# **Request for Clarification on Nest - Supplemental Data for California Smart Thermostat Work Paper** Request by: Andres Fergadiotti/SCE and IOUs | Revision June 24, 2016Response prepared on July 22, 2016

**Section 1.0**

*1. It seems that measure was evaluated for all CZs. However, the distribution of evaluated t-stat per climate zone it is not clear. Is this information available?*

**Response:** Our team would be happy to share a more detailed breakdown in a meeting, but would rather generalize for this distributed document. The distribution is as follows:

|  |  |  |
| --- | --- | --- |
| **California Climate Zone** | **Distribution of Thermostats in Sample (heating)** | **Distribution of Thermostats in Sample (cooling)** |
| CA1 | Under 1% | Under 1% |
| CA2 | 1% - 10% | 1% - 10% |
| CA3 | 10% - 20% | 1% - 10% |
| CA4 | 10% - 20% | 10% - 20% |
| CA5 | Under 1% | Under 1% |
| CA6 | 1% - 10% | 1% - 10% |
| CA7 | 1% - 10% | 1% - 10% |
| CA8 | 1% - 10% | 1% - 10% |
| CA9 | 10% - 20% | Over 20% |
| CA10 | 1% - 10% | 1% - 10% |
| CA11 | 1% - 10% | 1% - 10% |
| CA12 | 10% - 20% | 10% - 20% |
| CA13 | 1% - 10% | 1% - 10% |
| CA14 | Under 1% | Under 1% |
| CA15 | 1% - 10% | 1% - 10% |
| CA16 | 1% - 10% | Under 1% |

*2. Pooled fixed regression modeling – not clear if research included a control group. Please clarify.*

**Response:** The model is a fixed effects analysis designed to estimate how customer temperature set points affect those customer’s HVAC runtime. A control group is not needed for such an analysis, as it is not a pre/post analysis estimating a net impact or changes over time. In addition, because the analysis is based on Nest device data, a control group is not feasible.

*3. Does analysis for the supplemental data follow the same approach as this type of study – “*[*Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol” [Agnew and Goldberg*](http://energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf) *2013] including CDD/HDD weather data normalization. How specifically does adopted methodology used for this study vary from methodology used in referenced study? It seems that supplemental data excluded weather normalization (e.g., CDD/HDD).*

**Response:** The analysis is not a pre/post weather normalization of billing data and so does not directly follow methods, such as UMP, that were designed for that purpose. However, the overall analysis is indeed similar in that it included degree-day variables to capture the impact of weather on heating and cooling runtimes. Nest did not adjust the modeling results using “normal” year heating-degree-day (HDD) or cooling-degree-day (CDD) values because it isn’t clear whether the set points themselves might be affected by the actual HDD and CDD experienced, which could mean that any adjustment to different HDD/CDD values may not actually reduce bias. That said, with about two weeks lead time, Nest could run this additional analysis if the broader stakeholder group believes it would add significant value to the study.

*4. Were there any building characteristics collected as part of this study – e.g., single story vs. 2 stories; number of thermostats per household; home vintage; energy efficiency retrofits during the study – pre/post t-stat measure; number of occupants; occupancy patterns; type of HVAC equipment; HVAC efficiency/capacity; etc.*

**Response:** Nest has customer self-reported home square footage and vintage data for about half of the homes included in this sample. In addition, Nest can distinctly determine, based on wiring, whether each Thermostat is connected to cooling, a heat pump, forced air furnace, or boiler. If it would be helpful for the larger effort, Nest would be happy to add this type of data to the report as a next-step.

It is also worth noting that this regression analysis was not performed as part of a unique study (i.e. not a classic study that delivers devices to customers for the purpose of this study). Instead, this regression was conducted with data from existing Nest Thermostats installed throughout California.

*5. Was there any occupant behavior and/or user preferences on technology usage collected as part of this study?*

**Response:** No, this report was built using data from existing Nest Thermostats in California. Occupant behavior was included to the extent that the Nest Learning Thermostat learns customer behavior to build an energy efficient schedule that meets their needs. Their preferences are automatically included by the Thermostat, and that is reflected in this report.

