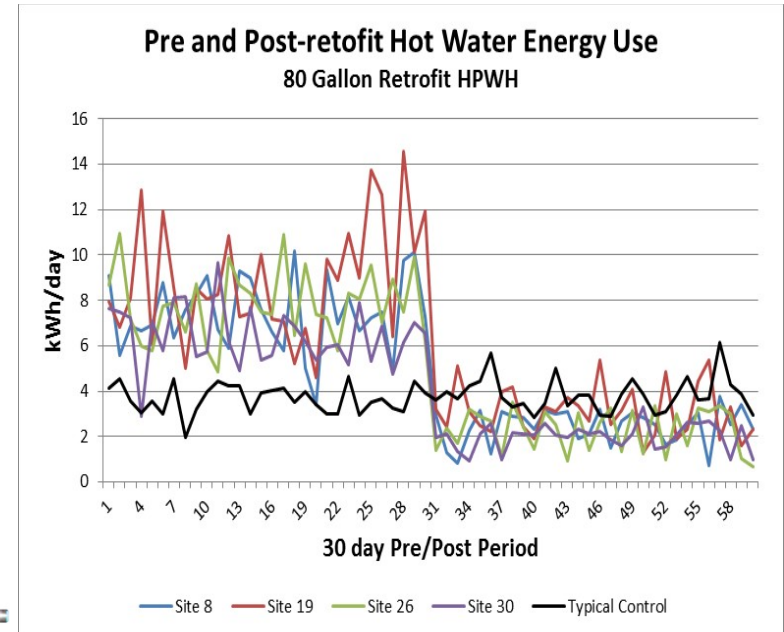
HPWH retrofit saves ~4 kWh/day

**Takeaway: HVAC & heat pump water heater
Retrofits produce reliable demand reduction**

Aug 15 2013 01:00:00 to Oct 01 2013 00:00:00

Heat Pump Water Heaters

- Dependable savings vs. replaced electric resistance Water Heaters
- 80 gal. models: 4+ person households
- 65% overall savings (3.6 kWh/day)
- 60 gal: 61% savings (2.1 kWh/day)
- 80 gal: 69% savings (5.2 kWh/day)

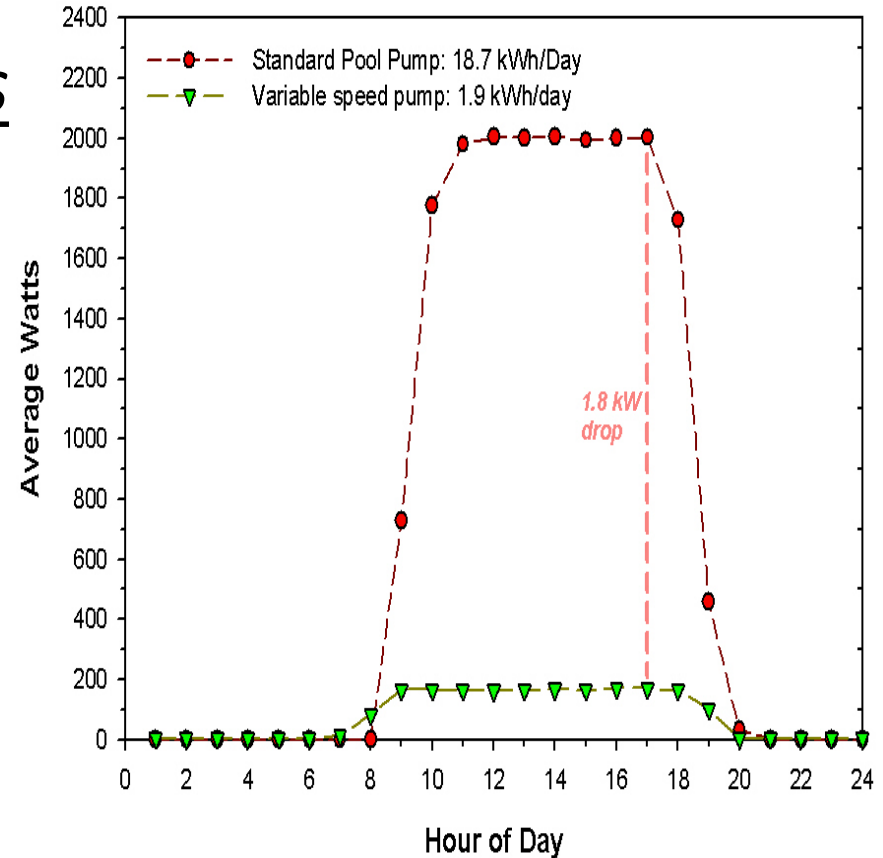


New Tech: Variable Speed Pool Pump

- Site #7: 18.7 kWh/day pre
- 1.9 kWh/day after replacement: 90% savings
- Huge demand reduction
- 1.8 kW @ 5 PM!



