

# Smart Thermostats: Available Information and Potential EE Workpaper for 2015



**PG&E, SCE, SCG, SDG&E**  
**JULY 2015**

# Presentation Overview

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**Objective: Seeking TF feedback on potential approach for workpaper by end of 2015 / early 2016 using best available information**

- Review of recent and relevant studies
- Review of available sources of data
- Discussion of proposed data source and analysis by SCE and SCG
- Feedback requested from the Cal TF

# Recent and Relevant Studies

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Author/ Year	Location	Description	Conclusions	Limitations
Nest Labs/ 2015	Oregon Indiana 39 US states	Whitepaper Energy Bill Analysis; 3 studies: National study of c.700 Nest homes w/matched comparisons; Oregon study of 185 homes with heat pumps; Indiana study of 300 Nest and 300 programmable t-stat homes	Avg. HVAC savings of 10-12% for heating and 15% of cooling .	<ul style="list-style-type: none"> <li>Household-level effect unknown</li> <li>No true experimental design</li> <li>2 pilots had small sample size</li> <li>Oregon Pilot was technology specific (heat pumps)</li> </ul>
Nest Labs/ 2013	Austin Energy, SCE and Green Mountain Energy (Vermont) service territories	Whitepaper on Seasonal Savings: opt-in program that automatically adjusts temperature setpoints over 3 weeks	<p>Avg. AC savings : 4.7% over 2 months.</p> <p>Avg. temp shift of 1° F. Customers retained 0.5F temp shift 2 months later. SCE meter data subset analysis found 4.4% AC savings compared to Nest's calculated 6.1%.</p>	<ul style="list-style-type: none"> <li>Focus on cooling season only</li> <li>Meter data analyzed only for small subset (139) of SCE customers; within-subjects modeled baseline for comparison</li> <li>AE and GME savings estimates are from Nest data and AC runtime models, not logger /meter data</li> <li>Findings specific to Seasonal Savings program</li> </ul>
Nest Labs/ 2012	Simulated cites distributed across 12 US continental climate zones	Whitepaper on Nest Learning T-stat Efficiency Simulation: savings due to learning, 1°carving, and Auto-away. Simulated sample of 10,000+	Avg. HVAC savings of 19.5%; Max. 36.1%.	<ul style="list-style-type: none"> <li>Simulated modeling only; no real world data</li> <li>Inflated savings estimates due to unrealistically inefficient baseline</li> </ul>

# Recent and Relevant Studies (Cont.)

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Author/ Year	Location	Description	Conclusions	Limitations
Cadmus/ 2013	New Hampshire	Liberty Utilities Wi-Fi Thermostat Pilot Program: Direct install of 32 Venstar ColorTouch T5800 thermostats to determine impact on gas consumption for heating. Billing analysis included data over the course of a year.	Avg. household savings of 8% or 69 Therms annually over the participants' baseline gas consumption.	<ul style="list-style-type: none"><li>• Small sample size 29 households, 32 devices</li><li>• Focused on heating season only</li></ul>
SCE/2014(?)	SCE service territory	SCE analysis of customer meter data for 426 customers who enrolled in Rush Hour Rewards and Seasonal Savings programs by Nest.	Avg. HVAC savings of 11.3% or 1.16 kWh/day and peak demand reduction of 0.10 kW; 1.87% of household kWh.	<ul style="list-style-type: none"><li>• Small household effect</li><li>• Focused on cooling season only</li></ul>

# Key Study Takeaways

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- Studies not very robust
  - Small sample size
  - Experimental design
  - Baseline
  - Simulation vs field data
  - Technology specific
- Overall household energy savings are less than 5% relative to programmable t-stat
- HVAC system energy savings % in low teens relative to programmable t-stat

# Recap of CA IOU Data Analysis Approaches

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- SCE: Leveraging existing DR program participant data, selecting non-participant group baseline using propensity score matching
- SCG: Data from a customer recruitment effort specifically to assess EE opportunity (not true RCT)
  - Data expected Q3 2015
- SDG&E: Leveraging existing DR program participant data to assess EE savings, using propensity score matching for baseline
  - 2014 results for May-Oct; 2015 results anticipated Q2 2016
- PG&E: Randomized control trial (RCT) through ET project
  - Data available Q3 2016

# SCE Data Overview

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Data Characteristics	Description
Sample selection – DR Program	Nest/EnergyHub reached out to their existing and new install base with an offer to join DR program; 10%+ signup rate. Limited to SCE bundled residential customers in SCE's service territory (all climate zones)
Sample size	Dependent on 2015 DR summer program, target 6,000 <ul style="list-style-type: none"><li>• 2013 study had 2,800 customers</li><li>• 2014 study had 3,200 customers &lt;-- Adjusted 2015 contract to include sharing of pairing date (when device was installed)</li><li>• 2015 Program targeting prior year(s) participants and new</li></ul>
Manufacturers	90% Nest + PCT/EnergyHub + others
Methodology	Pre and post interval usage data analysis triggered on pairing date of thermostat. Partnering with SCG on their WP effort to include EE on gas and electric.  M&E Data analysis – Propensity score model (see next slide)
Baseline	Non-participant group – Customers with one year of pre installation data.
Timing (data collection, analysis)	Preliminary analysis targeted for Q3 2015, final analysis Q4 2015