Also, as mentioned above, Nest has self-reported data and data produced by the thermostats that could be included in a second phase of this report.

**Section 1.2.1**

*1. It seems that the base case is based on the delta between the average (mean) temperature setpoints and/or “comfortable” settings “post” t-stat installation opposed to operating conditions between a manual t-stat and Nest/smart t-stat. This may not be representative of a “real” baseline conditions. Please clarify.*

**Response:** The Nest team recognizes that a true baseline may not be a constant temperature, which is why we felt it was important to add a reduction factor to ensure modest efficiencies in customer’s existing behavior was included in the baseline. The ⅓ factor we used as an adjustment appears to provide conservative estimates of energy savings compared to the independent billing analysis studies referenced in our report.

In addition, the Nest team has considered an update to this analysis with two other inputs to the baseline:

1. The DEER baseline for programmable thermostats; or
2. Data collected from a survey deployed by Nest to new Nest customers to learn about their pre-Nest behaviors (i.e. Did they have a manual thermostat? A programmable thermostat? Did they have a nighttime setback? A daytime setback?). This survey is currently being sent to all new Nest customers and the size of the data set should soon reach a level of statistical significance. At that point, Nest will be happy to share the insights with this larger stakeholder group and consider adjustments to the factor.

*2. It seems that energy savings are based on how temperature setpoints can be relaxed and/or disabling of system operation from that in baseline (e.g., AutoSchedule/AutoAway). Please clarify.*

**Response:** That is correct. Nest helps customers save energy in a few key ways:

* AutoSchedule: Reducing overall energy consumption by automatically creating an efficient schedule for customers. When compared to a manual thermostat used with a nearly flat schedule or a programmable thermostat used in hold mold (or an out-of-date schedule), these savings can be significant.
* AutoAway: The Nest Thermostat uses a combination of on-board sensors and presence of paired mobile phones to determine when customers are home or away. When customers are away, the Nest Thermostat will reduce HVAC consumption, thereby reducing consumption when an older thermostat would likely have otherwise continued to run.
* Airwave: The Nest Thermostat will shut off the compressor earlier than normal and use the fan to run air over the cool coils prior to most efficiently reach a customer’s target temperature.

**Section 1.3**

*3. “The regression model sample was restricted to single stage HVAC systems to avoid the uncertainty introduced by the unknown relative capacities of the stages” – how was the System Characteristic determined?*

**Response:** Nest Thermostats determine HVAC configuration based on the wiring they are connected to (for example, Nest can detect heat pumps based on the presence of an OB wire). As a result, two-stage heating and cooling systems based on the wires controlling those stages (some two stage systems may be wired as single stage, which would lead to some mis-classification for a fraction of systems)

*4. The first bullet point of section 1.3 mentions that the average set points and comfort temperature calcs were based on heating and cooling runtime weighted averages. Aren't the average setpoints based directly from setpoints determined by Nest's algorithm? Aren't setpoint and runtime two separate independent data points?*

**Response:** Yes, set points and run time are two distinct data points. However, the overall energy efficiency impact of the set points depends on the amount of HVAC runtime that is controlled at that set point (e.g. the cooling set point, when it is hot outside, is more important than the set point when it is cool outside). The need for weighting the set points by HVAC runtime is especially clear when considering that there may be entire months without any HVAC runtime due to mild weather and so the set points have no impact on energy use.

*5. Was equipment operation status (on/off) determined as part of the research and accounted in methodology? Was this information leverage to evaluate equipment runtime?*

**Response:** Yes. The Nest Learning Thermostat records the exact time (to the millisecond) of every HVAC on and off event. This data was the source of the runtime.