Average Time of Day Pool Pump Demand:
Site #7: Pre & Post Variable Speed Pool Pump Replacement



Evaluating New Technology: Energy Star Clothes Dryer

Samsung Clothes Dryer Model : DV457

Key Features

- 7.5 cubic feet capacity
- 8" Full Touch LCD
- Smart-Grid (DR) Ready
- Smart Control
- Smart Care
- Steam Dry
- Quietest VRT Plus™
- Smart Vent Sensing(Dryer)
- New Dryer technology saves up to 36% in energy!

Available April/May 2013!

Competitive Advantages

- Industry's Largest LCD
- Industry's first "Smart Control"
- Industry's first "WiFi Capable"

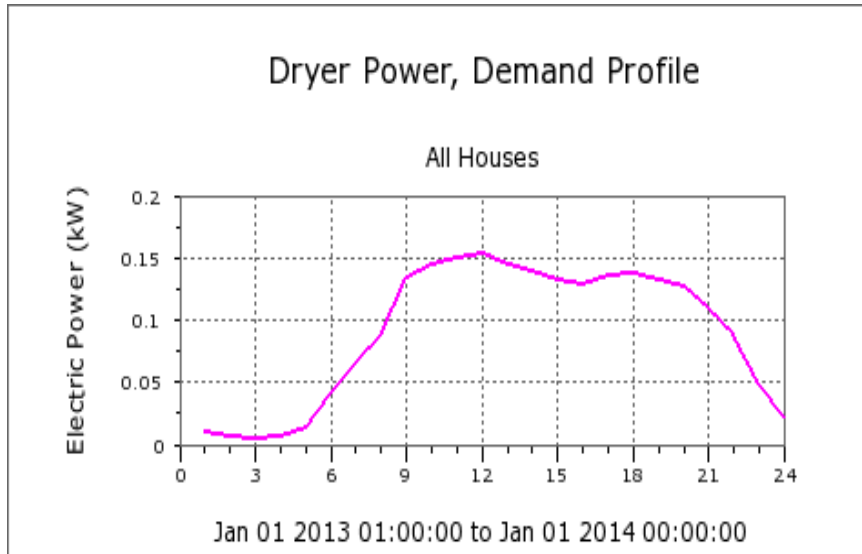
+ The Industry's first efficient vented dryer!