# SCE Propensity Score Matching

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- Obtain a sample of “treatment” customers with pairing date for smart thermostats.
- Identify sub-sample of treatment customers with sufficient pre- and post-data for analysis. (Ideal case would be a full year of interval data prior to smart thermostat adoption (pre-treatment), and full year post treatment.)
- Develop a propensity-score model based on pre-treatment customer behavior (usage patterns).
- Develop a pseudo-control group from larger population of non-smart thermostat customers. Match propensity scores to treatment sample to identify control customers who match as close as possible to treatment customers.
- Develop regression model on customer usage data, including treatment and control customers, covering pre- and post-treatment periods. Model accounts for seasonal patterns and weather variables (using “local” weather – matching data from closest weather station to individual customers).
- Model estimates treatment effect using “difference-in-difference” approach (comparing pre- and post-differences in treatment group to pre- and post-differences in control group).
- Treatment effect (model outcome) is estimate of savings as a function of weather conditions (likely CDD). As such, it can be used to estimate aggregate savings for a variety of weather conditions. In particular, typical “weather-years” can be determined for various climate zones, depicting expected weather conditions for an average year. These weather conditions are then used as inputs to the savings estimate function to develop savings estimates (annual kWh) per climate zone.



# SCG Data Overview

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Data Characteristics	Description
Sample selection – EE Pilot	Direct mail and email outreach to SF customers with Central AC excluding special territories. Customers are offered thermostat free of charge \$350 value (\$200 for thermostat and \$150 for installation)
Sample size	500 + 330 control group - all with advanced meters Multiple CZ, mostly the greater Los Angeles area (Inland Empire, Riverside, Central LA, Pasadena, Burbank, Glendale, etc.) Focused in customers with 20 – 80% heating consumption
Manufacturers	Nest
Methodology	Billing/usage analysis. 18 months with thermostat + 12 months before installation Gas + Electric (Jointly with SCE & municipal utilities)
Baseline	Control group (330)
Timing (data collection, analysis)	Data collection is being wrapped up. Expected report completed in early Q3 2015

# SDG&E Study Results

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- Res energy conservation effects of EcoBee Si with Zigbee estimated using a panel time-series regression analysis
- Participant sample, pre (2013) and post (2014) periods May – Oct
- Propensity score matched control group, pre (2013) and post (2014) periods May – Oct; 7 strata created based on climate zone and annual energy use
- ~3% EE savings weekday, 1.5% weekend

**Table 5-1: Daily Energy Savings Estimation by Month – Weekday Model**

Month	# Active Participants	kWh Observed	kWh Impact	kWh Reference	% Impact	Temp. (F)	t Value	p Value
May	45	21.29	-3.25	24.54	-13.26%	67.55	-6.22	<.0001
June	441	19.17	-0.30	19.47	-1.54%	67.43	-2.00	0.0451
July	997	25.12	-0.47	25.59	-1.85%	72.39	-5.03	<.0001
Aug.	1,097	26.02	-0.88	26.90	-3.28%	72.85	-9.68	<.0001
Sept.	1,097	26.22	-0.98	27.20	-3.59%	73.76	-10.01	<.0001
Oct.	1,097	19.16	-0.64	19.80	-3.24%	70.49	-7.21	<.0001

- Observed kWh – average observed consumption of participants
- kWh impact – average consumption estimated by model
- kWh reference – average consumption predicted by model w/o program
- % impact – kWh impact / kWh reference
- 2015 study results anticipated in Q1/Q2 2016 (sample size ~20,000)

# Feedback Requested from the Cal TF

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- Workpaper timing: Q4 2015 or Q1 2016
- Does the proposed existing data/information support a workpaper in the short term, with the expectation that it will be updated when better data becomes available?
  - Is further analysis required?
- What should be done for a more robust, longer-term workpaper?
  - RCT trial results in 2016
  - Further data analysis?
- Should studies from jurisdictions outside CA be considered?
  - Studies from other jurisdictions
  - SDG&E 2014 results using propensity score matching over 4-6 mo
- Do individual devices need to be tested to develop a broad set of technical specs and savings estimates?
  - Testing – lab vs. field
  - Obtaining algorithms from manufacturers or patents
- Is a distinct value needed for each climate zone using experimental data?
  - Aggregate climate zones (warm and cool)?