**Figure 1**

*It seems that the shoulder seasons were excluded from the analysis. Please clarify.*

**Response:** The analysis of set points and comfort temperatures was based on a full year of data. The regression modeling of how set points affect runtime, however, was restricted to the main portions of the heating and cooling seasons to provide the most robust indication of how set points affect runtime. Mild weather periods, where set points are more likely to be non-binding, can make the modeling results less reliable while trying to estimate impacts during periods of lower runtime.

***Section 2.5***

*“we have reduced the savings estimates by a factor of ⅓”” – not clear what was the reasoning and/or methodology used for estimating discounting factor.*

**Response:** The Nest team recognizes that a true baseline may not be a constant temperature, which is why we felt it was important to add a reduction factor to ensure modest efficiencies in customer’s existing behavior was included in the baseline. The ⅓ factor we used as an adjustment appears to provide conservative estimates of energy savings compared to the independent billing analysis studies referenced in our report.

In addition, the Nest team has considered an update to this analysis with two other inputs to the baseline:

1. The DEER baseline for programmable thermostats; or
2. Data collected from a survey deployed by Nest to new Nest customers to learn about their pre-Nest behaviors (i.e. Did they have a manual thermostat? A programmable thermostat? Did they have a nighttime setback? A daytime setback?). This survey is currently being sent to all new Nest customers and the size of the data set should soon reach a level of statistical significance. At that point, Nest will be happy to share the insights with this larger stakeholder group and consider adjustments to the factor.

**Table 1.**

*1. Not clear if indicated savings (kwh) are per t-stat or household. Please clarify.*

**Response:** Savings are per-thermostat.

*2. Not clear why the electric demand was not included in analysis. Are demand (kW) savings expected from measure?*

**Response:** Although the Nest team does believe that the Thermostat delivers coincident demand reduction, estimating the demand savings would require knowledge of the customer’s pre-period set point schedules, which we do not know. It would be possible to apply a typical cooling load shape coincidence factor to the kWh savings, but that estimate may not be as reliable as we’d like, because set point chnages can have either positive or negative impacts on demand depending on how the set points themsevles changed.

**Table 2**

*1. “System Sizing Assumptions” – was there any validation/verification process on this?*

**Response:** Nest has done very limited testing of our sizing estimation algorithms based on comparisons to the minimal existing literature. That said, we would welcome the opportunity to use any alternate set of assumptions, especially if there are more standard assumptions based on California-specific research.

**Section 2.4**

*1. Was equipment efficiency predicted? Was equipment efficiency accounted and/or included in Nest savings estimating algorisms?*

**Response:** The estimates of connected loads are based on estimates of system capacity and generic estimates of SEER and AFUE. As mentioned above, Nest would welcome any alternate set of capacity assumptions that should be employed instead.

**Others**

*1. Can we disaggregate setpoint deltas resulting from unoccupied setback vs occupied setback?*

**Response:** Nest could potentially quantify the amount of away time, but it would require a very large effort to try to separate out the impacts of away mode set points from other set points. This is something we could consider as a later addition to this report if it would be particularly valuable.

*2. Regarding calculation methodology, how was the set of data (one month heating and one month cooling) being compared in the regression analysis for HVAC runtime vs. reduction in setpoint temperature (sections 1.3 and 2.3)? Were the comparison samples in roughly the same climate? What about outdoor temperature? Were the data points aggregated for all thermostats before running the regression or was a regression conducted for each individual thermostat?*

**Response:** To clarify, Nest used two months of heating data and three months of cooling data (not one month), and there is no comparison sample. The outdoor temperatures were the temperatures during the listed timeframes for the thermostats in the listed climate zones. The data was not aggregated first, which is why our team conducted a thermostat-level fixed effects in the model

*3. How is DR addressed?*

**Response:** It is likely that a few thousand devices included in this regression analysis in Southern California are participants in SCE’s PTR-ET-DLC Demand Response program. However, the number of devices and number of demand response event days are both small compared to the sample of all data used in this analysis. Therefore, we did not believe it was necessary to separately consider the impact. Also, it is generally believed to be the case that overall consumption for DR customers may not rise or fall that dramatically in total. Instead, their consumption is shifted during the afternoon on an event day.