\$1,499 Onyx / \$1,399 White

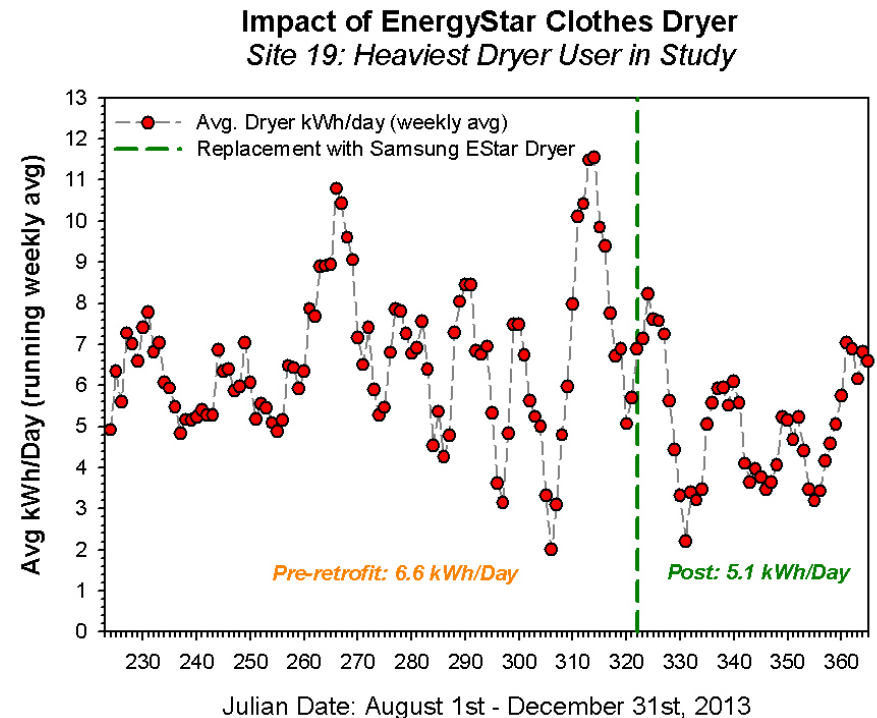


ENERGY STAR 2013

23% Energy Drop in Heaviest Use Site (good load shape reduction potential)



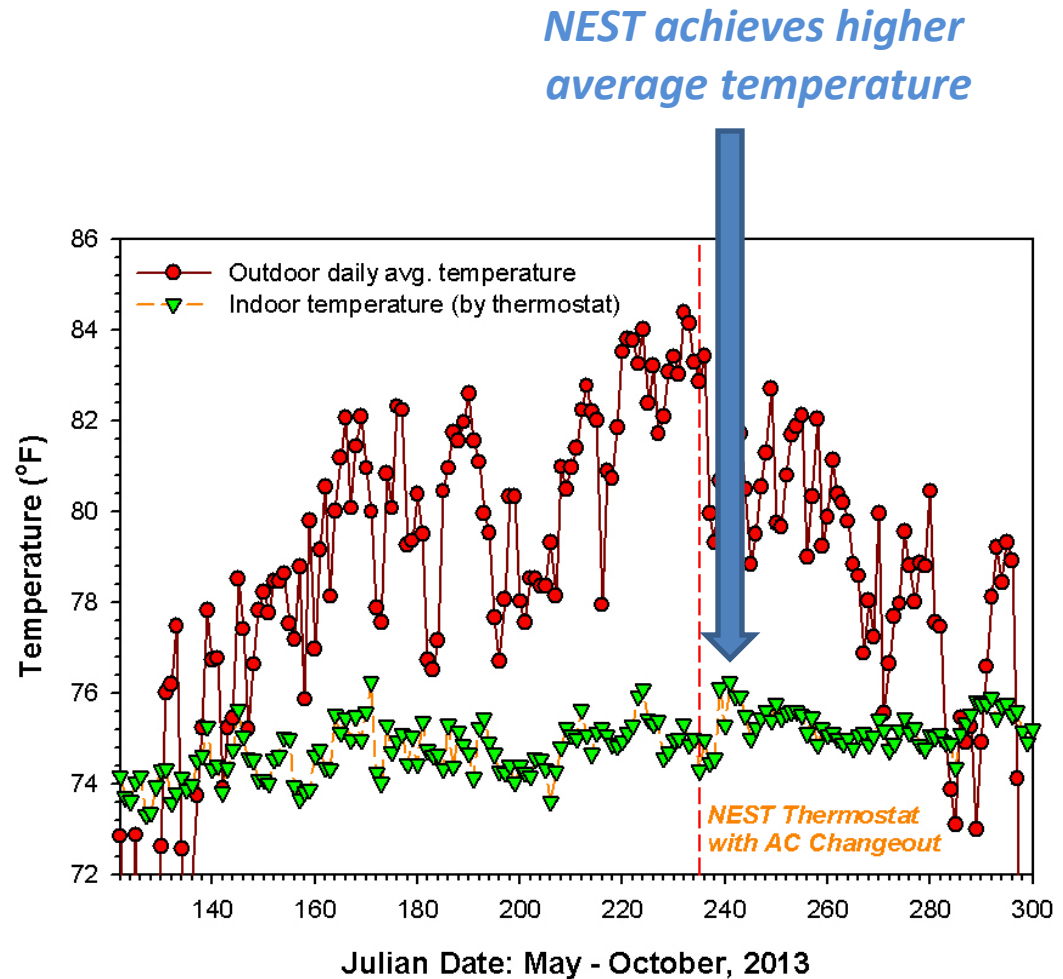
**Average 6 month savings
in eight sites: 18% (0.6 kWh/Day)**