# Appendix

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# PG&E Data Overview

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- EE workpaper completion target date of Q4 2016

Data Characteristics	Description
Sample selection – ET Project	Survey recruitment via email targeting customer segmentation information (persona) who meet requirements (e.g. SFH, climate zones 11-13, central AC, dual fuel)
Sample size	3,000 total (1,000 for each participating manufacturer)
Manufacturers	Nest, EcoBee, PCT(RTA CT50)/EnergyHub
Methodology	Randomized Control Trial (RCT), Billing/usage analysis Manufacturer operational data analysis 12 month prior usage data
Timing (data collection, analysis)	Data available by Q3, analysis ready Q4 2016
Statistical Confidence	High statistical confidence 90/10

# PG&E Data Analysis Benefits and Challenges

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- Benefits
  - Preferred methodology according to CPUC
  - High statistical confidence
  - Evaluating three different manufacturers
- Challenges
  - Expensive approach
  - Duration - results are available in 12-18 months
  - Focused on only three climate zones
- CPUC Feedback
  - Supportive of experimental design

# SCE Data Overview

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- EE workpaper completion target date of Q3 2015

Data Characteristics	Description
Sample selection – DR Program	Nest/EnergyHub reached out to their existing and new install base with an offer to join DR program; 10%+ sign-up rate. Limited to SCE bundled residential customers in SCE's service territory (all climate zones)
Sample size	Dependent on 2015 DR summer program, target 6,000 <ul style="list-style-type: none"><li>• 2013 study had 2,800 customers</li><li>• 2014 study had 3,200 customers &lt;-- Adjusted 2015 contract to include sharing of pairing date (when device was installed)</li><li>• 2015 Program targeting prior year(s) participants and new</li></ul>
Manufacturers	90% Nest + PCT/EnergyHub + others
Methodology	Pre and post interval usage data analysis triggered on pairing date of thermostat. Partnering with SCG on their WP effort to include EE on gas and electric
Timing (data collection, analysis)	Preliminary analysis targeted for Q3 2015, final analysis Q4 2015
Statistical Confidence	High statistical significance (approximate level, eg 85%)

# SCE Data Analysis Benefits and Challenges

- **Benefits**

- ❑ Cost-effective (leveraging existing BYOD customer base for analysis)
- ❑ High statistical confidence
- ❑ Short timeline leveraging 2 years of study data (results in Q3 2015)

- **Challenges**

- ❑ Uncertainty about sample size (subject to 2015 summer DR program recruitment) (SCE is targeting 6,000 total enrollments in 2015)
- ❑ Matching is challenging – As customers enroll, we will match them up against prior year enrollments and focus on those that have participated previously. Based on the pairing date, we will have interval usage data going back in some cases to 2013 to use in our analysis
- ❑ Variability of install dates – SCE may have to limit customer data analysis based on pairing date. Customers who are new to SCE's service territory may not have significant interval usage data needed for analysis

- **CPUC Feedback**

- ❑ SCE plans to review interval usage data analysis with the CPUC/ED to ensure we are in alignment on results



# SCG Data Overview

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- EE workpaper completion target date of Q3 2015

Data Characteristics	Description
Sample selection – EE Pilot	Direct mail and email outreach to SF customers with Central AC excluding special territories. Customers are offered thermostat free of charge \$350 value (\$200 for thermostat and \$150 for installation)
Sample size	500 + 350 control group - all with advanced meters Multiple CZ, mostly the greater Los Angeles area (Inland Empire, Riverside, Central LA, Pasadena, Burbank, Glendale, etc.) Focused in customers with 20 – 80% of space heating consumption
Manufacturers	Nest
Methodology	Randomized control trial (RCT), Billing/usage analysis. 18 months with thermostat + 12 months before installation Gas + Electric (Jointly with SCE & municipal utilities)
Timing (data collection, analysis)	Data collection is being wrapped up. Expected report completed in early Q3 2015
Statistical Confidence	High statistical significance (requires a large sample size to detect small savings) (can't say the statistical confidence level at this time)

# SCG Data Analysis Benefits and Challenges

- **Benefits**
  - Preferred methodology according to CPUC
  - High statistical confidence
  - Short timeline (results in Q2 2015)
- **Challenges**
  - Single manufacturer – plan to include all available products in WP
  - Identifying contributing specs/features to savings
  - Focus on gas savings, electrical data comes from different sources and might be difficult to analyze – SCE joined after the pilot launched. Cities are providing electrical data to SCG.
- **CPUC Feedback**
  - Notified about the pilot before launch, but no specific guidance received

# SDG&E Data Overview

- EE program under consideration

Data Characteristics	Description
Sample selection – DR Program	Direct mail followed up with email outreach to customers identified by disaggregation software with potentially high HVAC usage Building types - Asm, EPr, ESe, Htl, Mtl, RtS. Climate zones- 7, 10, 14, & 15 (DR workpaper by KW Engineering)
Sample size	~15,000 total 40% RES/60% COM (6,5K RES as of Jan 2015)
Manufacturers	EcoBee Si
Methodology	DR focused, possibly include EE analysis, Billing/usage analysis. DR EM&V impact study filing Apr 2015. Will not use manufacturer operational data.
Timing (data collection, analysis)	Data collection completion anticipated Q3 – Q4 2015, data analysis completion anticipated Q1 2016.
Statistical Confidence	Statistical significance level ~ 75 - 80 %.

# SDG&E Data Analysis Benefits and Challenges

- Benefits

- Large dataset
- Existing installation
- Possibly short timeline

- Challenges

- Single manufacturer for existing data, multiple manufacturers considered for 2015 by Q3
- Matching is challenging

- CPUC Feedback on DR WP

- RES EE savings negative
- NR EE savings baseline + GSA 25% multiplier