NEST Thermostat *Can Save*



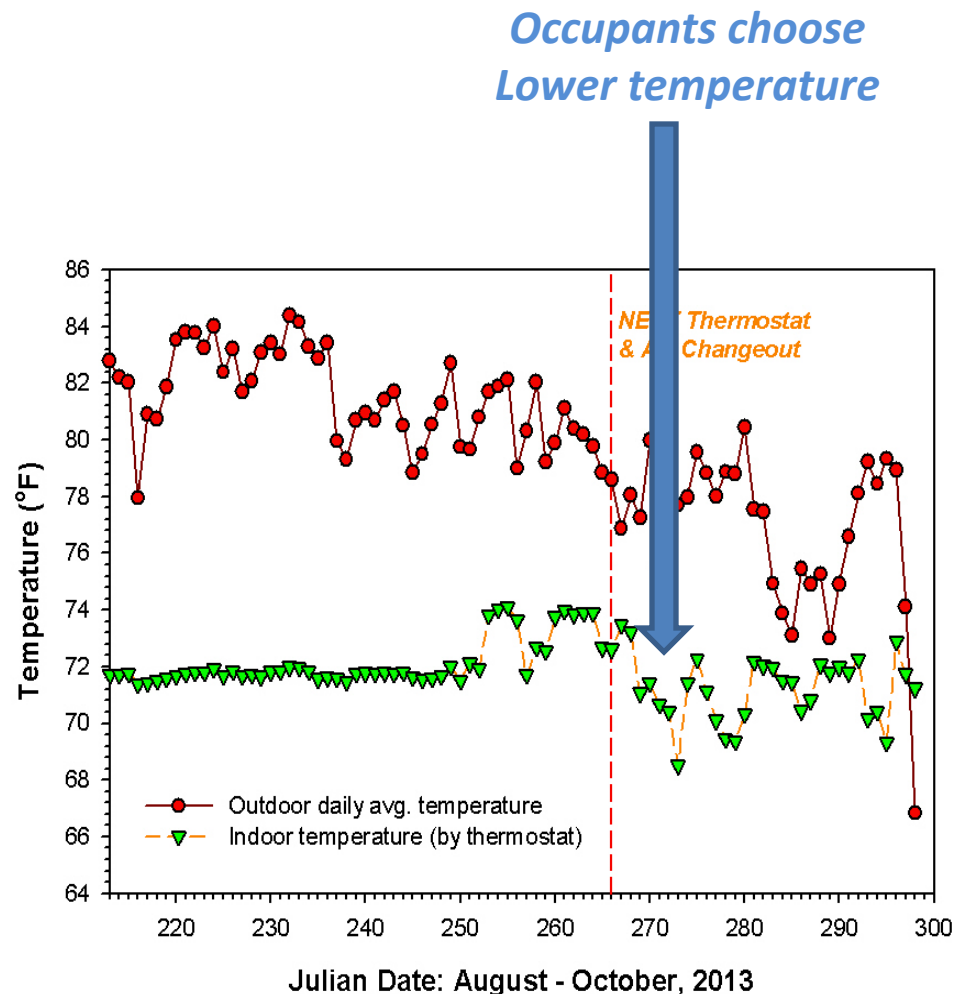
- Nine NEST retrofits in project
- 19% savings in one
- Obtaining load shape & humidity impacts



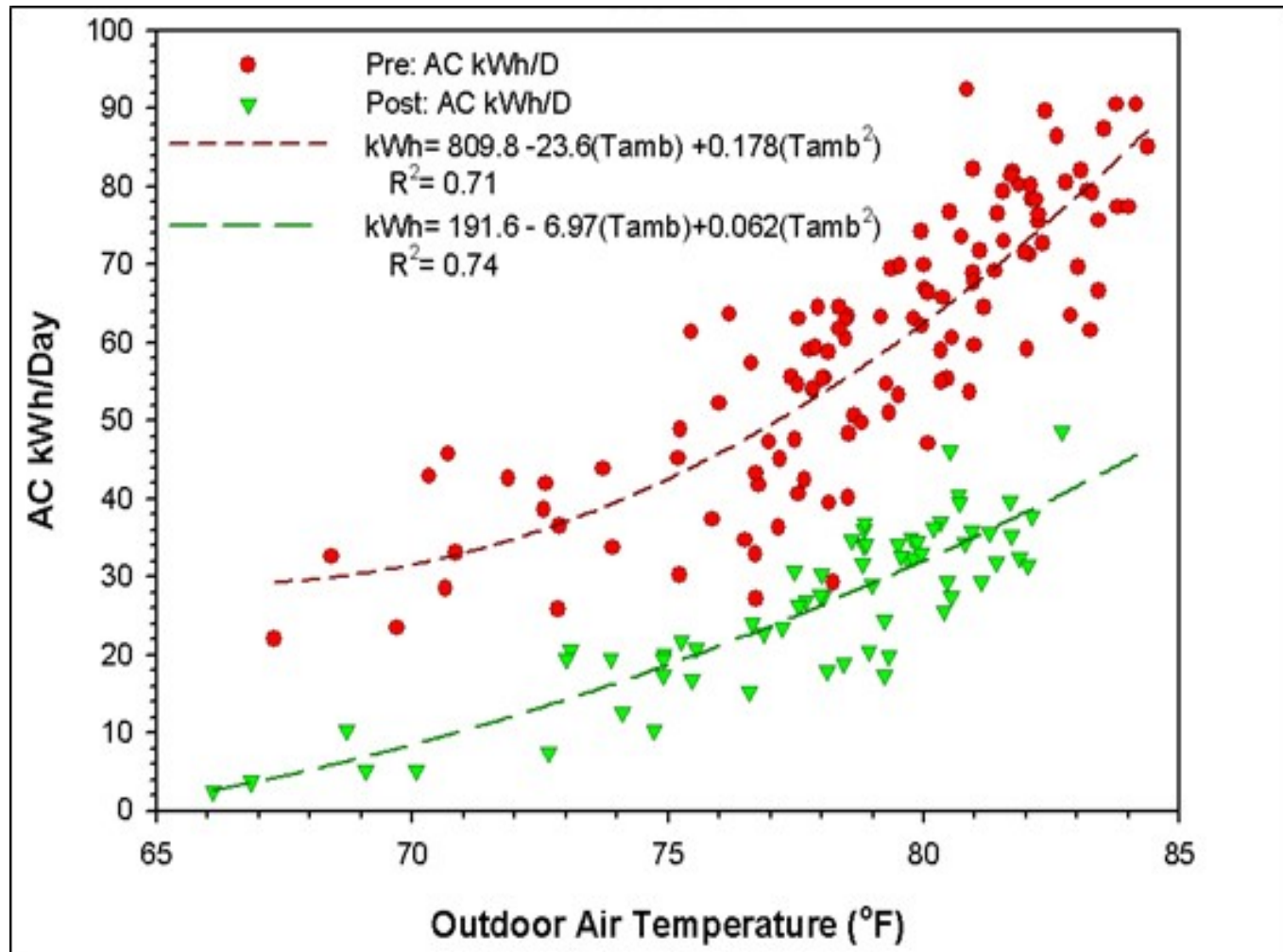
NEST Saves: But not Always ...



- Site 7: homeowners prefer low temperatures
- Set NEST lower to compensate for its attempts to elevate setting
- Defeated “ auto-away” feature
- Negative savings



Site 19 average air conditioning vs. outdoor temperature May – Oct, 2013

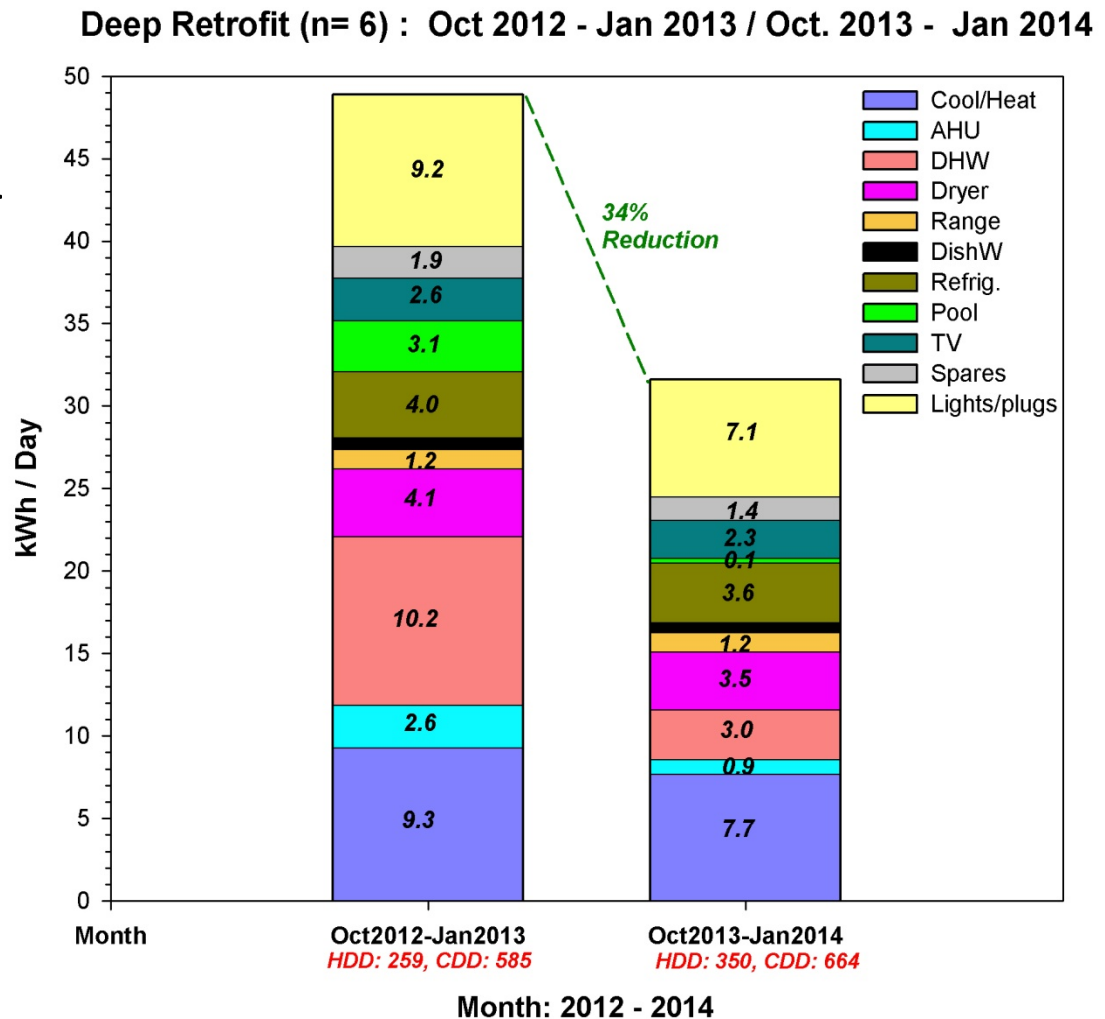


PDR Cooling Energy Savings Analysis Deeps (May – October, 2013)

Site	Pre kWh	Post kWh	Savings kWh	Percent Savings (%)	HVAC Saved (%)	Thermostat (°F)		Temperature-Related	
						Pre-Retrofit	Post-Retrofit	Savings (%)	Learning Thermostat Savings
7	38.3	33.8	4.5	12%	18%	72.10	71.10	-6%	-6%
8	35.4	14.7	20.7	58%	54%	77.90	78.50	4%	4%
10	57.7	25.9	31.8	55%	63%	77.80	73.80	-13%	*
19	61.0	30.8	30.2	50%	47%	75.10	75.40	3%	3%
26	41.2	21.8	19.4	47%	48%	75.10	73.60	-1%	-1%
30	19.3	16.5	2.8	15%	23%	77.80	76.90	-8%	-8%
37	40.0	33.6	6.4	16%	28%	78.30	75.80	-12%	**
39	23.2	15.0	8.2	35%	31%	78.30	79.10	4%	4%
40	32.4	20.6	11.8	36%	35%	75.40	75.70	1%	1%
51	39.7	21.5	18.2	46%	48%	80.50	79.20	-2%	-2%
Avg.	38.8	23.4	15.4	37.0	39.5	76.80	75.90	-1.9%	-0.6%

Early Analysis of Deep Retrofit Savings

- Six retrofits projects
- Compared pre & post
 - Pre: Oct 2012- Jan 2013
 - Post: Oct 2013- Jan 2014
- 34% savings
- Final savings likely ~40%
 - Period does not include energy intensive summer
 - Weather was more harsh in post period (both HDD and CDD)
 - Not all retrofits complete over entire post period



Preliminary Cost Analysis

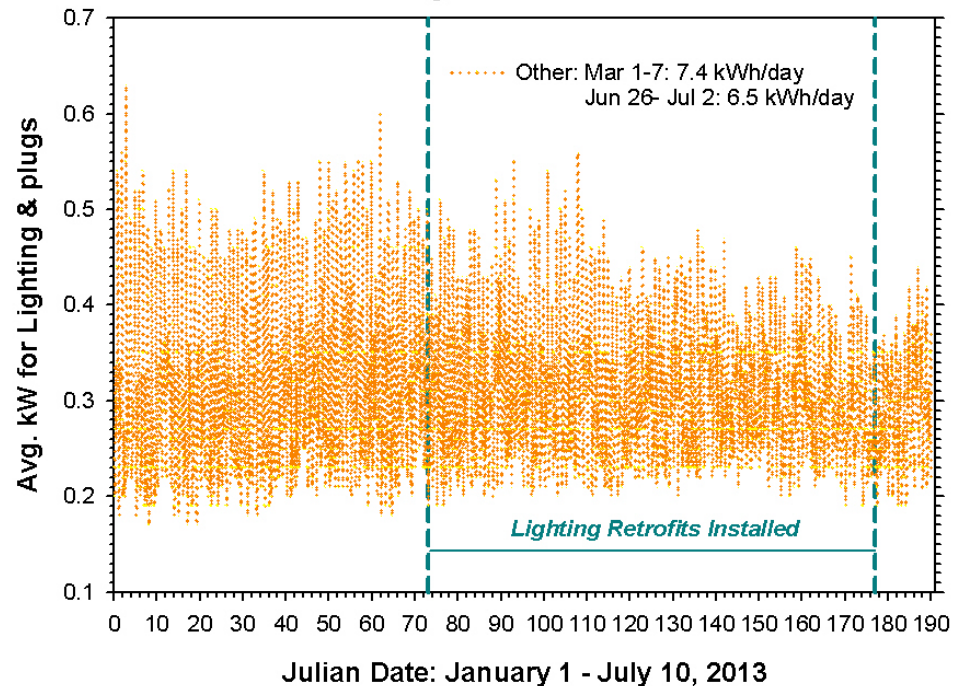
Shallow Retrofits

- Costs average: \$370/site
- Hard costs \$250
- Saves: 1,310-1,530 kWh/yr (\$15/mon)
- **Rate of Return: ~50%, 2 yr payback**
- *Disadvantage: invisible to consumer (swamped by seasonality)*

Deep(er) Retrofits

- Outright cost average: \$14.5K/site
- Incremental cost: \$7.2K
 - Replace at burnout
- Savings: ~ 7600 kWh/yr (\$80/mon)
- *Highly visible to consumer*
- Rate of Return: ROR/SPB:
 - Outright: ~6%, 16 yr payback
 - Incremental: ~13%, 8 yr payback
- **Takeaway: advantage of retrofit to coincide w/ major equipment & appliance replacement**

Measured Lighting, Fans and Plug Loads
January 1 - July 10, 2013:
Average Measured kW in 56 Study Homes
During Shallow Retrofits



Phased Deep Retrofit: Conclusions

- Shallow retrofits: 9% avg. measured savings & durable
- Deep retrofits: ~35-40% reduction
 - Range: 24-55%
- Shallows: highly cost effective
- Deeps: cost effective w/incremental costs
- Tech. w/ Hi Demand Reduction Potential
 - Variable-speed pool pumps
 - Two speed advanced AC systems
 - Excellent performance, but install critical (crew experience)
 - Heat pump water heaters with dependable large load reductions; collecting winter data in Phase II
- NEST thermostats: some surprises; may not always produce savings for customers desiring low temps



Phased Deep Retrofit: Potential

- Demonstrates shallow retrofit programs effective: small, very cost effective savings
- Effective engaging homeowner for larger improvements; gathering data
- Deep retrofit demonstrated hi-savings levels: 35-40% or greater
- Highly effective & reliable technologies
 - Large peak demand reductions
 - Noticeable reductions to utility bills
- Influential results to FL's largest utility
- Model for scale-up of effective staged utility programs in Florida and elsewhere
- Persuasive business model for retrofit services linked to HVAC /water heater replacement

